I.—THE NATURAL AND ECONOMICAL HISTORY OF THE AMERICAN MENHADEN.

By G. Brown Goode.

A—INTRODUCTION.

1.—Object of the memoir.

Previous memoirs in this series.

1. In the first report of the Commissioner of Fish and Fisheries,* was commenced the publication of a series of memoirs upon the important fishes of the United States. Professor Baird inaugurated the work with two treatises from his own pen with the following titles:

I. The Soup. *Stenotomus argyrops*, (Linn.) Gill.†

II. The Bluefish. *Pomatomus saltatrix*, (Linn.) Gill.‡

The present memoir is the third of this series. The work of preparing it was assigned to me in September, 1874. I have tried to make it exhaustive, including everything known about the subject, and statistics up to January 1, 1878. There are still, however, many questions which need further study, for the subject is not at all well understood. I send the manuscript to the printer with reluctance, hoping at some time to resume the study of the many unsolved problems.

The commercial importance of the menhaden.

2. The menhaden has grown greatly in favor within a comparatively short time. Twenty-five years ago, and before, it was thought to be of very small value. A few millions were taken every year in Massachusetts Bay, Long Island Sound, and the bays of New Jersey. A small portion of these were used for bait; a few barrels were occasionally salted in Massachusetts to be exported to the West Indies. Large quantities were plowed into the soil of the farms along the shores, stimulating the crops for a time, but in the end filling the soil with oil, parching it, and making it unfit for tillage. Since that time manifold uses have been discovered. As a bait-fish, this is found to excel all others. For many years much the greater share of all our mackerel have been caught by its aid, while our cod and halibut fleet use it, rather than

* United States Commission of Fish and Fisheries. | —— | Part I. | —— | Report | on the | Condition of the Sea Fisheries | of the | South Coast of New England | in | 1871 and 1872. | By | Spencer F. Baird, | Commissioner. | —— | With supplementary papers. | —— | Washington: | Government Printing Office. | 1873. 8vo., pp. xlvii, 852, 40 plates, 2 maps.

† Op. cit., pp. 228–235.

‡ Op. cit., pp. 235–252.

any other fish, when it can be procured. The Dominion mackerel fleet buy it in quantity, and its value has been thought an important element in framing treaties between our government and that of Great Britain. As a food resource it is found to have great possibilities. Many hundreds of barrels are sold, salted, in the West Indies, while thousands of barrels are salted down every year for domestic use by families living near the shore. In many sections the fresh fish are sold in the market. Within five years has sprung up an important new industry, which consists in packing these fish in oil, after the manner of sardines, for home and foreign consumption. The discovery made by Mr. Goodale, that from these fish may be extracted, for the cost of carefully boiling them, a substance possessing all the properties of Liebig's "extract of beef," opens up a vast field for future development. As a food for domestic animals, in the shape of "fish meal," there seems also to be a broad opening. As a source of oil the menhaden is more important than any other marine animal: its annual yield usually exceeds that of the whale (from American fisheries) by about 200,000 gallons, in 1874 not falling far short of the aggregate of all the whale, seal, and cod oil made in America. The refuse of the oil-factories supplies a material of much value for manures: as a base for nitrogen it enters largely into the composition of most of the manufactured fertilizers. The amount of "ammonia" derived from this source in 1875 was estimated to be equivalent to that contained in 60,000,000 pounds of guano from Peru, the gold value of which would not be far from $1,920,000. In 1876 the yield of the menhaden fishery was more than twice that of any other carried on by the fishermen of the United States. In the value of its products it was surpassed only by the cod and mackerel fisheries.*

Imperfect information regarding the species.

3. At the time of beginning the investigation, the results of which are partially detailed in this memoir, comparatively little was known about the menhaden. The species had been described or referred to in most of the books on the ichthyology of North America, and in

* The following table of estimates shows in a general way the relative values of the fisheries in 1876:

Fisheries.	Yield in pounds.	Value.
Menhaden fishery	462,000,000	$1,657,790
Cod fishery	215,000,000	4,825,540
Mackerel fishery	49,000,000	2,375,262
Fisheries of the great lakes (1872)	32,250,000	1,000,000
Salmon fishery of Columbia River	30,000,000	2,500,000
Halibut fishery	22,000,000	1,546,240
Shad fishery (estimate)	20,000,000	1,000,000
Scup fishery	7,760,000	504,400
Bluefish fishery	7,068,000	424,000
Swordfish fishery	1,500,000	165,000
Bonito fishery	2,200,000	143,000
Squeteague fishery	1,800,000	138,200
Flounders fishery	1,827,000	109,620
Herring fishery (partly in British waters)	27,033,500	507,977
Whale fishery	.....	2,850,000
Oyster fishery	.....	25,000,000

some of the general ichthyological treatises. Mitchill, Storer, and Dekay had given imperfect figures. Allusions were made to its economical value by some of the books mentioned, and in agricultural and statistical works occasional reference had been made to its importance as a manure. Up to the present day the reports of the Commissioner of Agriculture have barely referred to the existence of this source of fertilizing material. Many persons engaged in fishing or manufacturing had a comprehensive knowledge of some parts of its history, but these had never been written or printed. There was no adequate account of this fish accessible to the student. Recognizing the necessity of supplying this need, the Commissioner of Fisheries chose this species as the next to be studied.

2.—Means used to gather information.

4. A circular was issued, December 20, 1873, requesting information upon many points in the history of the menhaden, and propounding fifty-eight questions for the guidance of those disposed to aid in the investigation.* This was distributed to manufacturers, fishermen, and all known to be interested in the fisheries. Through the courtesy of the Secretary of the Treasury and the Chairman of the Light-House Board it was also sent to all collectors of customs and light-house keepers on the Atlantic and Gulf of Mexico. A second edition of this circular was issued in 1874.

5. Personal letters have been addressed to nearly all the intelligent respondents to the circular, and to many others, asking information upon uncertain points.

6. The attention of the marine branch of the Fish Commission has for four seasons been especially directed to the menhaden, especially with a view to learning about its food and its habits of spawning.

3.—Sources of information.

7. At the beginning of this work Professor Baird gave me five or six pages of closely-written manuscript containing his own observations made during five or six summers on the coast of New England. These have been of the greatest importance, and my own work has been little more than that of expanding and carrying out the suggestions there made. I have also made use of notes made by Professors Smith and Verrill, and by Mr. Vinal N. Edwards, and the testimony taken by Professor Baird, in 1872.

Personal observations and aid of individuals.

8. While with the Commission at Eastport, Me., in 1872; Portland, Me., in 1873; at Noank, Conn., in 1874; at Wood's Holl, Mass., in 1875; and at Salem, Mass., and Halifax, Nova Scotia, in 1877, I used every opportunity to study this fish. I have also had opportunities of observing it at the mouth of the Saint John's River, Florida; in the Potomac, at sev-

* This circular is reproduced in Appendix A.

eral of the fisheries; at Greenport, N. Y., and Provincetown, Mass. In October, 1877, I visited Mr. H. L. Dudley, at his works on Pine Island, Connecticut, and there had an excellent opportunity of observing the operations of an oil and guano factory. A similar opportunity was afforded me by the officers of the Pacific Guano Company at Wood's Holl. Here I was enabled, by the aid of Mr. Herbert Gill, stenographer, to obtain very full statistics.

In addition to the circulars, over two hundred personal letters have been written. In almost every case full and satisfactory replies were received. The following gentlemen have been particularly obliging:—

Mr. H. L. Dudley, Secretary of United States Menhaden Oil and Guano Association, New Haven, Conn.; Mr. D. T. Church, Tiverton, R. I.; Prof. C. A. Goessman, Massachusetts Agricultural College, Amherst, Mass.; Mr. E. H. Jenkins, Connecticut Agricultural Experiment Station, New Haven, Conn.; Hon. S. L. Goodale, Saco, Me.; Mr. E. G. Blackford, New York City; Mr. Barnet Phillips, New York City; Mr. W. O. Allison and Mr. Jasper Pryer, New York City.

I am also under obligation to Prof. W. O. Atwater, of Wesleyan University, who has written the portion relating to agriculture; to Mr. H. L. Dudley, for advice and criticism; and to Mr. Herbert A. Gill of the Smithsonian Institution, Mr. William Jameson, and Mr. Walter P. Stoddard, of Wesleyan University, for aid in preparing the manuscripts for the press. My associate, Dr. T. H. Bean, has worked with me in studying the specific characters of the two species of *Brevoortia*. The drawings are by Mr. J. H. Emerton, of Salem, and Mr. H. L. Todd, of Washington. Electrotypes have been obtained from the "American Agriculturist," from George W. Miles & Co., the American Sardine Company, and the Pacific Guano Company.

Responses to the circular of inquiry.

9. The circular of inquiry elicited responses from the correspondents named below, in Appendix B, most of which were carefully prepared, and in many cases give the results of years of observation. In Appendix N will be found these responses in full.

Published accounts of the species.

10. In discussing the history of the name and classification of the *Brevoortia tyrannus* and its allies, allusion is made to various books, and so incidentally under other heads. In Appendix C will be found a complete bibliography of the subject, containing about one hundred and forty citations. Many of these authorities have been quoted in the text. Some of the most important descriptions have been reproduced in Appendix D.

Most of the work on this report was done in the winter of 1874–'75. Since that time two pamphlets have been published, containing very valuable contributions to the knowledge of the menhaden. From these

I have derived much information and have quoted freely. The first was the report of Messrs. Boardman and Atkins.* The most recent contribution is that prepared by Mr. Luther Maddocks, under the auspices of the Maine association.† This is a most interesting little essay, especially valuable for the complete statistics of fisheries and manufactures in Maine, and the account of the relations of the fisheries to the fishermen, the shore population, and the property of the adjoining towns.

The collections of the United States National Museum.

11. The collections of the Fish Commission, deposited in the National Museum, contain over one hundred bottles of menhaden in alcohol, including probably over one thousand specimens, from many localities, with photographs and casts. A list of these is given in Appendix E.

There is also a model of the menhaden fishing steamer "Leonard Brightman" with seine-boats (No. 25824, Ethn. Cat.), made by Joseph Lawler, of Bristol, Me.; models of the Cape Ann seine-boat (No. 25800), with fittings, and the Cape Ann seining-dory (No. 25827), from Higgins and Gifford, of Gloucester; a full series of "fittings" for seine-boats, manufactured by Wilcox and Crittenden, of Middletown, Conn., including "cleats" (No. 25177), "steering rowlocks with stern-sockets" (Nos. 25113–'14), "oar-holders" of old and new models (Nos. 25171–'72), "davit-iron" (No. 25166), "tow-iron" (No. 25167), and "tow link and hook" (No. 25168); a pump box and haft for seine-boat (No. 29499) from Andrew Kennedy, of Provincetown. The Pacific Guano Company is represented by a large model of their works, the same which was exhibited in their pavilion at the Exposition grounds in Philadelphia, and there is a very satisfactory model of the oil factory of Joseph Church & Co., at Bristol, Me. (No. 26899), made by Joseph Lawler.

4.—Sources of error which have been shunned.

The difficulty of obtaining exact information.

12. It has been necessary to make allowances for many inaccuracies of statement on the part of our correspondents. Some of them, having

*The | Menhaden and Herring Fisheries | of Maine | as sources of fertilization. | A Report made to the Maine Board of Agriculture | By Samuel L. Boardman, Secretary of the Board | and | Charles G. Atkins, formerly Fish Commissioner of Maine, | 8vo. 1875, pp. 67.

Under direction of the Maine Board of Agriculture, Mr. Samuel L. Boardman, its secretary, visited in 1874 and 1875 nearly all the manufacturing establishments in Maine, thoroughly investigating their operations. The account of the agricultural uses of fish is the most complete which has yet been published (pp. 34–67). Mr. Charles G. Atkins, formerly commissioner of fisheries for the State of Maine, and for several years in charge of the salmon-hatching establishment at Bucksport, contributed a very thorough study of the habits of the fish (pp. 1–33).

†The Menhaden fishery of Maine | with statistical and historical details | its | relations to Agriculture | and as a | direct source of human food | —— | New processes, products, and discoveries | —— | Published by the | Association of the Menhaden Oil and Guano Manufacturers of Maine | Press of B. Thurston & Company, Portland, 1878. 8vo. p. 46, 4 cuts.

been unable to obtain exact information, have ventured to guess at what they did not really know from experience. I do not think that there has been intentional misrepresentation or any effort to withhold information. There being no ulterior object, such as future legislation, in collecting this information, there has been no temptation to concealment; still the testimony has been partly that of interested persons. The most fair and honorable men, however careful may be their observations, are involuntarily influenced by preconceived opinions or by considerations of personal interest, and, even if it were possible to secure unprejudiced opinions, these necessarily would express only part of the truth. Then, too, the movements of fishes are so capricious, the opportunities of observation so few and so imperfect, that satisfactory results can, in most cases, be reached only after years of constant study.

Prejudices and superstitions.

13. Some curious prejudices and fancies have been encountered among the fishermen. These refer chiefly to the time and manner of spawning, the character of the eggs, the nature of their food, and the relation of the fish to its peculiar parasite.

Inaccuracies of observation and statement.

14. There has been some difficulty in eliminating unreliable data from the great mass of facts contributed by correspondents. This, however, has not been so great as was apprehended at the beginning of the work, since a knowledge of the beliefs and traditions current among seafaring men renders it easy to detect many of the errors at once. The concurrent testimony of a number of reliable correspondents has been thought sufficient to establish points in question: when possible, these have been investigated personally, to render their establishment doubly certain. A large proportion of the communications received have evidently been prepared with much care. It is believed that many facts hitherto unrecorded have been brought to light by this investigation. All communications are given in full in Appendix N. This has been done both to show the character of the testimony upon which this history has been founded, and to put upon record many facts which, while not directly connected with the subject under consideration, are nevertheless of value to the student of the fisheries.

B.—THE NAMES OF THE MENHADEN.

5.—Popular names.

Local names and usages.

15. *Brevoortia tyrannus* has at least thirty distinct popular names, most of them limited in application within narrow geographical boundaries. To this circumstance may be attributed the prevailing ignorance regard-

ing its habits and migrations, which has perhaps prevented the more extensive utilization of this fish, particularly in the Southern States. It accounts for the extraordinary blunder of the compilers of the fishery statistics of the census of the United States for 1870, in which the oils produced from the whitefish of the great lakes (*Coregonus albus*) and the whitefish of Connecticut are classed as identical, a blunder which is followed by a number of others of the same character and quite as certain to mislead. The discrepancy of local names also enables us to understand how the extensive manufacturing interests and fisheries connected with this fish have gradually sprung up, little noticed save by those directly interested in the business.

The geographical distribution of the popular names.

16. In Maine and Massachusetts the name "pogy" is almost universally in use, though in the vicinity of Cape Ann it is partially replaced by "hard-head" and "hard-head shad." The name "menhaden" is exclusively applied in Southern Massachusetts, the Vineyard Sound, Buzzard's Bay, and Narragansett Bay, where it appears to have originated. From the eastern boundary of Connecticut to the mouth of the Connecticut River the name "bony-fish" predominates, while in the western part of the State the species is usually known as the "white fish." In the waters of New York the usage of two centuries is in favor of "mossbunker," a name which also holds throughout New Jersey. In Delaware Bay, the Potomac, and Chesapeake Bay other variations are found in "alewife" and "greentail." Virginia gives us "bug-fish" in its various forms, while in North Carolina we first meet the name of "fat-back," which is more or less prevalent as far south as the Saint John's River, Florida. In all the Southern States, especially in the vicinity of Beaufort, N. C., the names "yellow-tail" and "yellow-tailed shad" are occasionally heard. I am informed that in the Indian River, Florida, the fish is occasionally called the "shiner" and the "herring."

17. The following table gives the usage at a number of points on the coast chosen to exhibit most clearly the geographical distribution of the popular names of *Brevoortia tyrannus*:

Passamaquoddy Bay, Me.....Pogy; Bony-fish.
Castine, Me.....Pogy; Menhaden.
Belfast, Me.....Pogy.
Brooklin, Me.....Pogy.
Cranberry Isles, Me.....Pogy.
Sargentsville, Me.....Pogy.
Matinicus Rock, Me.....Pogy; Porgie; Menhaden.
New Harbor, Me.....Menhaden.
Manhegin Island, Me.....Pogy.
Damariscotta, Me.....Pogy; Mossbunker.
Pemaquid, Me.....Pogy; Menhaden.

Muscongus, Me .....Pogy; Menhaden.
Boothbay, Me .....Pogy; Menhaden.
Bristol, Me .....Pogy; Menhaden.
Round Pond, Me.....Pogy.
Waldoboro', Me.....Pogy.
Pond Island, Me.....Pogy; Menhaden.
Portland, Me .....Pogy.
Pine Point, Me .....Pogy.
Portsmouth, N. H .....Pogy.
Rockport, Mass .....Pogy; Menhaden.
Gloucester, Mass .....Pogy; Porgie; Menhaden; Hardhead.
Salem, Mass.....Pogy; Hardhead.
Marblehead, Mass .....Hardhead; Pogy; Menhaden.
Swampscott, Mass .....Pogy; Menhaden.
Plymouth, Mass.....Pogy; Menhaden.
Wellfleet, Mass .....Pogy; Hardhead.
Truro, Mass .....Pogy.
Provincetown, Mass.....Pogy; Menhaden.
Chatham, Mass .....Pogy; Menhaden.
Hyannis, Mass .....Pogy; Menhaden.
Nantucket, Mass.....Pogy; Poggie; Menhaden.
Edgartown, Mass .....Menhaden.
North Tisbury, Mass .....Menhaden.
Woods Holl, Mass .....Menhaden.
New Bedford, Mass .....Menhaden.
Tiverton, R. I.....Menhaden.
Newport, R. I.....Menhaden; Mossbunker.
New Shoreham, R. I., (Block Isl'd)Menhaden.
Point Judith, R. I.....Menhaden.
Watch Hill, R. I.....Bony-fish.
Stonington, Conn .....Bony-fish.
Mystic, Conn .....Bony-fish.
Noank, Conn .....Bony-fish.
New London, Conn.....Bony-fish.
Groton, Conn .....Bony-fish.
Lyme, Conn .....Bony-fish.
Saybrook, Conn.....Bony-fish; White-fish
Westbrook, Conn .....White-fish.
Guilford, Conn .....White-fish.
New Haven, Conn.....White-fish; Menhaden.
Milford, Conn.....White-fish; Menhaden.
Stratford, Conn.....White-fish; Menhaden; Bunker.
Bridgeport, Conn .....White-fish.
Norwalk, Conn .....White-fish.
Montauk Point, N. Y.....Bony-fish.
Napeague, N. Y.....Bony-fish.

Jamesport, N. Y.....Mossbunker; Menhaden.
Sag Harbor, N. Y.....Mossbunker.
New York City and vicinity....Mossbunker.
Port Monmouth, N. J .....Mossbunker.
Tuckerton, N. J .....Mossbunker.
Atlantic City, N. J .....Mossbunker.
Somers Point, N. J .....Mossbunker.
Cape May, N. J.....Bony-fish.
Bombay Hook, Del .....Mossbunker; Oldwife; Bug-fish.
Mispillion River, Delaware.....Old-wife.
Maurice River .....Mossbunker; Old-wife Chebog.
Hog Island.....Mossbunker; Ell-wife.
Tangier Sound, Maryland .....Alewife.
Pocomoke Sound, Maryland ....Alewife.
Marlboro', Md.....Alewife.
Nanjemoy, Md.....Alewife.
Point Lookout.....Alewife.
Apateague Island, Va .....Alewife.
Washington, D. C.....Alewife; Bug-fish.
Potomac River .....Alewife; Bug-fish; Greentail.
York River, Va ..... Alewife; Bug-head.
Rappahannock River, Virginia..Old-wife; Wife; Bug-head.
Cape Henry, Virginia .....Alewife; Bony-fish.
Edenton, N. C.....Bug-fish.
Cape Hatteras .....Fat-back; Menhaden.
Beaufort, N. C.....Fat-back; Yellow-tail shad.
Body's Island, N. C .....Fat-back.
Fort Macon, N. C.....Fat-back.
Charleston, S. C .....Menhaden; Mossbunker.
Saint Mary's, Ga.....Menhaden.
Saint John's River, Florida .....Menhaden; Mossbunker; Fat-back.

Discrepancies in the popular names.

18. These names are not separated in their distribution by sharply-defined boundaries. Still, as a glance at the table will show, the *habitat*, if that term may be legitimately used, of each local appellation appears to be clearly marked. Where there is a discrepancy it can usually be explained. For instance, the general use of the name "menhaden" in the vicinity of Boothbay, Me., is due to the presence of a large number of fishermen and laborers from Rhode Island who carry on the oil-factories in that region. In the same way the name "bony-fish" has been naturalized at Montauk Point and Napeague, N. Y. The factories in that neighborhood are owned by firms in Eastern Connecticut, and the Connecticut "bony-fish fleet" has a favorite cruising ground in the waters of Eastern Long Island. The names "menhaden" and "mossbunker" have been introduced into Florida by northern fishermen, who

prosecute the winter shad fisheries on the Saint John's, and these same names are more or less familiar all along the coast wherever the northern coasters and fishing vessels are known.

The name preferable for adoption.

19. The adoption of some one suitable name for popular use is eminently desirable. "Menhaden" is the name most generally known, as well as the most distinctive. It has the additional recommendation of having been derived from an aboriginal language. It has been used in the titles of the two manufacturers' associations, and it is hoped that this usage will soon be conformed to by all.

Trade-names.

20. Among the manufacturers in Port Monmouth, N. J., who prepare the menhaden as an article of food, a number of trade-names are in use, such as "American sardine" (in distinction from the European fish, which is prepared in a similar manner), "shadine," and "ocean trout." *

Etymologies.

21. A few words concerning the origin of the above-mentioned names may not be out of place. "Pogy" and "menhaden" are derived somewhat remotely from the Indian dialects of New England, the latter apparently from that in use in Massachusetts and Rhode Island, the former from a more northern source. The writer is indebted to Prof. J. Hammond Trumbull, of Hartford, Conn., for the following very suggestive letter:

* This fanciful name has been the occasion of many erroneous statements. In the New York Times for April 12, 1874, appeared an article entitled "American Sardines," which contained the following bit of biography: "The fish selected as the substitute for the sardine of Europe is the menhaden, more commonly known as the moss-bunker, and the scientific name of which is *Trutta Oceana*, or ocean-trout. Its color is silver, spotted with dark brown, and in the night-time assumes a reddish or fiery tinge. They abound in the seas east of the Canadas and in the bays and deep rivers which indent the New Brunswick, Newfoundland, and Nova Scotia coasts, and from which they migrate in the spring of the year to the southward, and appear in great shoals along the coast of Long Island and in the Raritan and Lower New York bays. A mile or two to the northward of Sandy Hook is their favorite feeding-ground for the spring and summer, and thither they rendezvous toward the close of April in vast schools, numbering millions. They invariably come on with the warm weather, and remain until fall. Their breeding time is late in the winter," &c. These ridiculous statements, evidently compiled in part from printed accounts of the sea-trout (*Salmo immaculatus*, Storer) of the North, partly from the statements of the menhaden fishermen, but principally from the imagination of the writer, would perhaps not be worthy of notice had they not been copied by the European newspapers. A translation, with emendations which make it still more absurd, appeared in *Das Ausland* for August 17, 1874. The Stuttgart paper emends its name to *Trutta trutta*, and states that it resembles in color the brook-trout to which it is very closely allied.

"HARTFORD, CONN., *Dec.* 19, 1874.

"Mr. G. BROWN GOODE:

"MY DEAR SIR: In reply to yours of the 14th respecting the local names of the *Brevoortia menhaden*, about all I can give you is in my note to the new edition of Roger Williams' Key, ch. xix. Williams names, together, among spring fish, "*Aumsûog* and *Munnawhatteaûg*." Under the former name are included several species of the herring tribe, *aum'su* (plural, *aums'uog*) meaning 'small fish.' *Munnawhatteaûg*, corrupted to *Menhaden*, means, literally 'fertilizer' ('that which *manures*.') This name was applied to the herring and alewife as well as the 'menhaden' proper,—all these species being used by the Indians for manuring their cornfields.

"In the northern and eastern parts of New England the *Brevoortia* is commonly called *Pauhagen*, and probably in some localities 'poghaden' (as you write it and which is nearer the Indian original) though I have not heard it so pronounced by eastern fishermen. This name in the eastern dialects has precisely the same meaning as 'menhaden' (or rather *munnawhatteaûg* in Southern New England). The Abnaki (*i. e.*, coast of Maine) name was *Pookagan* as Rasles wrote it, and the verb from which it is derived he translated by 'on engraisse la terre.'

"*Mossbunker* is classic. Dr. Bartlett in his Dictionary of Americanisms quotes from Dow, jr.'s Sermons a remark that 'under the surface [of some smooth faced people] there may be found as many asperities as there are bones in a *mossbunker*.'

"Jacob Steendam mentions it in his poem 'in the Praise of New Netherland,' printed in 1661. Dankers and Sluyter, the Journal of whose Voyage to New York, 1679, was translated by Mr. Murphy for the L. I. Historical Society's Collection, vol. i. (p. 100), saw in the bay schools of innumerable fish, and a sort like herring called there '*Marsbanckers*.'

"I have never looked for the origin of this name, but have had the impression that it was Dutch, perhaps transferred from some European species. I can make nothing of it as Indian.

"Yours truly,

"J. HAMMOND TRUMBULL."

22. According to Mr. J. V. C. Smith,* the older fishermen of Northern Massachusetts, New Hampshire, and Maine called the fish by the Indian name "Pauhagen," and I myself have heard it called "poghaden" by old fishermen about Cape Cod. The modern name may easily have been derived from this by dropping the final syllable. At the present day this name is almost universally in use among the fishermen north of Cape Cod, though it is occasionally varied by "poggie" and "porgy." The use of the latter name should be carefully avoided: the same name, a corruption of the Indian "scuppaug," being commonly applied to

* Natural History of the Fishes of Massachusetts, embracing a practical essay on angling. By Jerome V. C. Smith, M. D., Boston. Allen and Ticknor, 1833.

another fish, the "scuppaug" or "scup" (*Stenotomus argyrops.*)* As may be supposed, the name of Narragansett origin is most exclusively used in Southern Massachusetts and on the shores of Narragansett Bay, the former home of that tribe of Indians. In its present form it first appeared in print in 1792, in the New York Agricultural Transactions, in an article by the Hon. Ezra L'Hommedieu.†

23. "Hard-head" and "bony-fish" explain themselves, both referring to the same peculiarity of structure. The former name was first used about 1813 by Belknap in his History of New Hampshire; the latter, as well as "white-fish," by President Dwight in his Travels in New England.

24. The application of "white-fish" is also sufficiently evident, although this name is not a distinctive one, being applied to a large group of North American fresh-water fishes, the *Coregonidæ*, and in certain localities to the bluefish (*Pomatomus saltatrix*). In England the term "white-fish" is used to designate cod, haddock, hake, ling, pollock, soles, turbot, plaice, halibut, and whiting

25. "Mossbunker" is a relic of the days of the Dutch colony at New Amsterdam, and the name is still lovingly retained by the inhabitants of Manhattan Island. It was in use as early as 1661, as we learn from an allusion in Jacob Steendam's poem in "Praise of New Netherland" (*'t Louf van Niew Nederland*).‡

The allusion to the Mossbunker is as follows:

"Swart-vis, en Roch, en Haring, en Makreel
Schelvis, Masbank, en Voren die (so veel)
Tot walgins toe, de netten'vuld: en heel
Min ward ge-eeten."

"The black and rock-fish, herring, mackerel,
The haddock, mossbanker, and roach, which fill
The nets to loathing; and so many, all
Cannot be eaten."

Allusion has already been made in the letter of Professor Trumbull, to the great schools of "marsbanckers" seen by Dankers and Sluyter on their visit to New York, in 1679, and every one remembers the reference to this fish in Irving's "Knickerbocker," in connection with the death of the renowned trumpeter, Antony Van Corlear, where the name first appears crystallized in its present form.§

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*This probably misled De Kay, who stated that the menhaden were known at the eastern end of Long Island as "skippaugs." He also remarked that "pauhagen" (pronounced *Pauhaugen*) was the Narragansett epithet, while "*menhaden*" was that applied by the Manhattan Indians.

†Appendix O.

‡This poem, cited by Professor Trumbull in the Report of the Commission of Fish and Fisheries for 1871–'72, p. 168, was printed, with an English translation, by Hon. Henry C. Murphy, for the Bradford Club, of New York (Anthology of New Netherland: Bradford Club Series, No. 4, 1865, pp. 52, 55).

§A History of New York * * * By Diedrich Knickerbocker. New York, 1809.

"It was a dark and stormy night when the good Antony arrived at the creek (sagely denominated Harlem *river*) which separates the island of Mannahatta from the main

The derivation of this name may be easily traced, it having evidently been transferred by the Dutch colonists from the scad or horse-mackerel, *Caranx trachurus* (Linn.) Lacepede, a fish which annually visits the shores of Northern Europe in immense schools, swimming at the surface in much the same manner as our *Brevoortia*, and which is known to the Hollanders as the *Marsbanker*.*

In the Museum Ichthyologicum of Gronow,† published in 1754, the name *Marsbanker* is used in speaking of a scombroid fish, frequently taken with the herring, probably the same below referred to.‡

The name is variously spelled "mossbunker," "mossbonker," "massbanker," "mousebunker," "marshbunker," "marshbanker," and "morsebonker," and is also familiarly shortened into "bunker," a name in common use at the eastern end of Long Island.

26. The name "alewife" was given by the Virginia colonists to this species from its resemblance to the allied species known by that name in England. This name is preoccupied by the *Pomolobus pseudoharengus*, and should never be applied to *Brevoortia*.

27. The presence of a parasitic crustacean (*Cymothoa prægustator*) in the mouth of *Brevoortia*, when found in southern waters, explains the name "bug-fish" prevalent in Delaware and Cheaspeake Bays, the Potomac and Rappahannock Rivers, and the inlets of North Carolina, with its local variations of "bug-head" and "buggy-head."§ "Yellow-

land. The wind was high, the elements in an uproar, and no Charon could be found to ferry the adventurous sounder of brass across the water. For a short time he vapored like an impatient ghost upon the brink and then, bethinking himself of the urgency of his errand, took a hearty embrace of his stone bottle, swore most valorously that he would swim across in spite of the devil (Spyt den Duyvel), and daringly plunged into the chasm. * * * An old Dutch burgher, famed for his veracity, and who had been a witness of the fact, related to them * * * that he saw the duyvel, in the shape of a huge moss-bonker, seize the sturdy Antony by the leg and drag him beneath the waves. * * * Nobody ever attempts to swim across the creek after dark, and as to the moss-bonkers, they are held in such abhorrence that no good Dutchman will admit them to his table who loves good fish and hates the devil."

* See Schlegel, Die Dieren van Nederland, Visschen, p. 4.

† Museum | Ichthyologicum, | sistens | Piscium | indigenorum & quorundam exoticorum, | qui in | Museo | Lawrentii Theodori | Gronovii, J. U. D. | adservantur, descriptiones | ordine systematico. | Accedunt | nonnullorum exoticorum Piscium icones æri incisæ. | * * * * * * | (Cut) | Lugduni Batavorum, | Apud Theodorum Haak, | MDCCLIV. | folio, 10 preliminary pages, pp. 70.

‡ 80. *Scomber* linea laterali aculeata, pinna ani ossiculorum triginta, *Arted. Gen.* 25, n. 3, *Synon.* p. 50, n. 3.

Scomber linea laterali curva, tabellis osseis loricata, *Gronov. act. ups.* 1742, p. 83, ibique defer. Trachurus, *Bossuet*, epigr. p. 74, *Bellon. Aquat.* p. 180, *Dale.* Hist. of Harw., p. 131, n. 5.

Belgis *Marsbanker* Frequentissime in Mari Septentrionale cum Clupeis p. 5, n. 4, descriptis capitur.

Op. cit. p. 34.

§ Captain Atwood states in the Proceedings of the Boston Society of Natural History, x, 1865, p. 67, that the half-grown menhaden are called "bug-fish" by the Virginia negroes, because they believe them to have been produced from insects, since they never find spawn in them there.

tail," "yellow-tailed shad," and "green-tail" refer to the yellowish-green tint of the caudal fin, observed only in Southern specimens. The former of these names has led to some confusion among our correspondents, the same name being applied in Georgia and Florida to a very different fish, *Bairdiella punctata* (Linn.) Gill.

28. An allusion to the oily nature of the flesh is found in "fat-back," a name in general use in the Southern States. This name is sometimes applied in Northampton County, Virginia, to the mullet (*Mugil lineatus*). In the last century it was used for the *Albula conorhynchus*.*

The conflict of names among the American representatives of the herring family.

29. The representatives of the herring family most abundant in the waters of Great Britain are three—the shad (*Alosa finta*), the alewife (*Alosa vulgaris*), and the herring (*Clupea harengus*). Their names were at an early date appropriated for representatives of the same family on our own coast. The name "shad" is, from Maine to Florida, yielded by common consent to our *Alosa sapidissima*, which, in many particulars, resembles its namesake, though they "be bigger than the English Shaddes and fatter," as an early writer declares.†

In the Southern States this fish is sometimes called "white-shad," to distinguish it from the *Dorosoma Cepedianum*, there known as the "mud-shad" or "gizzard-shad." On the coast of New England, the mattowocca or tailor-herring (*Pomolobus mediocris*) is sometimes called the "hickory-shad," and also the "sea-shad," under which name it is often confounded with the true shad, which is known from recent investigations to be frequently taken far out at sea in company with mackerel, alewives, and menhaden. In the Bermudas, there being no large clupeoid fish, the same name has been for centuries applied to two species which somewhat resemble it externally—*Eucinostomus gula* and *Eucinostomus Lefroyi*, Goode.

The "herring," or "English herring," of New England north of Cape Cod is identical with that of Great Britain, but at certain points in Southern New England, such as New Bedford, this name is transferred to *Pomolobus pseudoharengus*, and on the Hudson River the usage is general, though the species is occasionally called the alewife. South of the Hudson the name "herring" is universally used in connection with this species of *Pomolobus*, and the allied *Pomolobus mediocris* or "mattowocca," which is known as the "tailor-herring" or sometimes, as in the Saint John's River and about Cape Cod, as the "hickory-shad." In the great lakes the name "herring" is also represented, being applied to one of the whitefish family, the lake-herring (*Argyrosomus clupeiformis*).

To *Pomolobus pseudoharengus* the name "alewife" is commonly ap-

* See Garden, in Correspondence of Linnæus, p. 335.

† New England's Prospect. By William Wood. London, 1634.

applied in New England, and even, occasionally, as mentioned above, in New York. South of New York it is used for *Brevoortia tyrannus* only. The name is corrupted into "old-wife" and "ell-wife," "wife," and on the Connecticut River appears under the guise of "ell-whop." At Maurice River the *Brevoortia* is called "old-wife chebog," "chebog" being probably of Indian origin. Thomas Morton, writing in 1632 of the fishes of Virginia, gives the names "shadd" and "allize" as in use among the colonists at that time.* The original derivation of the word "alewife" is somewhat obscure, though it may probably have originated in *Alausa*, the name applied by Ausonius to the European shads in his celebrated poem on the Moselle River—

> Quis non ——— norit,
> Stridentesque focis opsonia plebis alausas.

The transition through the French "alose," the English "allis," "allice," or "alize," is not difficult, and when we find these names together with "alewife" applied indiscriminately to the same fish, it is, to say the least, suggestive. Such an etymology is at least more satisfactory than that of Josselyn, so often quoted: "The Alewife is like a Herrin, but has a bigger bellie; therefore called an Alewife."†

6. Zoological names.

Latrobe's description of Clupea tyrannus.

30. Our species was first described by Mr. B. H. Latrobe, in a communication to the American Philosophical Society in 1802,‡ under the name *Clupea tyrannus*. Although this article, and the name therein proposed, have long since been lost sight of, there can be little doubt that they refer to the menhaden, and that the laws of priority demand that the species shall henceforth be known as *Brevoortia tyrannus*. The fishes of the Chesapeake and its tributaries have, until within the past three years, been very little studied, and the habits of the menhaden in those waters are so different that it is not strange for Northern ichthyologists to have made mistaken identifications of Latrobe's specific name.§ In fact, it was supposed, not many years since, that the southern limit of the menhaden was north of the Capes of Delaware, while its habit of ascend-

* New English Canaan; or New Canaan; containing an abstract of New England. Force's Hist. Tracts, vol. ii, Tract 5.

† An Account of two voyages to New England, a Description of the country, natives, and creatures. By John Josselyn, Gent. 1675. Col. Mas. Hist. Soc., 3d series, III. 1833.

‡ A Drawing and Description of the Clupea Tyrannus and Oniscus prægustator. By Benjamin Henry Latrobe, F. A. P. S. < Transactions of the American Philosophical Society held at Philadelphia for promoting useful knowledge. Vol. V, 1802, p. 77.

§ Dr. Dekay, misled by the name "alewife," which he supposed to be applied to the same species at the north as in southern waters, applied Latrobe's name to the northern "alewife," calling it *Alosa tyrannus*, a usage which was concurred in by Storer and by Cuvier and Valenciennes. The same name was referred to the shad by Professor Gill in some of his earlier writings.

ing the rivers of the South and the presence of the peculiar parasite were quite unknown.

Latrobe's description is reproduced in Appendix D, and the reader may decide the question for himself. It is believed that the following circumstances clearly indicate the meaning of its author:

(1.) The figure, while undeniably bad, resembles the menhaden very closely, and manifestly cannot be intended to represent any allied species. The contour, were the missing dorsal fin supplied, is similar to that of the menhaden, the black spot upon the scapular region is constant in the menhaden only, though a similar one is occasionally seen upon the shad and the alewife. While the figure resembles somewhat the menhaden, it does not resemble the allied species.

(2.) The name "bay alewife" is still applied to the menhaden in this region. This is a strong argument, for, although seventy-five years have passed since Latrobe wrote, the persistence of popular names is very remarkable, as I have elsewhere pointed out.* Moreover, Latrobe was also acquainted with a "herring" and a "shad." These being eliminated, there is no fish but the menhaden to which the description in question can refer.

(3.) The habits of the alewife as described by Latrobe are essentially the same as those of the menhaden in the present day. As has been remarked, it is only recently that the river-ascending habits of the species have been understood, and the statement that the alewife began to ascend the Potomac in March, which was two months earlier than the menhaden was known to strike our coast, formerly was thought to throw the identity of the two out of question.

(4.) The presence of the crustacean parasite is the strongest argument of all. While this is found in the mouths of a large percentage of the southern menhaden, it has never once been found attached to any other species, although careful search has been made by several persons. As has been remarked, the northern menhaden are free from this parasite, and this is still another reason for the failure to identify.

31. The next mention of this species was by Professor Mitchill, under the name *Clupea menhaden*.† By this specific name it has been known ever since, and it is to be regretted that it is necessary to replace by another a name so appropriate and of such long standing.

Descriptions of later dates.

32. In 1818, the eccentric Rafinesque redescribed the species as *Clupea neglecta*, the specific name being chosen because he supposed the species to have been neglected by Dr. Mitchill in his comprehensive catalogue of the fishes of New York.‡

* Catalogue of the Fishes of the Bermudas, 1876, p. 15.

† The fishes of New York described and arranged. < Transactions of the Literary and Philosophical Society of New York, Vol. I, 1815, p. 453.

‡ American Monthly Magazine, Vol. II, 1818, p. 206.

33. In Belknap's History of New Hampshire, this species is mentioned under the name "*Clupea dura lævi mystax* (hardhead)."* Since no description is given, this name can have no significance.

34. Mitchill's "New York Shadine" (*Clupea sadina*)† appears to be identical with *Brevoortia tyrannus*, as is indicated by the smutty opercular spot, the wide and toothless mouth, and protruding gill apparatus. The deciduous character of the scales may have been due to poor preservation of the type specimen.

Gronow, in 1763, described the species under the name *Clupea Carolinensis*,‡ but his manuscript was not published until 1854, and his name must yield precedence to those which are really much more recent.

The Gulf Menhaden.

35. A second North American species of menhaden has recently been discovered. A description will be given in a subsequent paragraph (42). This species has been reported only from the Gulf of Mexico. The name chosen for it has reference to the presence of a parasite which has already been mentioned, and which was described by Latrobe as the *Oniscus prægustator*. This parasite is common to both *Brevoortia tyrannus* and *Brevoortia patronus*, the gulf form; the specific name of the latter has been selected to carry out the quaint conceit of Latrobe, who fancied that the menhaden resembled a Roman ruler in having a "taster" who first tested every dish to prove its harmlessness.

The Menhaden of Brazil.

36. The species described, from Brazil, by Agassiz and Spix, under the name *Clupanodon aureus*§ does not appear to be distinctly separated from *Brevoortia tyrannus*. No diagnostic characters can be detected in the descriptions of either Agassiz or Günther; that is to say, characters which do not disappear upon the study of a large series of specimens. Agassiz's specimens, collected probably at Bahia, and in 1829 preserved in alcohol in the Munich Museum, were eight inches long. He himself seems to have had an inkling of their identity with the North American species, from the fact that he cites, doubtfully, as a synonym, Mitchill's *Clupea menada*. The difference in spelling this specific name is doubtless an attempt to put in Latin form the Indian name used by Mitchill. Two specimens from Sambaia, Brazil, and one from Rio Janeiro, collected by the Thayer expedition, agree closely with the figure in Spix's

* Belknap's History of New Hampshire, 2d ed., 1813, III, p. 133.

† Trans. Lit. and Phil. Soc., N. Y., 1814, pp. 457, 458.

‡ Catalogue of Fish, collected and described by Lawrence Theodore Gronow, now in the British Museum. Published by order of the Trustees, London, 1854, pp. 140.

§ Selecta | Genera et Species | Piscum | quos | in Itinere per Brasiliam | Annis MDCCCXVII-MDCCCXX | * * * | collegit, et pingendos curavit | Dr. J. B. de Spix, | * * * | digessit, descripsit, et observationis anatomicis illustravit | Dr. L. Agassiz, | * * * | Monachii, | Typis C. Wolf | = | 1829, p. 52.

work. The species is not well separated, and is at best but a geographical race of *Brevoortia tyrannus*.

Darwin's Menhaden.

37. The *Alosa pectinata* described by Jenyns,* from specimens collected by Charles Darwin at Bahia Blanca, appears to be a well-defined species, distinguished chiefly by the lesser number of transverse rows of scales. In the Natural Museum is a specimen (No. 1709) collected by Captain Page, U. S. N., in the expedition of the United States steamer "Waterwitch" to Paraguay. The extremely pectinate scale, given in the figure of *Alosa pectinata*, and upon which so much stress is laid by Mr. Jenyns, is taken from one of the differentiated rows immediately in front of the dorsal fin, which are alike pectinate in all species of the genus. Two specimens belonging to the Museum of Comparative Zoology, collected in the Rio Grande, agree thoroughly with Mr. Jenyns' description and with the Paraguay specimens already referred to.

Generic relations.

38. Dr. Storer first referred the species to the genus *Alosa*, where it stood until 1861, when Professor Gill proposed for it a new genus, which he named *Brevoortia*, in honor of the Hon. J. Carson Brevoort, of New York City. This genus is characterized by peculiarities of structure in scales, gills, gill-rakers, and alimentary canal.

A revision of the American species.

39. The type of the genus *Brevoortia* of Gill is the species described in 1802 by Latrobe under the name *Clupea tyrannus*, and later by Mitchill under the name *Clupea menhaden*. As has already been indicated (Proceedings U. S. National Museum, vol. 1, p. 5), the former name has the prior claim to adoption, and the species must be called *Brevoortia tyrannus*. Of this species there appear to be two geographical races or subspecies. One of these is the typical form of the Atlantic coast of the United States, the other a closely-allied form from the coast of Brazil, already described by Spix under the name of *Clupanodon aureus*. For the species the name of Latrobe should be retained, and the two subspecies may be distinguished as *Brevoortia tyrannus, menhaden* and *Brevoortia tyrannus, aurea:* a third subspecies is temporarily adopted to include some aberrant forms from Noank, Conn., for which the name *Brevoortia tyrannus brevicaudata* is proposed. On the coast of Patagonia and Paraguay occurs a well-marked species, described by Jenyns under the name of *Alosa pectinata*. This species is readily distinguished by its larger scales, which are arranged in 18 to 20 lateral rows, instead of 25 to 27, as in *B. tyrannus*. The generic relations of this species were recognized many years ago by Professor Gill, and its name should stand as *Brevoortia pectinata*, (Jenyns) Gill.

* The Zoology of the Voyage of H. M. S. Beagle, &c. * * * Part IV. Fish. * * * London, 1842., p. 135, pl. xxv.

A third species occurs in the Gulf of Mexico. It is distinguished by its larger head and fins and other characters. It appears to have never been described, and, for this form, the name of *Brevoortia patronus* is proposed. It is accompanied by the same crustacean parasite that is found in the mouths of *B. tyrannus*, to which Latrobe gave the significant specific name of *prægustator*.

C.—DESCRIPTIONS OF THE AMERICAN SPECIES OF MENHADEN, WITH ANATOMICAL AND PHYSIOLOGICAL NOTES.

7.—TECHNICAL DESCRIPTIONS.

Brevoortia tyrannus.

40. The following is a careful description of the common menhaden, which occurs on the east coast of the United States and Brazil:

Brevoortia tyrannus (Latrobe) Goode. THE MENHADEN.

Diagnosis.—Head and jaws short; the length of the head less than one-third of the length of the body less the caudal fin; especially short in subsp. *aurea*, the maxillary in length much less than three-twentieths of the length of the body.

Height of body about one-third of total length, in very fat individuals about three-eighths. Fins comparatively short, the height of the dorsal less than length of maxillary, and considerably less than three-tenths of length of body; that of the anal usually less than half that of maxillary; that of ventral always less than one-tenth of total length; the length of middle caudal rays one-fifth that of body, and less that of exterior caudal rays, usually about three-fourths, often less than two-thirds, and rarely more than five sixths of total length. Fins all shorter in subsp. *aurea*. Insertion of ventral far behind tip of pectoral. Insertion of dorsal about equidistant from snout and base of middle caudal rays, but varying two or three one-hundredths to either side of this median point, and always slightly behind the vertical from insertion of ventral.

Scales of medium size, much serrated, arranged very irregularly in 24–26 transverse and 60–80 longitudinal rows. Scales forming sheath at base of pectoral not large. Squamation of caudal lobes moderate. Operculum strongly striated in subsp. *menhaden*, almost smooth in subsp. *aurea*. Scapular blotch conspicuous.

This species is easily distinguished from *Brevoortia patronus* by its shorter head and fins, by its slender body and its pectinated scales, and from *B. pectinata* by its smaller, less regularly arranged, and more numerous scales, and its shorter, less furcate caudal fin.

Individual variations and special descriptions.

Head.—The length of the head varies from 28 to 33 hundrdths of total length. The posterior end of the maxillary extends to a point in the vertical from the centre of the orbit. The length of the skull, as

indicated by the "distance from snout to nape," varies from .19 to .23. The length of snout, measured from a line drawn perpendicularly through the centre of the orbit, varies from .09 to .11. The length of maxillary varies from .12 to .14½; that of mandible from .15 to .18. The diameter of the eye enters 4½ times in the length of the head; its width varies from .11 to .15 in very fat individuals.

Shape of body.—This is exceedingly variable, and the variation is caused largely by the fatness of the individual. In very plump ones, the expansion of the belly throws back the origin of the ventrals and anal, and greatly changes the appearance of the fish. In the specimens before me the height of the body ranges from .31 to .38½. The table of measurements subjoined shows the effect of increased height of body upon the other measurements of proportion.

Fins.—The range of variation in the position of the dorsal is indicated in the diagnosis. There is no appreciable correlation between the positions of the dorsal and anal in the same specimen. The insertion of the anal is distant from the snout from .68 to .75. The length of the rays in dorsal, anal, ventral, and caudal vary much, as the table of measurements indicates. In the caudal the upper lobes vary from .16 to .25, the lower lobes from .18 to .27. The relation of the pectoral and ventral fins is much affected by the length of the head, the insertion of the former being thrown much farther back in long-headed individuals.

Scales.—The degree of serration varies much in individuals as well as the squamation of the bases of the vertical fins, and the number and regularity of the body-scales. In young individuals the scales are arranged with much regularity, but in the adults I have strong reason to believe that other scales are intercalated here and there throwing the arrangement into great disorder and rendering an accurate enumeration impossible.

Subspecies.

The series before me embraces some two hundred specimens of *Brevoortia tyrannus* of various ages, seasons, and localities. Almost every feature is subject to wide variations, and there is usually no decided correlation between different characters except that a long head is accompanied by long jaws and a pectoral set farther back and extending more nearly to the insertion of the ventral. There are, however, certain groups of individuals which can be included within a diagnosis, which may serve to distinguish them from all the others of the same species. To what extent it is desirable to define varieties which are not separated geographically, I am not well satisfied. The exact meaning of the terms "sub-species" and "variety," as employed by Cope, Coues, Gill, Yarrow, and other recent writers, has not been definitely interpreted. It seems desirable, however, to designate in some way the limits of variation from the normal specific types in different directions. With this purpose, and remarking that by a subspecies I mean simply a divergent form connected by intermediate forms with the typical specific form, I have

thought it desirable to name provisionally two varieties, and to call attention to others which may possibly exist. This is done with much hesitation, and only with a view to an attempt to formulate the minor differences to be observed between fish of the same species on different parts of our coast. A precisely parallel case is to be found in the shad of the different Atlantic rivers, which are well-known to exhibit strong distinctive marks. Very possibly every school of menhaden has its own characteristics. In every case where I have had an opportunity to observe them, the individuals composing the same school were closely similar to each other.

The typical form of the species, as now defined, is taken from the coast of Southern New England and the Middle States. It has the height of the body about one-third of the total length, the head three-tenths of the total length, or a little more; the maxillary long (.14 to .14½), and exceeding the height of the dorsal.

The species described by Spix, under the name of *Clupanodon aureus*, cannot be distinguished by any apparent specific characters from *Brevoortia tyrannus*, since one or more of the specimens of the latter species before me partakes of some of the peculiarities of the Brazilian form. There is, however, a general average of character exhibited by the Brazilian specimens, as well as the figure of Spix, with which they closely agree, which seems to me to entitle them, for the present at least, to recognition as belonging to a distinct geographical race. The distinctive characters appear to consist in (1) a greater average height of body; (2) a lesser length of head; (3) a lesser average length of maxillary and mandible; (4) a slightly lower anal and dorsal fin; (5) a greater average distance of anal from snout; (6) a greater average length of the medial caudal rays; (7) a shorter average length of pectoral; (8) a more regular arrangement of the scales, and a more luxuriant growth of small scales at the basis of the fins.

A number of specimens from Noank, taken in 1874, vary quite as much from the normal type, and in almost the same respect as the variety just described. The maxillary and mandible are shorter, however, than in the Brazilian form, the anal fin lower and the lobes of the caudal are extremely short, sometimes hardly exceeding in length the pectoral fin. But for the fact that these specimens show almost all the characters of the Brazilian *Brevoortia*, and in some cases exaggerations of them, I should be inclined to consider the *aurea* a distinct species. Having with some hesitation allowed to this the rank of a subspecies, the question must be decided as to the propriety of also allowing subspecific rank to this peculiar form from Noank. The exact meaning of the terms subspecies and variety, as recently employed by zoologists, is not very clear to my mind, but I infer a "subspecies" to be composed of an assemblage of individuals varying uniformly from the typical specific forms in a degree sufficient to be susceptible of description and definition, though not necessarily separated from it by the absence of

connecting forms. Premising, then, that in giving to the Noank specimens a subspecific name, my object is simply to define the limits of variation from the normal type in a given direction, I would provisionally propose that they be designated as subspecies *brevicaudata.*

The specimens from the Saint John's River, Florida, are extremely variable in every respect. Certain individuals show a tendency to elongation of the head and fins, and also a slenderness of the posterior part of the body, and nearly all the individuals from that region are more lightly and gracefully shaped; they all have a tendency to a yellow coloration, especially upon the caudal lobes. I have not felt justified, however, in calling it a subspecies.

I have not had an opportunity to study the Maine schools, but am inclined to believe that their differences are very perceptible.

In plate VI are shown the chief variations of form. Fig. 1 shows the typical form; fig. 2 the subspecies *brevicaudata;* fig. 3 the average form from the Saint John's River, Florida; fig. 4 the subspecies *aurea.*

Table of measurements.

Current number of specimen	10,405 = 709 C. A. S.		10,405 = orig. No. 247.		20,666 *a.*	
Locality	Wood's Holl.		Wood's Holl.		Wood's Holl.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
	Very fat.		*Plump.*			
Extreme length	251		243		130	
Body:						
Greatest height		38¼		31½		34½
Least height of tail		9				
Length of caudal peduncle		9½				
Head:						
Greatest length		32		31		31
Distance from snout to nape		20		20½		20½
Greatest width		15				
Length of snout from perp. from centre of orbit		10		10		10½
Length of operculum		9		9		9
Length of maxillary		14½		14½		14
Length of mandible		17½		17½		17
Distance from snout to center of orbit		10½		10½		10½
Dorsal:						
Distance from snout		54		51		49
Length of base		19		17½		17½
Origin of pectoral to origin of dorsal		41		33½		35½
End of dorsal to end of anal		25½		24		25
Length of longest ray		12½		11		12½
Length of last ray		6		7		6½
Anal:						
Distance from snout		73		72		72
Length of base		14		14½		15½
Origin of anal to origin of dorsal		39		33		36
Length of longest ray		6½		5½		6½
Length of last ray		5½		4½		4½
Caudal:						
Length of middle rays		5½		4½		5½
Length of external rays, superior		23		20½		20
inferior		26½		23		23
Pectoral:						
Distance from snout		30		32		30
Distance of tip from snout		48½		48		46
Length		19		17½		18
Length of longest axillary appendage		11				
Ventral:						
Distance from snout		53		53		51
Length		8½		7½		9
Origin of ventral to end of dorsal		38		31		33
Dorsal	18		20		20	
Anal	21		20		21	
Number of scales in lateral line	94		107			

Table of measurements—Continued.

Current number of specimen	20,666 *b*.		18,049 *b*.		1,696 *a*.	
Locality	Wood's Holl.		Saint John's River.		Indian River, Florida.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
					Fat.	
Extreme length	132	.....	140	.....	196	.....
Body:						
Greatest height	.....	34	.....	34	.....	37
Head:						
Greatest length	.....	32	.....	30	.....	30
Distance from snout to nape	.....	23	.....	21	.....	20
Greatest width	.....	.....	.....	11	.....	.....
Length of snout from perp. from center of orbit	.....	11½	.....	10	.....	10
Length of operculum	.....	9	.....	9½	.....	9
Length of maxillary	.....	14½	.....	13	.....	13½
Length of mandible	.....	17½	.....	16	.....	17
Distance from snout to center of orbit	.....	12	.....	.....	.....	.....
Dorsal:						
Distance from snout	.....	53	.....	49	.....	50
Length of base	.....	19	.....	18	.....	17
Origin of pectoral to origin of dorsal	.....	35	.....	34	.....	36
End of dorsal to end of anal	.....	24	.....	26	.....	30
Length of longest ray	.....	12	.....	12	.....	13
Length of last ray	.....	6	.....	6½	.....	5
Anal:						
Distance from snout	.....	72	.....	71	.....	72
Length of base	.....	15	.....	16	.....	16
Origin of anal to origin of dorsal	.....	34	.....	36	.....	38
Length of longest ray	.....	6½	.....	8	.....	*5+
Length of last ray	.....	5	.....	5	.....	*3+
Caudal:						
Length of middle rays	.....	6	.....	6½	.....	*4+
Length of external rays, superior	.....	22½	.....	24	.....	*22
inferior	.....	27	.....	27	.....	*24
Pectoral:						
Distance from snout	.....	32	.....	30	.....	30
Distance of tip from snout	.....	48½	.....	47	.....	.....
Length	.....	18	.....	17	.....	.....
Ventral:						
Distance from snout	.....	52	.....	50	.....	50
Length	.....	9½	.....	9	.....	.....
Origin of ventral to end of dorsal	.....	33	.....	33	.....	35
Dorsal	20	.....	19	.....	18	.....
Anal	21	.....	20	.....	20	.....

Current number of specimen	5,152.		17,927.		19,046.	
Locality	West Florida.		Saint John's River, Fla.		Saint John's River, Fla.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
			(7-*inch*.)			
Extreme length	101	.....	178	.....	230	.....
Body:						
Greatest height	.....	38	.....	34½	.....	32
Least height of tail	.....	.....	.....	10	.....	9
Length of caudal peduncle	.....	.....	.....	8	.....	8
Head:						
Greatest length	.....	29	.....	31½	.....	33
Distance from snout to nape	.....	20	.....	20½	.....	20½
Greatest width	.....	.....	.....	12	.....	12
Length of snout from perp. from center of orbit	.....	10	.....	10	.....	10½
Length of operculum	.....	9½	.....	9½	.....	9½
Length of maxillary	.....	13	.....	14	.....	14½
Length of mandible	.....	15	.....	18	.....	18
Distance from snout to center of orbit	.....	.....	.....	11½	.....	10½
Dorsal:						
Distance from snout	.....	48	.....	52	.....	52½
Length of base	.....	18	.....	21	.....	17
Origin of pectoral to origin of dorsal	.....	36	.....	34½	.....	34
End of dorsal to end of anal	.....	30	.....	26	.....	25
Length of longest ray	.....	.....	.....	12	.....	12
Length of last ray	.....	.....	.....	5	.....	.....

* Broken.

Table of measurements—Continued.

	5,152.		17,927.		19,046.	
Current number of specimen						
Locality	West Florida.		Saint John's River, Fla.		Saint John's River, Fla.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Anal:			(7-inch.)			
Distance from snout				68		72
Length of base				16		16
Origin of anal to origin of dorsal				38		32½
Length of longest ray				6½		6
Length of last ray				5		6½
Caudal:						
Length of middle rays				5		5½
Length of external rays, superior				21		20
inferior				23		24
Pectoral:						
Distance from snout				31½		32
Distance of tip from snout				49		50
Length				19		18
Length of longest axillary appendage				12		
Ventral:						
Distance from snout				49		48
Length				9		9
Origin of ventral to end of dorsal				33½		30
Dorsal	20		21		18 or 19	
Anal	21		21		21	

	19,044.		18,049 *a*.		19,468.	
Current number of specimen						
Locality	Saint John's River, Fla.		Saint John's River, Fla.		Virginia.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	192		144		234	
Body:						
Greatest height		34		34		32
Least height of tail						9
Length of caudal peduncle						9
Head:						
Greatest length		29		29		32½
Distance from snout to nape		19		19		20½
Greatest width		12		11		12
Width of interorbital area						7
Length of snout from perp. from center of orbit		9½		10		10
Length of operculum		10		10		9
Length of maxillary		13		13		14
Length of mandible		16		16½		18
Distance from snout to center of orbit		10		11		11
Dorsal:						
Distance from snout		49		49		51
Length of base		17		17		18½
Origin of pectoral to origin of dorsal		35		35		34
End of dorsal to end of anal		27		29		23
Length of longest ray		12		12½		11
Length of last ray		6		6½		5½
Anal:						
Distance from snout		71		71		72
Length of base		17		17½		14½
Origin of anal to origin of dorsal		34		37		33
Length of longest ray		6		7		5½
Length of last ray		6		4		6
Caudal:						
Length of middle rays		6		5		4
Length of external rays, superior				25		
inferior		23		27		24
Pectoral:						
Distance from snout		30		30		32
Distance of tip from snout		45		45		49
Length		16		17		18
Length of longest axillary appendage						12
Ventral:						
Distance from snout		49		50		51
Length		9		8½		9
Origin of ventral to end of dorsal		34		34		30
Dorsal	19		18		19	
Anal	23		21		21	

Table of measurements—Continued.

Current number of specimen	14,846 *a*.		14,846 *b*.		Brevoortia aurea. M. C. Z.	
Locality	Noank.		Noank.		Rio Janeiro.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	157		156		236	
Body:						
Greatest height		34		34½		35
Head:						
Greatest length		29		28		27½
Distance from snout to nape		20				21
Length of snout from perp. from center of orbit		10		9		10
Length of operculum		9½				
Length of maxillary		13		12		12
Length of mandible		14½		14		15
Distance from snout to center of orbit		10				
Dorsal:						
Distance from snout		49		47		51
Length of base		19		20		
Origin of pectoral to origin of dorsal		35		34		
End of dorsal to end of anal		25		25		
Length of longest ray		10		9		10
Length of last ray		6		6		4
Anal:						
Distance from snout		74		72½		73
Length of base		15		16		
Origin of anal to origin of dorsal		36½		37		
Length of longest ray		4½		5		5
Length of last ray		4		4½		4
Caudal:						
Length of middle rays		4½		5½		5
Length of external rays, superior		17		16		23
inferior		18		20½		
Pectoral:						
Distance from snout		28		28		28
Distance of tip from snout		41		43		42
Length		12		15		15
Ventral:						
Distance from snout		52		50		49
Length		7		7		8
Origin of ventral to end of dorsal		34		36		
Dorsal	20		20		II 17	
Anal	19		20		19	

Current number of specimen	B. aurea, A.		B. aurea, B.		Average.
Locality	M. C. Z. Sambaia.	Thayer Exp.	M. C. Z. Sambaia.	Thayer Exp.	
	Millim.	100ths.	Millim.	100ths.	100ths.
Extreme length	164		154		
Body:					
Greatest height		37		34	35
Head:					
Greatest length		28		29	28
Distance from snout to nape		19		22	21
Length of snout from perp. from center of orbit		9		10	09⅝
Length of maxillary		13		14	13
Length of mandible		15		17	15⅛
Dorsal:					
Distance from snout		49		48	49½
Length of longest ray		12		10	10⅝
Length of last ray		5		5	04⅝
Anal:					
Distance from snout		75		73	73⅝
Length of longest ray		6		5	05½
Length of last ray		4		3	03⅝
Caudal:					
Length of middle rays		6		5	05½
Length of external rays, superior / inferior		25		23	23⅛
Pectoral:					
Distance from snout		29		30	29
Distance of tip from snout		44		47	44½
Length		16		16	15⅝
Ventral:					
Distance from snout		53		52	51½
Length		7		7	07⅛
Dorsal	II. 17		II. 17		
Anal	20		22		

Brevoortia patronus.

41. The following is a careful description of the new species of *Brevoortia* from the Gulf of Mexico:

Brevoortia patronus, *spec. nov.* Goode. THE GULF MENHADEN.

Diagnosis.—Head larger than in the other American forms; its length usually more than one-third that of the body, the maxillary about three-twentieths of the length of the body.

Height of body always more than three-eighths of its total length, its anterior inferior profile cultrate, convex, giving an obtusely rounded profile to the subpectoral outline, and throwing the snout above the median horizontal axis of the body. Fins long and powerful; the height of the dorsal usually equal to the length of the maxillary and about three-tenths of total length of body; that of the anal equal to a greater than half the length of the maxillary; that of the ventral one-tenth of body-length; length of middle caudal rays always more than one-fifth and often more than one-fourth the length of the head; that of the exterior rays almost equal in length to the head and rarely less than five-sixths of its length. Insertion of the ventral under or slightly posterior to the tip of the pectoral. Insertion of dorsal always posterior to a point on the dorsal outline equidistant from the snout and the base of the medial caudal rays (sometimes as much as seven-one-hundredths of total length), and always in advance of the vertical from the insertion of the ventral.

Scales of medium size, with entire fluted margins arranged regularly (in young) in 24–25 transverse and 50–70 longitudinal rows. Scales forming sheath at base of pectoral very large, round squamations of caudal lobes inconspicuous. Axillary appendages large. Operculum smooth or very delicately striated; scapular blotch inconspicuous.

The variations of individuals are sufficiently indicated in the subjoined table of measurements. The most characteristic specimens occur at Brazos Santiago, Tex., and the more northern specimens show a tendency to shortening up of the head, jaws, and fins.

* *Description.*—The body is much compressed, especially below and in advance of the pectorals; the contour of the belly between the ventrals and the gill-opening is cultrate, projecting, obtusely rounded. The height of the body equals two-fifths of its length, and the least height of the body at the tail is one-fourth of its greatest height in front of the pectorals. The length of the caudal peduncle, from the end of the anal to the base of the exterior lobes of the caudal, is one-fifth of the height of the body and one-twelfth (.08) of its length.

The head is elongated and large, triangular; its length is more than one-third (.35 and .34) that of the body, and its height at the nape is slightly more than its length. The length of the skull, as indicated by the distance from snout to nape, is about one-fourth (.24 and .24½) of the

* To avoid confusion this is drawn up from the Brazos Santiago specimens, which are most characteristically developed.

length of the body, and the greatest width of the head (.13) slightly exceeds the half of this. The width of the interorbital is about equal to the diameter of the orbit and slightly more than one-fourth the length of the head. The maxillary reaches to the vertical from the posterior margin of the pupil; the mandible nearly to the vertical from the posterior margin of the orbit. The length of the maxillary is about equal to that of the longest ray of the dorsal fin (.15 to .16); that of the mandible (.19), to half the distance from the origin of the anal to the origin of the dorsal (.38), or to the length of the base of the anal (.18). The distance from the tip of the snout to the center of the orbit (.13 to .13¾) equal the greatest width of the head. The length of the operculum is equal to that of the eye; the opercular striations are fine, but distinct and numerous. The dorsal fin is inserted posteriorly to a point equidistant from the snout and the base of the caudal, and in advance of the vertical from the insertion of the ventrals. Its length of base (.20 to .21½) is double that of the operculum. Its greatest height is nearly half the length of the head. It is composed of 19 rays, of which the third is the largest. Its upper edge is slightly emarginated. The height of the last ray (.10) is equal to half the length of the base. The distance of the anal from the snout is slightly less than three-fourths of the length of the body (.70–.72); its length of base (.18–.18½) one-fourth of this distance. The distance from the origin of the pectoral to the origin of the dorsal (.37–.37½) is about equal to that from the origin of the anal to that of the dorsal (.38). Its height (.9–.9½) is about half its length of base; its least height (at last ray), one-third of the same (.6–.5½). The fin is composed of 22 rays, its edge slightly emarginated. The caudal fin is much forked and elongate; the middle caudal rays (.08) half the length of the maxillary; the exterior rays above (.31–.32) twice that length; the lower exterior rays (.35–.34) nearly equal to twice the length of the mandible.

The pectoral fin is strong, falcate, inserted under the angle of the subopercnlum at a distance from the snout (.35–.34) about midway to the insertion of the anal. Its tip extends beyond the insertion of the ventrals, its length (.22) being nearly two-thirds that of the head. The axillary appendages are half as long as the fin, or more.

The distance of the ventral from the snout (.54–.55) is about the same as that of the dorsal, though by the contour of the body it is thrown slightly behind the point of dorsal origin. Its length (.10) is equal to that of the last ray of the dorsal. The scales are quite regularly arranged in about 24 to 25 horizontal and 50 vertical rows. Their free portion is narrow and high. They are entire at the edges and fluted or crenulated. There are two rows of differentiated scales upon each side of the dorsal line, but they are scarcely pectinated. The scales forming the sheath at the base of the pectoral are large and round. Color: silvery, with a brassy sheen upon the sides and greenish-gray upon the back.

Table of measurements.

Current number of specimen	892 *a*.		892 *b*.		891 *a*.	
Locality	Brazos Santiago, Tex.		Brazos Santiago, Tex.		Mouth of Rio Grande.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	106	.....	104	.....	96	.....
Body:						
Greatest height	.....	40½	.....	40½	.....	38
Least height of tail	.....	11	.....	10	.....	10
Length of caudal peduncle	.....	8	.....	8	.....	.....
Head:						
Greatest length	.....	25	.....	34	.....	33
Distance from snout to nape	.....	24½	.....	24	.....	23½
Greatest width	.....	13	.....	13	.....	11
Length of snout from perp. from center of orbit	.....	12	.....	11½	.....	12
Length of operculum	.....	10	.....	10	.....	11
Length of maxillary	.....	16	.....	15¾	.....	16
Length of mandible	.....	19	.....	18½	.....	19
Distance from snout to center of orbit	.....	13¾	.....	13	.....	12½
Dorsal:						
Distance from snout	.....	53	.....	53½	.....	51
Length of base	.....	21½	.....	20	.....	17
Origin of pectoral to origin of dorsal	.....	37	.....	37½	.....	37
End of dorsal to end of anal	.....	25	.....	26	.....	26
Length of longest ray	.....	15	.....	16	.....	14½
Length of last ray	.....	10	.....	9	.....	7½
Anal:						
Distance from snout	.....	72	.....	70	.....	70½
Length of base	.....	18½	.....	18	.....	19
Origin of anal to origin of dorsal	.....	38	.....	38	.....	36
Length of longest ray	.....	9	.....	9½	.....	7½
Length of last ray	.....	6	.....	5½	.....	5
Caudal:						
Length of middle rays	.....	8	.....	8	.....	8
Length of external rays, inferior	.....	31	.....	32	(*)	26
					(†)	28
Pectoral:						
Distance from snout	.....	35	.....	34	.....	33½
Distance of tip from snout	.....	55	.....	54	.....	53
Length	.....	22	.....	22	.....	18½
Length of longest axillary appendage	.....	11	.....	13	.....	.....
Ventral:						
Distance from snout	.....	53	.....	52	.....	54
Length	.....	10	.....	10	.....	10
Origin of ventral to end of dorsal	.....	36	.....	35	.....	33
Dorsal	19	.....	19	.....	18	.....
Anal	22	.....	22	.....	22	.....
Number of scales in lateral line	47 to 50	.....	47 to 50	.....	‡65	.....

Current number of specimen	891 *b*.		891 *c*.		5,804 *a*.	
Locality	Mouth of Rio Grande.		Mouth of Rio Grande.		New Orleans Academy.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Extreme length	90	.....	73	.....	86	.....
Body:						
Greatest height	.....	41½	.....	40	.....	38
Least height of tail	.....	11	.....	.....	.....	.....
Length of caudal peduncle	.....	7½	.....	.....	.....	.....
Head:						
Greatest length	.....	33	.....	30	.....	32
Distance from snout to nape	.....	23	.....	22½	.....	23
Greatest width	.....	11	.....	.....	.....	.....
Length of snout from perp. from center of orbit	.....	11	.....	11½	.....	12
Length of operculum	.....	12	.....	10	.....	10
Length of maxillary	.....	14½	.....	14	.....	14
Length of mandible	.....	18	.....	17½	.....	17
Distance from snout to center of orbit	.....	13	.....	12	.....	.....
Dorsal:						
Distance from snout	.....	52	.....	57	.....	50
Length of base	.....	19	.....	17	.....	16
Origin of pectoral to origin of dorsal	.....	39	.....	37	.....	36
End of dorsal to end of anal	.....	28	.....	27	.....	31
Length of longest ray	.....	17	.....	14	.....	14
Length of last ray	.....	9	.....	7	.....	8

* Superior. † Inferior. ‡ About.

Table of measurements—Continued.

Current number of specimen	891 *b*.		891 *c*.		5,864 *a*.	
Locality	Mouth of Rio Grande.		Mouth of Rio Grande.		New Orleans Academy.	
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.
Anal:						
Distance from snout	.....	69	.....	69	.....	72
Length of base	.....	20	.....	19	.....	19
Origin of anal to origin of dorsal	.....	39	.....	37	.....	37
Length of longest ray	.....	8½	.....	7	(*)	7
Length of last ray	.....	4½	.....	5	(*)	5
Caudal:						
Length of middle rays	.....	7	.....	9	.....	7
Length of external rays, superior	.....	25+	.....	27	.....	27
inferior	.....	27+	.....	27	.....	30
Pectoral:						
Distance from snout	.....	32	.....	30	.....	33
Distance of tip from snout	.....	52	.....	47	.....	48
Length	.....	20	.....	17	.....	18
Length of longest axillary appendage	.....	.....	.....	.....	.....	.....
Ventral:						
Distance from snout	.....	51	.....	52	.....	53
Length	.....	9½	.....	10	.....	9
Origin of ventral to end of dorsal	.....	35	.....	16	.....	32
Dorsal	18	.....	18	.....	19	.....
Anal	22	.....	21	.....	22	.....
Number of scales in lateral line	†65	.....	†65	.....	†70	.....

Current number of specimens	5,864 *b*.		5,864 *c*.	
Locality	New Orleans Academy.			
	Millim.	100ths.	Millim.	100ths.
Extreme length	81	.....	74	.....
Body:				
Greatest height	.....	36	.....	38½
Head:				
Greatest length	.....	30	.....	33
Distance from snout to nape	.....	21½	.....	24
Length of snout from perp. from center of orbit	.....	10	.....	11
Length of operculum	.....	10	.....	10
Length of maxillary	.....	13½	.....	14½
Length of mandible	.....	16	.....	17½
Dorsal:				
Distance from snout	.....	57	.....	52
Length of base	.....	18½	.....	19
Origin of pectoral to origin of dorsal	.....	33	.....	36
End of dorsal to end of anal	.....	26	.....	25
Length of longest ray	.....	12	.....	14
Length of last ray	.....	5½	.....	7
Anal:				
Distance from snout	.....	70	.....	70½
Length of base	.....	17	.....	19
Origin of anal to origin of dorsal	.....	36	.....	37
Length of longest ray	.....	6	.....	9
Length of last ray	.....	4	.....	6
Caudal:				
Length of middle rays	.....	6	.....	9½
Length of external rays, inferior	.....	25	.....	.....
Pectoral:				
Distance from snout	.....	30	.....	32
Distance of tip from snout	.....	47	.....	50
Length	.....	17	.....	19
Ventral:				
Distance from snout	.....	53	.....	52
Length	.....	8	.....	10
Origin of ventral to end of dorsal	.....	32	.....	35
Dorsal	18	.....	19	.....
Anal	20	.....	21	.....
Number of scales in lateral line	†55	.....	†55	.....

* Imperfect. † About. ‡ Or more.

Brevoortia pectinata.

42. The following is an exact description of Jenyns species of *Brevoortia* from the Atlantic coast of Paraguay and Patagonia:

Brevoortia pectinata (Jenyns) Gill. DARWIN'S MENHADEN.

Diagnosis.—Proportions of head and jaws as in *B. tyrannus*. Height of body almost three-eighths of total length, and greater proportionally than in *B. tyrannus*. Fins nearly as in *B. tyrannus*, but uniformly averaging slightly more; the height of the dorsal somewhat less than three-twentieths of total length; that of the anal equal to or slightly less than half the length of the maxillary. The caudal fin is somewhat longer and more furcate; the length of the external rays never being less than five-sixths of the length of the head, while that of the medial rays remains proportionally the same as in the species first described. Insertion of ventral somewhat behind tip of pectoral, this fin and this dorsal being uniformly somewhat farther back than in *B. tyrannus;* the insertion of the latter from one to four one-hundredths posterior to a point equidistant from the snout and the base of the median caudal rays, and, as in *B. tyrannus*, behind the vertical from the insertion of the ventrals.

Scales very large, considerably serrated, and arranged regularly in 18–20 transverse and 50 longitudinal rows.

Scales forming sheath at base of pectoral not large. Operculum smooth or with inconspicuous and few striations. Squamation upon lobes of caudal extensive and conspicuous.

Variations.

The variations in the individual specimens studied are not of great importance, and are indicated in the tables of measurements.

Table of measurements.

Current number of specimen	1,709.		A.		B.		Average.
Locality	Paraguay.		M. C. Z. Rio Grande.		M. C. Z. Rio Grande.		
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.	100ths.
Extreme length	250	.....	224	.....	209	.....	.....
Body:							
Greatest height	.....	35	.....	36½	.....	36	36
Head:							
Greatest length	.....	33	.....	30	.....	30	31
Distance from snout to nape	.....	21	.....	21	.....	21	21
Length of maxillary	.....	14½	.....	13	.....	14	14
Length of mandible	.....	18	.....	16	.....	16½	17
Dorsal:							
Distance from snout	.....	54	.....	53	.....	51	52⅓
Length of longest ray	.....	12½	.....	12	.....	12	12
Length of last ray	.....	6	.....	6	.....	6	6
Anal:							
Distance from snout	.....	70½	.....	70	.....	72	71
Length of longest ray	.....	7	.....	6	.....	5	6
Length of last ray	.....	6	.....	4	.....	4	4⅓

Table of measurements—Continued.

Current number of specimen	1,709.		A.		B.		Average.
Locality	Paraguay.		M. C. Z. Rio Grande.		M. C. Z. Rio Grande.		
	Millim.	100ths.	Millim.	100ths.	Millim.	100ths.	100ths.
Caudal:							
Length of middle rays	.....	6½	.....	6	.....	6	6
Length of external rays, superior	.....	24+	.....	25	.....	25	25
Length of external rays, inferior	.....	26	.....	27	.....	28	27
Pectoral:							
Distance from snout	.....	32	.....	29	.....	30	30½
Distance of tip from snout	.....	50	.....	47	.....	47	48
Length	.....	18	.....	17	.....	18	17½
Ventral:							
Distance from snout	.....	51½	.....	48	.....	49	49½
Length	.....	9½	.....	8	.....	8½	8½
Dorsal	19	.....	II. 17	.....	II. 17	.....	.....
Anal	22	.....	I. 20	.....	I. 20	.....	.....
Number of scales in lateral line	*50	.....	49	.....	49	.....	.....
Number of transverse rows	*20	.....	20	.....	20	.....	.....

*Approximately.

8.—SIZE AND RATE OF GROWTH.

Length and weight.

43. The largest specimen on record is represented by a plaster cast in the National Museum, which is 20 inches in length. The average size of the fish upon the coast of Connecticut and Massachusetts is not far from 12 to 15 inches. The United States Menhaden Oil and Guano Association, in estimating the number of fish in a certain bulk, allow 22 cubic inches to each fish. The relation between length and weight is indicated in the following measurements, made at Noank, Conn., in 1875. These fish were all members of the same school.

Number.	Length.	Weight.	Number.	Length.	Weight.
	Inches.	*Ounces.*		*Inches.*	*Ounces.*
1	12½	11	16	12½	12
2	12½	10	17	12	11
3	12½	11	18	12	11
4	12½	12	19	12½	12
5	12½	12	20	12½	12
6	12½	12	21	12½	11
7	13	13	22	12	10
8	12	11	23	12	11
9	12½	12	24	13	12
10	12½	12	25	12½	12
11	12½	12	26	12	11
12	12½	11	27	12	11
13	12½	13	28	12	11
14	12½	12	29	12	11
15	13	16	30	12	11
	13	12			

Variations in the schools.

44. The table given in the preceding paragraph indicates a very decided uniformity in the size of the individuals making up the same school. I have observed this uniformity in many schools, though I have not often measured many individuals from the same school. This

uniformity in length and weight is less remarkable, however, than the uniformity to be noticed in the shape and proportions of the members of the same schools. Variations are chiefly observable in the thickness and height of the body and the head and in the length of the fins, especially the pectorals and the caudal. These differences in shape are necessarily correlated with the activity and swiftness of the fish.* Hence the differences in the wariness, swiftness, and difficulty in capture, so often referred to by old menhaden fishermen.

As a general rule, according to Mr. Dudley, the fall fish are mixed together without reference to fatness; the latest ones, however, which are supposed to be the main fish on their southern migration, are generally fat.

Annual rate of growth.

45. The shad is supposed to attain its full size in four years. Captain Atwood believes that the mackerel requires an equal length of time in which to grow to its adult size of 17 or 18 inches. From studies made in 1856, he concluded that they grew to the length of 2 inches in about thirty days, and 4 inches in forty-five days, becoming 6½ or 7 inches long before the October migration, the spawning having taken place about the middle of May. In the second year they are the "blinks;" in the third, "tinkers;" and in the fourth, full-grown mackerel. The menhaden must require three and perhaps four years to attain adult size. Those which strike in at midsummer on the coast of New England are probably hatched from the eggs spawned in the previous fall and winter. They are from 2 to 5 inches long. The second year's growth is doubtless represented by the smallest sizes of the schooling fish, measuring from 7 to 10 inches, such as are catalogued in bottles Nos. 14045, 14846, and 18049. The third year's fish would be represented by the abundant schools of fish of 12 and 14 inches, like those with measurements specified in paragraph 43. The full-grown fish are the immense ones taken in Maine and Massachusetts, measuring 16 and 18 inches.

A most interesting circumstance is narrated by Mr. George W. Miles, to whom I am indebted for many very valuable suggestions utilized elsewhere. His observations were made in Long Island Sound. He writes:—"In 1873 there were immense numbers of small fish, from 1 to 2 inches long, which appeared on the surface in the month of September. Thousands of schools could be seen at a time and great numbers in each school. They appeared to take possession of all the waters for the remainder of that season. In 1874 these fish appeared again, late in the season, and were about double the size they were in 1873. In 1875 they appeared again, much earlier, and in 1876 they came in about the first of June, having increased in size and numbers. Apparently they occupied the whole waters of the sound, so much so, that the larger fish which frequented the sound were actually crowded out of it or left for other waters, and remained off Block Island at sea the remainder of the

season, and gave up the field to be occupied by the smaller fish. The result of this abundance of small fish was a complete failure of the fishery for the two years 1875 and 1876. In 1877 we provided ourselves with smaller-meshed nets, and proceeded to catch the smaller fish, which had now attained about two-thirds the average size of fish in this locality and weighed about half a pound each. We could catch these by using nets of $2\frac{3}{8}$-inch mesh. About 15,000,000 of them were taken by our twelve gangs." Mr. Miles's observations seem to indicate that the period of growth sometimes, if not always, extends over a period of five or six years.

Seasonal rate of growth.

46. There is probably a much greater proportional increase in the size of individuals in the three or four months of their sojourn in northern waters than in the winter and spring. This is clearly indicated by the emaciated condition in which they make their first appearance in our waters, their winter's existence having been apparently sustained by the absorption of the fatty tissues elaborated in summer. Indeed, as will be shown below, there is some reason to believe that the winter months are passed in partial or total torpidity.

9.—COLOR AND OTHER MINOR CHARACTERISTICS.

Color of Northern fish.

47. The adult menhaden is a most beautiful fish. Its color is pearly opalescent, like that of the cyprinoid fishes from which the commercial *Essence d'Orient*, or liquid pearl, used by artists, and in the manufacture of paste jewelry, is prepared. Each scale has all the beauty of a fine pearl, and the reflections from the mailed side of a fish just taken from the water are superb. The scales of the back and the top of the head are of a purplish blue. The blotch of black upon the scapular region, just above the origin of the pectoral, is very constant, although I have seen fish in which it did not occur. Many, especially the older and fatter ones, have a number of irregular, roundish, blue-black blotches upon the sides and flanks. The young fish are not so brilliantly colored, and, in general appearance, resemble the young of the shad.

Color of Southern fish.

48. Many of the Southern fish show metallic, brazen, and golden reflections from the flanks and fins. Agassiz's *Clupanodon aureus*, from Brazil, was similarly colored. The name "yellow-tail," commonly applied to this species in the Southern States, is in common use as far north as Cape Hatteras.

Axillary appendages.

49. In the axils of the paired fins are long differentiated scales, which cover the angles of the fins, and are evidently intended to promote swift

progression in the water. Those attached to the pectoral are often nearly as long as the fin itself. A series of large shield-like scales cover the bases of these fins, apparently with the same object as the axillary scales. These are particularly large in the species from the Gulf of Mexico.

Scales.

50. The scales are, in the young fish, arranged in comparatively regular rows. In adult specimens of the *Brevoortia tyrannus* all semblance of regularity disappears, and it is impossible to count either longitudinal or vertical rows. The number of scales is enormously increased, apparently by the growth of additional scales in the interspaces between those already arranged in regular order. The number of scales in the longitudinal rows is from 60 or 70 in young individuals, to 110 in adults; in the vertical rows, 25 or 26.

10.—INTERNAL ORGANS.

Gill-strainers.

51. There are no vestiges of teeth in the mouths of any members of the genus *Brevoortia.* These fish do not feed upon living animals, and teeth would be useless to them. Their place is supplied by an arrangement of setiform appendages, attached to the anterior edges of the arches supporting the gills. These are closely set, flexible, and in *Brevoortia tyrannus* about 170 in number on each side of each of the arches. There being thus four rows upon each side of the mouth, there must be in the mouth of the menhaden from 1,400 to 1,500 of these thread-like bristles, from one-third to three-quarters of an inch long. These may be so adjusted that they form a very effective strainer, much resembling that of the right whale. This strainer is much finer and more effective than in the whale, the number of bristles being much more numerous than are the plates of baleen in the mouth of the right whale. The uses to which this strainer is applied will be discussed below, in paragraphs 119–125.

The accessory branchial organ.

52. There is also a curious accessory branchial organ, situated between the top of the fourth branchial arch and the base of the skull. This has been described from dissections of a fish identified as *Clupanodon aureus*, Spix, in a paper by Prof. Joseph Hyrtl,* cited in full in the Bibliography.

The alimentary canal.

53. The alimentary canal in the menhaden is peculiar. The pharynx is continued, in a straight canal, to the point of the siphonal stomach, which extends backward nearly to the posterior extremity of the intestinal cavity, then turning at an acute angle returns nearly to the

*Denkschriften Kaiserl. Akad. Wiss. Mat.-Nat. Class, vol. x, 1855, p. 49.

head, where it expands into a globular pear-shaped muscular organ with thick walls, which have their inner surfaces rugose, like those of the gizzard of a gallinaceous bird. At the anterior end of the stomach is a mass of fine, filiform, pyloric appendages, surrounding the origin of the intestine, which is very long and is arranged in two coils, one upon each side of the stomach, enveloping it completely. The length of the intestine is five or six times that of the whole fish.

The swim-bladder.

54. The swim-bladder is small and inconspicuous. Its walls are thin. It is not probable that it contains enough gelatine to be of commercial importance. Hyrtl was unable to detect its presence in the fish studied by him as *Clupanodon aureus*, but which was probably something very different.

III.—GEOGRAPHICAL DISTRIBUTION AND MOVEMENTS.

11.—GEOGRAPHICAL RANGE.

Limits in 1877.

55. It is not easy to define exactly the boundaries of geographical range for any species, unless they be marked by some impassable boundary. It is especially difficult in the case of fishes. The limits of their wanderings appear to depend directly or indirectly upon temperature, and to vary considerably, from season to season, with the seasonal variations in the mean temperature of the water.

As nearly as it can conveniently be expressed the range of the northern menhaden, *Brevoortia tyrannus*, is as follows: it is to be found at some period during the year in the coastal waters of all the Atlantic States from Maine to Florida (approximately between the parallels of north latitude 25° and 45°); on the continental side it is limited approximately by the line of brackish water; on the ocean side, by the inner boundary of the Gulf Stream. What may be the limits of its winter migrations it is impossible to say. A surface temperature of about 51° is necessary for its appearance in waters near the shores.

Variations of the northern limit in the past.

56. Its northern limit of migration seems to have always been the Bay of Fundy. Perley, writing in 1852, stated that they were sometimes caught in considerable numbers in weirs within the harbor of Saint John's, N. B.*

*Descriptive Catalogue (in part) of the fishes of New Brunswick and Nova Scotia, by M. H. Perley, esq., Her Majesty's emigration officer at St. John's, New Brunswick. (Second edition.) Fredericton: J. Simpson, Printer to the Queen's Most Excellent Majesty, 1852, p. 30.

Mr. G. A. Boardman, of Calais, Me., informs me that large schools have been seen during the summer in Passamaquoddy Bay and the lower Bay of Fundy.

James Lord, of Deer Island, Charlotte County, N. B., testified before the Halifax Commission that he had taken porgies in the neighborhood of Campo Bello, but that none had been seen there for ten years or more.*

Mr. J. F. Whiteaves declares that of late years none have been found in New Brunswick, nor to the north of Grand Manan.†

The claim of Professor Hind that they have been found as far north as Canso, is not, to my knowledge, supported by satisfactory evidence.

At present the eastward wanderings of the schools do not appear to extend beyond Isle au Haut and Great Duck Island. These islands are less than forty miles westward of the boundary of Maine and New Brunswick.

Southern limit of range.

57. Dekay supposed the southern limit of the menhaden to be in the neighborhood of Chesapeake Bay; but it has for some years been known that they occur in great abundance on the coast of North Carolina. I found them to be abundant in the Saint John's River, Florida, in March and April, 1874 and 1875, and it is quite certain that they are found there throughout the winter. In the National Museum are specimens (Catalogue No. 7696) collected at Indian River by Mr. Wurdemann. Mr. Charles Dougherty, of New Smyrna, Fla., tells me that he has observed numerous large schools during the winter in the open ocean off Cape Canaveral and Mosquito Inlet.

Old fishermen from Key West, who are perfectly familiar with the fish, assure me that it is never seen about the Florida Keys.

Oceanic limits of range.

58. Beyond these bounds nothing certain is known. The thorough and indefatigable labor of the twenty years during which Professor Poey has been investigating the ichthyology of Cuba justifies us in taking his word that the menhaden is not found in those waters. It has not been found at any other point in the West Indies, nor is it recorded from the coast of South America, though other species of the same genus have been found there. The investigations of Mr J. Matthew Jones and myself have failed to discover it about the Bermuda Islands, and it appears to be unknown to the fishermen at that point.

Menhaden in the Gulf of Mexico.

59. Mr. S. H. Wilkinson, keeper of Cat Island light-house, Mississippi Sound, writes that no fish resembling the menhaden is found in

* Proceedings Halifax Commission, 1877, Appendix F, p. 245.

† Sixth Report Department of Marine and Fisheries, Appendix U, p. 195.

those waters; and a similar statement is made by Capt. D. P. Kane, of the Matagorda light-station, Texas, who is a native of Maine, and has been engaged in pogy-fishing in that State. He has for the past eight years been engaged on the coast from Florida to Mexico, and has never seen menhaden or heard of their being caught south of Cape Hatteras, with one exception.

Capt. William Nichols, pilot, residing in Saluria, Tex., informed Captain Kane that in September, 1872, great quantities of pogies drifted upon the beach at Saluria, and that the waters of the Gulf of Mexico and Matagorda Bay were full of them. Capt. William E. Spicer, of Noank, Conn., is positive that he has encountered schools of these fish while seining for the Mobile market off Tampa, Fla.

These statements probably refer to the Gulf menhaden, recently discovered at various points in the northern Gulf of Mexico, and easily distinguished from the northern species.

Range of other species.

60. On the coasts of Brazil and at Montevideo occurs a geographical race of our northern species, the *Brevoortia tyrannus, aurea*, while still farther south, in the waters of Buenos Ayres, is another species, *Brevoortia pectinata*. The latter was first taken by Charles Darwin, on his memorable voyage around the world, in a net on a sand-bank at Bahia Blanca (latitude 39° S). Very probably the species is abundant along the coasts of the Argentine Republic, in the broad mouth of the Rio de la Plata, and from the analogy of our species, well up the southern coasts of Brazil, perhaps to Rio Janeiro. It is not unlikely that the eastern coast of South America is as abundantly supplied as our own with these most valuable fishes. Valenciennes states that the Portuguese of South America call the *Brevoortia aurea* by the name *Savega*.

Again, on the coasts of West Africa occurs a species, *Brevoortia dorsalis*, closely resembling the menhaden. An old fisherman in Maine told me that he had seen the menhaden in immense quantities on the western coast of Africa, where the negroes spear them and eat them.

Illustrations and descriptions of all the known American species are given elsewhere in this memoir.

Alleged occurrence on the Pacific coast.

61. The Hon. S. L. Goodale, of Saco, Me., writing under date October 25, 1877, states that some menhaden fishermen of Bristol, Me., have recently sent one of their number to prospect for them on the Pacific coast, and that his reports were so favorable that several of them with their families had left a few weeks previously for Washington Territory, where they were informed that "pogies" were abundant. If this report be true, it is quite certain that the explorers are doomed to disappointment. No fish resembling the menhaden occurs in the Pacific Ocean.

It should be noted, however, that wherever representatives of this genus of fishes occur there is doubtless an opportunity for establishing new industries of great value. It would be well worth while for enterprising fishermen to investigate this subject. The Government of Japan has recently employed one of the best informed of our New England fishermen * to instruct the natives of that country in the arts of catching and preserving food-fishes.

As has already been stated, there are abundant supplies of these fish on both sides of the South Atlantic. There is apparently no reason why extensive manufacturing interests may not be inaugurated in Brazil, the Argentine Republic, Paraguay, and Africa.

12.—THE ARRIVAL AND DEPARTURE OF THE SCHOOLS.

Causes influencing times of arrival and departure.

62. The date of the earliest appearance of the schools of menhaden at any given point upon the coast corresponds very closely with that of the arrival of scup, shad, bluefish, and other of the non-resident summer species. It depends primarily upon the temperature of the water. This element is of more importance, perhaps, in the case of the menhaden than with the carnivorous fishes, since the food-supply of the former is not likely to be affected by changes of temperature. There are other questions to be considered, such as the movements of hostile species and the direction of the prevailing winds, though the latter may, perhaps, be merged in the question of temperature. Their departure is regulated by the same causes, though, since their food-supply is less uncertain, they linger later in our waters than most of their companion species of the spring.

Material available for the determination of dates.

63. The material for determining the movements of the schools is very unsatisfactory, though perhaps of necessity so. Although many of our correspondents give dates of arrival and departure, these are understood to be merely approximations to the truth. The only series of observations showing the dates of the arrival of menhaden for a period of several successive years is one from the Waquoit weir, and this professes to show nothing except the date at which the fish began to be abundant. In the nature of the case, observations of a more definite nature are impracticable. Since so little that is definite can be recorded, it may be desirable to review the statement, of some of our correspondents, thus putting on record a series of observations all carefully made and many of them extending over a long period of years. In this way the movements of the menhaden at different points upon the coast will be described more accurately and graphically than they could be by any compiled account, however carefully it might be prepared. It is

* Capt. U. S. Treat, of Eastport, Me.

hoped, too, that this course may suggest and elicit fuller observations from persons living in our seaboard towns.

A review of the general movement along the coast.

64. At the approach of settled warm weather the schools make their appearance in the coast waters. They remain in the bays and near the shores until they are warned away by the breath of coming winter. The date of their appearance is earlier in the more southern waters, and the length of their sojourn longer. It is manifestly impracticable to give anything but approximate dates to indicate the time of their movements. In fact, the comparison of two localities, distant apart one or two hundred miles, would indicate very little. When wider ranges are compared there becomes perceptible a proportion in the relations of the general averages. There is always a balance in favor of earlier arrivals at the more southern localities. Thus, it becomes apparent that the first schools appear in Chesapeake Bay in March and April, on the coast of New Jersey in April and early May, and on the south coast of New England in late April and May, off Cape Ann about the middle of May, and in the Gulf of Maine about the latter part of May and the first of June. Returning they leave Maine in late September and October, Massachusetts in October, November, and December, Long Island Sound and vicinity in November and December, Chesapeake Bay in December, and Cape Hatteras in January. Farther to the south they appear to remain more or less constantly throughout the year.

Coast of Florida.

65. In the Saint John's River, Florida, menhaden are abundant throughout the winter. They appear in November clogging the shad-nets. It is not known how far they proceed up the river, but I was unable to learn that they have been taken above Buckley's Bluff, twelve miles above Jacksonville and thirty-six from the mouth of the river; they are particularly numerous at the mouth and in the vicinity of Mayport and Yellow Bluff. That they remain as late as May is well established, and it is the opinion of Mr. Kemps that they are found throughout the summer, the young fish, at least. I have found the grown and half-grown fish abundant at Arlington and Jacksonville in April, 1874 and 1875. After the first of May the opportunities are not favorable for observation, the use of shad-nets being then discontinued. Young fish are seen from May to October, according to Mr. Kemps, in schools over two miles long and extending from shore to shore of the river. Along the coast of Florida, from Cape Canaveral north, the schools of adult fish are said to be common through the winter months.

Coast of Georgia.

66. Mr. Joseph Shepard, of Saint Mary's, Ga., states, on the authority of a Saint Andrew's Bar pilot, that small schools of menhaden are seen in Saint Andrew's Sound during the summer months, coming over

the bar with the flood tide and going out with the ebb, and that the same fish are also seen in large schools in calm weather during the winter months outside the Sea Islands in about seven fathoms of water, and three to four feet below the surface. Mr. Charles C. Leslie, a fish-dealer in Charleston, S. C., informs me that schools of menhaden frequently are seen in the winter off Charleston Harbor; a statement which is confirmed by others, among them Mr. Daniel T. Church, of Rhode Island.

Coast of North Carolina.

67. Mr. A. C. Davis, of Beaufort, N. C., writes that the fat-back first approaches the coast at that place in June, the main body arriving in July from the south, entering the rivers and drifting up with the flood tide and down with the ebb; their appearance is regular and certain, and has never failed, the numbers seeming to be greater every year. They remain in the rivers and inlets throughout the summer, gradually departing toward the close of October and the first of November to the southward. During the season they are constantly coming in at intervals. Those which first arrive are one-quarter to one-half grown, no full-grown fish appearing until later in the season. In bad weather, especially with northern winds, they leave for the sea, returning in moderate weather, with southerly winds.

Mr. A. W. Simpson, jr., of Cape Hatteras light-station, records several interesting facts concerning the movements of the fat-back around that cape. They first make their appearance in June and remain until December; they generally come in to the shore on the northern coast of the cape, running south along the beach and entering the inlets and rivers. In the first of the season they may be seen, in moderate weather, five or six miles at sea, in large schools half a mile in length, apparently floating upon the surface of the water. They always make their appearance from the north and leave the coast by the same route. Some are seen in the sounds and rivers all the year. When the second large run occurs in the fall they appear in immense numbers. This is sometimes in November and in other seasons in December. In 1873 they were first seen on the coast about the 6th of December, and the main body arrived about the 10th of December. Many schools may be seen at one time. They seldom come near the coast in high winds and rough seas, or if they do they swim so low that they are not seen from land. Their appearance is certain and they are about the same in abundance every year at the spring run, but the fall and winter runs vary somewhat, the number in some seasons being very much smaller. Mr. Simpson thinks that the tides do not affect their movements in any respect, except that they prefer to swim against the tide; he has convinced himself, by careful observation, that more enter the inlets on the ebb than on the flood, though they are frequently seen drifting up and down channels with the flood and ebb. The one and two years' fish school by themselves, the young in large schools along the sandy shores. Many fish pass the winter in the inlets and rivers,

but most of them leave the coast by a northern route, the spring runs leaving in October, the fall runs about the middle of January. Some seasons they go to sea in large schools and others they drop away gradually. The first of the spring-runs are usually the smallest. During the summer the large schools are only seen occasionally, though Mr. Simpson thinks that they are on the coast continually. They only come near the outer sea-beach when driven in in October and November by the tailor (*Pomatomus saltatrix*), or blue-fish of the North, and the dog-fish (*Mustelus lævis*).

Coast of Virginia and Chesapeake Bay.

68. According to Mr. Henry Richardson, the alewives are caught in the vicinity of Cape Henry as early as March, though the main body does not come in until June and July. During these months they are constantly passing the Virginia capes and entering Chesapeake Bay, coming from the south.

The Potomac fishermen inform me that they appear in the spring soon after the shad and herring, remaining in the Potomac during the season, where they prove a serious hinderance to the working of the shad seines. Young fish seven inches in length were taken in the lower Potomac at Nanjemoy Reach as late as December 10, 1874, but disappeared after the first heavy frost. The first schools appeared late in March and early in April, 1875, and in 1878 early in March.

At Apateague Island, Accomac County, Virginia, according to Mr. J. L. Anderton, they are first seen swimming northward near the coast in April, the main body arriving in June. Their appearance is regular. They run in-shore on the flood, drifting off with the ebb. In November they are seen making their way toward the south.

In Tangier and Pocomoke Sounds, says Mr. Lawson, they appear about May 1, the fish of different sizes in separate schools; they are found there in quantity throughout the season, the southward migration beginning in August and continuing until the middle of October.

I find a manuscript note by Professor Baird to the effect that they are found in large schools at Cape Charles, Virginia, from April to October, being most numerous on the bay side of the peninsula.

Delaware Bay.

69. Mr. James H. Bell, keeper of Mispillion River light-house, Delaware Bay, states that fish are first seen in those waters early in March, and grow more numerous until about the middle of April, when they are frightened away by the sea-trout. They soon return in increasing numbers until the middle or last of May, after which they begin to disappear in large schools until the first of August, when they again become numerous, and continue so if the weather is mild, when they begin to disappear, working out to sea through the channel. The opinion of Mr. Bell is that after entering the bay they follow the main channel, spread-

ing toward the shores on either side as they advance, until arrested by brackish water. The western shore of the bay is very shallow, the tide near the beach seldom rising above six or seven feet. When the tide is three-quarters flood the fish run in close to land and are caught within twenty yards of the beach; from slack water to first quarter ebb, if it is calm, the water is spotted with the break or ripple, and as the tide recedes they float out with it to deep water. Medium and small fish are found together, not probably in the same schools, but close enough together for the seine to catch fish ranging in length from three to nine inches.

Coast of New Jersey.

70. According to Mr. Albert Morris, menhaden make their appearance in Great Egg Harbor, New Jersey, about May 1, the main body arriving about June, and leaving about the middle of September, the "eastern run" coming along in October or November.

Mr. A. G. Wolf, keeper of Absecom light, Atlantic City, N. J., writes that the appearance of the first schools is regular and takes place in April, the main body coming in July. They come from the returning south by degrees in the fall, beginning in September.

D. E. Foster, of Cape May light-house, states that they appear from the south about April, larger but not so fat as the second arrivals in July, the majority of which are from four to six inches in length. They disappear in November, heading to the north.

Eastern end of Long Island.

71. In the vicinity of Greenport, N. Y., according to Captain Sisson, the first arrivals are in March and April, and according to Mr. Havens, about April 1, while Hawkins Brothers, of Jamesport, put it about the 1st of May. These gentlemen agree that the first schools contain the largest fish; that they are followed for some weeks by other runs, and that the schools leave for the south on the approach of cold weather in October and November.

Mr. Dudley tells me that his steamer usually starts out from Pine Island from the 1st to the 12th of May. She never fails to find fish outside of Montauk Point. The gangs which started out for the season, April 20, 1877, found plenty of fat fish on the first day out.

The late schools of large fish which come upon the Connecticut coast about the 1st of November, and which are supposed to come from the coast of Maine, usually strike across from Watch Hill and Fisher's Island to the Napeague shore, where they sometimes remain several days before their final disappearance from those waters.

Long Island Sound.

72. In the western part of Long Island Sound, at Stratford, according to Mr. Lillingston, they appear about the 1st of May and remain until Octo-

ber, when they leave at once, swimming east. They approach from the east. The largest fish he thinks are found in August. In August and September immense numbers "strike on" and follow up the Housatonic River, and these are invariably poor.

At Milford, Conn., we are informed by Mr. Miles, the first white-fish are seen in April or May, the main body arriving in Long Island Sound in June and July. Sometimes the first fish are the largest. The schools or runs appear to come at intervals of from two to three weeks. The fish come in around Montauk Point, the early fish follow along the Connecticut shore and up the rivers; later in the season they are found off-shore in deep water, though they occasionally work inshore and up the rivers. Their appearance is regular and certain. The schools are mixed as regards size, in the opinion of Mr. Miles. The schools begin to disappear about the 1st of September, passing around Montauk Point to the south, and are all gone by the 1st to the 15th of October.

At Westbrook, according to Captain Stokes, they appear about the middle of May and leave in November in continuous schools, passing around Montauk, bound to the south. In July the schools are the largest.

At Saybrook, says Captain Ingham, the first bony-fish are seen in May, the main body arriving in June. The first are scattering and generally the largest; there are several runs at irregular intervals. The appearance of the fish is regular and certain. They leave in October mostly in a body.

Captain Beebe, of the Cornfield Point light-vessel, writes that the first bony-fish are seen in April, but that these are not the largest. They work along the bays and rivers of the sound, drifting in with the flood and out with the ebb. They leave about the middle of November in a body, passing around Montauk Point to the southward. They ascend the Connecticut above the Shore Line Railway bridge, where they are often followed by the seining gangs belonging to Luce Brothers, of Niantic.

Block Island Sound.

73. Captain John Washington, of Mystic River, Conn., states that the first bony-fish arrive in Block Island Sound early in April, followed by larger schools toward the last of the month, and that they continue to come in during the first half of the summer. They come in around Montauk in large schools, and after passing the outer islands, the large schools break up into smaller ones, which make their way toward the rivers and coves. Their arrival is certain and quite regular, varying but a few days from year to year. They begin to leave in October, and by the last of November are gone. A few stragglers are seen in the Mystic River until the beginning of freezing weather. They swim southward in their fall migration, going faster than when coming north in the spring.

Capt. Jared S. Crandall observes that they first appear in Block Island Sound about May 1, coming from the southward and through the east

end of Long Island Sound, working to the eastward and westward. Their appearance is certain, though their abundance is greater in particular seasons. They leave gradually in November and December, working to the westward after leaving the sound. Small and large are mixed indiscriminately in the schools.

At Block Island, according to Mr. Henry W. Clark, they appear about the 1st of May, and continue running in until about the middle of June. Their appearance is certain but their number variable. They work in and out with the tide, but when they are making a passage the tide does not stop them. They start southward about the middle of October, and continue running for a month.

Mr. Dudley on the schools of Eastern Connecticut.

74. Mr. Dudley, whose vessels ply their nets in both Block Island and Long Island Sounds, tells me that fishing begins at Pine Island from May 1 to May 12, and that for quite a number of years fish have been taken the first day the vessels went out. In 1877 the vessels which started April 20 found plenty of fat fish. Whether the season be hot or cold, the fish come at about the same date. Of late years the first schools have been very fat; immediately followed a run of poorer fish. The run which begins in the middle of April and continues for three or four weeks, is composed of fish yielding from five to seven or eight gallons to the thousand. The next run of fish continues until about the 1st of July. These yield not over four gallons. Then follows a poorer run, averaging two gallons. In 1877 millions of fish have been taken which have not averaged above one quart to the thousand. In 1876 it was much the same, but in July, when the poor fish were most abundant, a few schools made their appearance which yielded ten gallons to the thousand. Of two gangs, fishing side by side, one might make a haul of ten-gallon fish, while the other secured only half-gallon fish. Good fish are usually expected in the fall. In 1876, however, they were few and poor. In 1877 the schools of fat fish made their appearance near Point Judith on the 30th of October.

Narragansett Bay.

75. At Point Judith they come in from the westward, according to the statement of Joseph Whaley. They appear about the 20th of May, and continue to pass, moving eastward, until July. Their arrival is very regular, but sometimes cold weather and easterly winds put them back ten or fifteen days. They begin to leave in October.

Mr. Daniel T. Church, of Tiverton, R. I., states that the menhaden make their appearance in Narragansett Bay about May 1, and continue running in during the season; their arrival in Narragansett Bay for the past eighteen years has been certain, though the time of arrival varies with the weather; they drift with the tide at times, and at others swim against it. No fish are taken in the purse-nets after the cold weather

of the fall, but the gill-nets often take them as late as New Year's. Benjamin Tallman caught 1,600 barrels (400,000) on December 3.*

Martha's Vineyard Sound.

76. At Menemsha Bight the menhaden appear from April 21 to May 10, according to Jason Luce & Co., and swim west. Mr. Marchant, of Edgartown, thinks that they enter the Vineyard Sound from the southwest. It is more than likely that both are right, and the fish enter the sound at either end indifferently. They are seen here in November.

According to Captain Edwards, menhaden come to the vicinity of Wood's Holl, Massachusetts, in May, and remain until October. Captain Hinckley, of the same place, states that they first appear to the westward, striking Montauk Point and following along the coast exactly like the scup, but going more into the bays; they go in more shallow water; he has seen them in 12 feet. A school looks reddish. He has seen a school a mile wide and a mile and a half long. They frequently swim near the surface and make a ripple that can be seen. The first school swims rather deep, but as they become more plenty they can be seen. They generally come in about the 10th of May; in 1871 the first were taken the 21st of April, about three weeks earlier than the average. But they strike off again for about a fortnight before they come regularly.

Capt. Isaiah Spindel, of Wood's Holl, took the first menhaden of the season of 1870, April 23, and the first mackerel at the same time; these were only stragglers, and the best time for catching menhaden that year was about the 10th or 15th of May; in 1871 they came on the 21st of April, when a thousand were caught; a few stragglers had been taken before, perhaps as early as the middle of April. In 1872 no menhaden were seen after the 15th of October.

In the autumn of 1877, which was unusually late and warm, the menhaden lingered on the coast until very late. Vinal Edwards saw many taken, November 28, by the North Truro fishermen, and himself found them at Wood's Holl, December 1.

A very definite idea of the date of appearance of the menhaden in the Vineyard Sound may be gathered from a table given in the Report of the Massachusetts Commissioners of Inland Fisheries for 1871, and here reproduced with additions for convenience of reference.

* Report of the U. S. Commissioner of Fish and Fisheries, 1873, p. 184.

77. *Table showing days of first appearance in abundance of menhaden, alewives, scup, and bluefish, at Waquoit weir, since* 1859.

Year.	Menhaden.	Alewives.	Scup.	Blue-fish.
1859	May 6	April 7	May 5	May 16
1860	May 4	April 3	May 2	May 15
1861	May 1	April 1	April 27	May 17
1862	May 6	March 30	May 10	May 13
1863	May 2	March 29	May 8	May 15
1864	May 5	March 28	May 6	May 17
1865	May 1	March 29	May 1	May 16
1866	May 7	April 2	May 8	May 15
1867	May 3	March 28	May 4	May 14
1868	May 15	March 30	May 10	May 19
1869	May 10	March 31	May 7	May 17
1870	May 8	March 28	May 2	May 11
1871	April 21	March 24	April 25	May 24

Irregularities of movements shown by returns of Waquoit weir.

78. The returns of Waquoit weir, which was rented in 1871, by the Massachusetts commissioners of inland fisheries, for the purpose of getting exact statistics on the subject of pound-fishing, show how uncertain and irregular are the movements of the menhaden and their capture in any fixed locality upon the shore. April 21, 1871, 6,000 were taken; April 23, 13,300; May 1, 17,420; May 5, 35,920; May 9, 10,020; May 10, 16,800; May 11, 14,945; May 13, 14,200; May 15, 7,300; May 16, 900; May 18, 1,280; May 19, 1,040; May 20, 7,600; May 22, 6,000; May 23, 26,000; May 24, 2,205; May 25, 780; May 31, 40,300; June 1, 13,260; June 10, 7,540; June 14, 27,300; June 16, 93; June 17, 19. In 1865, from April 21 to May 15, were taken 175,300, and from May 16 to June 2, 35,800; in 1866, between these dates, respectively, 213,730 and 104,780; in 1867, 82,680 and 121,060; in 1868, 45,706 and 79,020; in 1869, 66,680 and 79,030; in 1870, 152,590 and 255,340; in 1871, 136,005 and 99,256.*

South shore of Cape Cod.

79. At Hyannis, Mass., writes Mr. A. F. Lathrop, they appear in May in small numbers, the greatest season of plenty occurring in June. They work along the shore line and into the sounds, bays, and rivers. Their appearance is regular and certain, and they disappear in a body about the 1st of October.

Capt. Reuben C. Kenney, of Nantucket, Mass., states that they appear in the vicinity of that island about the 1st of May, or a little earlier if the season be favorable. They appear to come from the direction of Sandy Hook and the coast of New Jersey. They are most abundant in June and July, and begin their return in October, all disappearing in November.

Capt. Josiah Hardy second, of Chatham, Mass., writes:—"The menhaden seen here are on their route to the eastern shores, coming from

* Report of the Massachusetts Commissioners of Inland Fisheries for 1871, and Report of United States Commissioner of Fish and Fisheries 1871–'72, pp. 174–176.

the west; when they strike Chatham Bay they swim in large schools, coloring the water and followed by numerous sea-birds. They are governed by the winds and weather about showing themselves; in fine moderate southerly weather they come up on top of the water. They have been caught in our bay as early as the 15th of April, but generally not before the 1st of May. I never knew them to fail coming; they generally follow the shores, making their way down the sound by Monomoy Point, and those that get within the point, into the bay, follow the shore to get out on their transit east. There is no difference in their size in the spring, or a very slight one in some schools. In our bays, ponds, and rivers they will head the tide; they come inshore at high water on this coast and at low water keep off the flats and shoal water into the channel or deep water, which is from three to seven fathoms in our bay. I do not think it makes any difference to them about the depth of water; they seem to have a natural instinct, and are just as regular in their course and movements as a flock of sea-fowls; when one is frightened they all start, if one turns all in the school turn, if one goes down all in the school follow. One peculiar trait in them that cannot be accounted for is, that on this coast, as well as on the eastern shore, sometimes for hours there is not a fish to be seen, then all at once they rise to the surface and it is literally full of schools, sometimes turning in a complete circle, at other times all headed one way, then all at once every one has disappeared. The fish pass here (the cape), bound south, in the latter part of September and the first part of October, all moving about the same time. Sometimes in their transit south they find their way into our ponds and creeks and get bothered and belated; they chill very quick in a cold night. Their route south is outside of Nantucket Island."

Cape Cod Bay.

80. Mr. David F. Loring, keeper of Highland light, at the northeasternmost point on Cape Cod, states that pogies appear in that vicinity from the last of April to the middle of May, making their appearance in large schools on the surface. After passing by the cape in the spring, they frequently throughout the summer make their appearance in Provincetown Harbor, the bluefish chasing them. They are very seldom seen to school on the ebb tide, but as soon as it turns flood they are seen on top of the water. Mr. Loring states: "I have seen the surface of the water literally covered with schools on the flood tide, while on the ebb there is hardly a fish to be seen. I have seen them under water on the ebb tide, two or three fathoms down, in schools, but they move very slowly until the tide turns flood. Then they school up to the surface of the water and are quicker in their movements. I have seen them in the fall of the year when not schooling, but whether schooling or not they generally play on the surface of the water, except on the ebb tide." They commence to leave the coast about the 1st of October, moving south by

degrees. During the month of November, 1874, the small seining steamers belonging to an oil and guano company in Fall River, Mass., which has a large factory in Boothbay, Me., having left the Maine fishing-grounds after the pogies had left the coast, fell in with large schools just outside of Provincetown Harbor and took 30,000 barrels of them in a short time.

According to Mr. Heman S. Dill, light-keeper on Billingsgate Island, pogies appear in Barnstable Bay about May 10, not varying over four or five days from year to year.

Vicinity of Cape Ann.

81. At Marblehead, Mass., we are informed by Mr. Simeon Dodge, the fish appear about May 9, a larger body appearing in July; their course is northward, their appearance certain. Their favorite locality is at the mouths of fresh-water streams, moving up the creeks with the flood and and down with the ebb. They take their departure in a body about the last of October.

Capt. F. J. Babson, of Gloucester, Mass., states that the appearance of this fish for the past thirty years has been regular and certain. They first appear in Massachusetts Bay about the 15th of May, and are present in the greatest numbers a month later. When in deep water they are not affected perceptibly by the tide, but when near the shore run in and out of the rivers and creeks with the tide. They swim low during easterly winds, but in warm and pleasant weather play at the surface. They begin to leave the coast about October 1, and by the last of the month are all gone.

Gulf of Maine.

82. According to Judson Tarr & Co., they come on the coast of Maine about the 1st of June, though they are not plenty until June 20; they continue coming until July. They follow the shore coming and going, and their appearance is certain; they have never been known to fail. They leave the coast about October 1, on the approach of cold weather.

Mr. J. Washburne, jr., of Portland, Me., states that pogies appear in that vicinity June 10 or 15. They come in two schools; the first, which are small, usually come about ten days before the second school. They remain during the summer and work in shore on the flood tide and out on the ebb. They leave for the South about October 1; in 1874, some were taken November 4.

Mr. G. B. Kenniston, of Boothbay, Me., who is largely engaged in the menhaden fisheries, thus gives the result of his personal observations: "The pogies are first seen about May 20 in occasional schools. The main body arrives about June 20, which, passing to the eastward, is followed by others continually for about thirty days longer. There is considerable difference in the size of the fish caught. At times, mixed sizes are taken at the same set. Usually those arriving at different periods differ

in size, the larger may come sooner or later; nothing certain is known as regards this. After rounding Cape Cod, some touch the coast in the vicinity of Gloucester, Mass., but by far the larger portion it appears keep off shore, and near it anywhere from Cape Elizabeth to Monhegan. The main body of these fish continue to pass toward the east till about the 20th of July, when that impetus seems to be checked, and for thirty or forty days their movements are seemingly local. Then they begin their return to the west, and continue to repass until in October. The last bodies are urgent in their westward course. Their appearance is regular, and they have never been known to fail. The temperature of the air affects them; they will not 'show' or come to the surface when cold north or east winds prevail."

Boardman and Atkins state that the latest date at which menhaden have been observed on the western coast of Maine, between Cape Elizabeth and Pemaquid, is October 25, and the period of greatest abundance about the last of July or the first of August, although for several weeks preceding and following that date, there is little variation in their number. Since the publication of his report Mr. Atkins has observed small menhaden as late as December in the vicinity of Bucksport.

Mr. Benjamin F. Brightman, of Round Pond, Me., also largely interested in the fisheries, states that the first fish make their appearance about the 1st of June, though usually scattering. Seining begins about the 15th; the fish are poor then and rather smaller than those taken in August and September, when the smacks go off shore from five to thirty miles to get larger and fatter fish. Seining begins about the 15th of June, and continues until the 15th of October. They are most abundant and easily seen on a warm, sunshiny day. The fish start to go west about the middle of September, and continue going until the last of October.

Mr. John Grant, keeper of Matinicus Rock light-station, writes that they arrive about the 1st of June, the larger body from the middle to the last of June, the last school being much the largest and fattest. There are commonly several schools at irregular intervals. A favorite playing-ground is between Seguin Island, and Matinicus Rock, and in the bays and mouths of rivers between those two points. The fish leave about the middle of October in a body.

On the eastern side of Penobscot Bay near Brooklin, according to Messrs. J. C. Condon and R. A. Friend, pogies come in from the 10th to the 15th of June, and leave by degrees after the 1st of October. They are most abundant in June and July.

In the same vicinity, according to Mr. Z. D. Norton, the first menhaden seen are scattering individuals that are caught in gill-nets and weirs in May, often as early as the middle of the month. The schools do not appear until the middle of June, on an average. They leave in September commonly. In Bluehill Bay they are sometimes known to stay as late as October.

Mr. William H. Sargent, of Castine, Me., has known them to come in as early as May 25, and has seen them in November.

Eastward from this point the stay of the menhaden is materially shortened up. At Jonesport, according to Mr. George R. Allen, it is almost confined to the month of August, scattering ones being taken in July. In Passamaquoddy Bay and vicinity menhaden are now rarely seen. Formerly they were found in all these waters in August.*

Mr. Maddocks on the Maine schools.

83. Mr. Maddocks states: "Its appearance on the coast of Maine is from about June 1, to October 1. The date of coming rarely varies more than five days; that of departure is sometimes delayed until October 15, if the weather continues mild and calm. It usually disappears from the surface during the continuance of cold northerly winds; and even in favorable weather alternately rises and sinks during the day, the morning and evening being the time of most general appearance. The first straggling comers are generally discovered on the 'outer grounds,' so called, some forty miles off shore. The numbers increase with the advance of the season, the fish gathering in schools or bunches from the size of a dining table to ten acres large, and fifty of these being frequently visible at once from the mast-head. In these bunches the fish extend from the surface two or three fathoms deep, more or less, as far at least as can be seen, in a compact mass, either lying perfectly still or moving slowly with their heads all pointed one way as if intently gazing upon an object before them."† And again: "It is certain that the disapparance of the menhaden from the Maine coast in the autumn is accomplished by a movement of vast numbers (not necessarily the whole or even the greater number) to the west and south along the shore. The withdrawal is nearly simultaneous, but in a body so immense that the vanguard reaches Cape Cod before the rear has left the Maine waters. Our fishermen follow the retreating army as far as Cape Cod and Sandy Hook, and make large captures."

13.—MIGRATIONS.

Migrations of fishes and their causes.

84. It was formerly believed that all seasonal migration was directed toward and from the equator, but zoologists of the present day recognize another kind of migration quite as important although not usually so extended. At the approach of the hot season in subtropical climates the birds seek a cooler temperature, either by flying northward or by ascending the high mountains. In like manner the fishes of any region may find water of suitable warmth by moving north or south along

* Goodale & Atkins, op. cit., p. 4.

† The Menhaden Fishery of Maine, p. 4.

the shores of the continent, or by changing to waters of less or greater depth. The former may be called equatorial, the latter bathic migration.

Bathic migration is the most common. The cod family, the halibut, and flounders, the scuppaug, tautog, sea bass, and sculpins, are well known examples. The cod prefers a temperature of from 35° to 42° F. and this it secures in a temperate climate, such as that of Southern New England by remaining on the off-shore banks in 15 to 30 fathoms of water, coming near the shore in winter. On the coasts of Labrador, Newfoundland, Nova Scotia and Eastern Maine they are near the shore in summer and in deep water in winter. In Norway the fish are caught to some extent in the fiords in the summer season, though more in winter. In summer they still remain on the off-shore banks. The halibut moves up and down on the sides of the great oceanic banks and the continental slopes, with the seasonal changes of temperature. In summer they are abundant in the shallows of South Greenland, while in winter they are in deep water. On the coast of Massachusetts they come near the shores only in the dead of winter, though abundant in summer on the edges of the outside banks in 80 to 300 fathoms of water. The sand dabs (*Hippoglossoides dentatus*) are abundant in July in water of 60 and 80 fathoms ten miles off Cape Ann; in the middle of winter they swarm upon the sand flats in two or three fathoms depth.

The Spanish mackerel, the bonito, and the tunnies are good examples of nomadic species. In summer they throng our northern waters; in winter they are under the tropics.

Others, like the sea-herring, appear to migrate in two ways. Their movements are, approximately, both parallel with and vertical to the coast line; that is to say, they secure changes of temperature both by leaving the upper strata of the ocean and by moving toward and from the equator. The researches of Boeck in Norway, show that the schools approach the coast by gullies or submarine valleys from the oceanic depths. Such is doubtless the case on our own coast, in their earliest approaches, though having reached the shallows near the shore, the schools range along great stretches of coast line. Since fishes have no restrictions upon their movements except those of food and temperature, all active species must traverse areas of many hundreds of miles during the year.

The tendency of all the researches made during the past few years has been to confirm the views advanced by Professor Baird in an unpublished letter written in 1873 to the Hon. Hamilton Fish, Secretary of State.

"The question in regard to the migration of fishes is one that has attracted the attention of both fishermen and naturalists for many years past, and a great deal of eloquence has been expended by Pennant and other writers, in their history of the movement of herring and other species.

"For many years it was considered beyond question that the sea herring, having their homes in the northern seas, were in the habit of

prosecuting extensive journeys, in the course of which they successively visited the shores of Europe and of America, penetrating into their bays and sounds, and returning afterwards to the point from which they started; the adults decimated by the predaceous fishes and their capture by man, but their numbers kept up by the progeny, the result of their spawning operations, for which purpose it was supposed their journeys were initiated.

"In the same manner the shad and the fresh-water herring of the American coast were supposed to start in the late winter along the southern coast of the United States, in a huge column, the herring first, and afterward the shad, first entering the Saint John's River in Florida, and while passing up the coast sending off detachments into all the principal rivers, and finally stopping in about the latitude of the mouth of the Gulf of Saint Lawrence.

"This theory is at present almost entirely abandoned, and there is reason to believe that after the herring and shad have spawned in the rivers they proceed to sea, and spend the period until their next anadromous movement in the immediate vicinity of the mouths of the rivers, where they are followed in due course of time by their young. This is illustrated by the fact that fish of nearly every prominent river show some peculiarities by which both the fish-dealer and the naturalist can distinguish them; the difference not being sufficient to constitute a specific rank, but such as to mark them as local races. Numerous captures, too, in gill-nets and otherwise, off the northern coast, during the period when they should be gathered together in the southern waters, prove that a portion at least remain. It is difficult to imagine how a shad or a river herring, spawned in the Saint Lawrence River or any northern stream, could avoid entering a more southern river, if in its vicinity; but if any fact has been well established of late years in the history of the fishes, it is that the anadromous fish, or such as run up the rivers from the sea to spawn, will return if possible to the river in which they first saw the light. So true is this, that where there may be two or three rivers entering the sea in close proximity, which have become destitute of shad or herring in consequence of long-continued obstructions, and the central one only has been restocked by artificial means, the fish, year by year, will enter that stream, while those adjacent on either side will continue as barren of fish as before."

The influence of ocean temperature on the movements of menhaden.

85. The influence of ocean temperature on the menhaden is not at all well understood, and I can here record only crude generalizations founded upon very unsatisfactory data. I have before me three tables showing the variations of temperature, by monthly means, for Key West, Fla.; Jacksonville, Fla.; Savannah, Ga.; Charleston, S. C.; Wilmington, N. C.; Norfolk, Va.; Baltimore, Md.; New York City; New London, Conn.; Wood's Holl, Mass.; Portland, Me.; and Eastport, Me. Table I shows

the monthly means of surface temperature; Table II, of temperature at the bottom near the shore; and Table III, the average means of the surface and bottom temperatures. The observations were all made at 3 p. m., and are continuous from March 1, 1876, to March 1, 1877. These are reproduced in Appendix F. There is, also, a table of the daily observations of temperature at the surface at the same stations. A study of these tables, which, for convenience, were mapped out in curves upon section paper, affords some interesting results.

Minimum limits of temperature and the dates of appearance and disappearance of the schools.—The monthly mean of surface temperatures at Eastport is greatest in September, when it is 50°.6, while the highest daily observation is 51°.5. The menhaden do not visit Eastport in midsummer. Let us divide the monthly averages for May, at Portland, into quarterly periods. The average for May 16–23 is 47°.1; for May 24–31 is 51°. The quarter-month averages for October are 53°.8, 50°.8, 47°.9, 48°.8.

The schools of menhaden arrive in Eastern Maine late in May and early in June, and depart, usually, before the middle of October.

At Wood's Holl the quarter-month averages for May, as taken by the Signal Service observer, are 48°.2, 49°.6, 53°.1, and 57°.6, approximately, or the monthly average, 52°.3. These observations are made in the Great Harbor, at the railroad-wharf. Another series of observations, made by Captain Edwards, for the Light-House Board, in the Little Harbor, are believed to indicate more nearly the temperature of the Vineyard Sound. These, however, are only for bottom. The difference between the monthly mean of bottom temperatures for May, at the two stations, is almost two degrees (1°.8), the figures being 51°.5 for Great Harbor, for Little Harbor 53°.3. It does not seem assuming too much to place the quarter-month average for the first half of May at 50° and 51°.4. For November the Great Harbor quarter-month means are 51°, 51°, 47°.7, 43°.3.

The menhaden strike into Vineyard Sound early in May or late in April, and linger until November, and even December.

At New London the quarter-monthly averages for the last half of April and the first half of May are 49°, 48°.5, 52°.5, 54°.5; for late October, 55°.2, 54°.9; for November, 53°.5, 51°.1, 48°.1, 46°.1.

The fish come on the eastern coast of Connecticut late in April, and are frequently taken as late as the middle of November. The temperatures of New London suggest that there may be something in error in the Wood's Holl observations in so far as they are supposed to indicate the temperature of the ocean in its immediate vicinity. The periods of appearance and disappearance at Waquoit and Menemsha, in the Vineyard Sound, agree nearly with those of Eastern Connecticut.

The temperature of the Chesapeake must be studied from the observations made at Baltimore and Norfolk. At the latter place the April means are 52°, 56°.5, 61°.2, 60°; the November means, 59°, 54°.6, 53°.5,

48°.5; at the former for April, 45°.6, 50°, 54°.5, 55°.7; for November, 54°.2, 52°.1, 50°, 47°. At Norfolk the averages for the last half of March are 48° and 50°.

The movements of the menhaden in other waters have not been very carefully observed, but we know that they enter the Potomac late in March and early in April, and that they linger till the last part of November.

In 1874 the young menhaden lingered in the Lower Potomac until the middle of December. In 1876 the average for December surface temperature at Norfolk was 36°.8, for bottom temperature 36°.4. In 1874 the surface average for December at Norfolk was 43°, or 6°.4 higher than in 1876, the year from which our tables of observations are made up. The average for Norfolk surface temperature in November was, in 1876, 53°.4, in 1874, 55°.1 or 1°.7 higher. It is quite probable that in 1874 the water of the Lower Potomac did not become colder than 50° until December.

At Wilmington the monthly means of bottom temperature in 1876 and 1877 were for December, 43°.1, January, 43°, February, 48°.5; in 1874 and 1875, December, 48°.1, January, 43°.8, February, 45°.5. December, 1876, was unusually cold, the mean temperature of the air being 46°.3, against 59°.1 for the same month in 1874. January and February of 1874 were relatively cold, their air temperature being 48°.1 and 53°.1, against 57°.1 and 52°.5 in 1876. The surface quarter-month averages for the last half of February, 1877, are 49°.1, 50°.5; for the first half of March, 1876, 52°.6, 57°; for late November and early December, 1876, 57°.1, 53°6, 46°.6, 45°.3.

No observations have been made upon the movements of the menhaden at Wilmington. At Beaufort, 30 miles farther north, they appear to be absent during the winter.

It is much to be regretted that there are no temperature observations from Cape Hatteras. The relations of this locality to the Gulf Stream are peculiar, and corresponding peculiarities in the temperatures no doubt exist. The hundred fathom curve is distant about 40 miles from the point of the cape, and the average summer limits of the Gulf Stream, as laid down upon the British Admiralty charts, extend nearly into this curve. The observations made at Wilmington, situated as it is in a bend of the coast, at least 100 miles from the summer limits of the Gulf Stream, and at the mouth of a river which rises 200 miles away in the elevated central portion of North Carolina, can hardly be taken as criteria of the temperatures of Cape Hatteras. This is still more unfortunate from the fact that the movements of the menhaden, bluefish, "sea-trout," and other warm-water species are very peculiar at this point. It will be strange if the monthly mean of water temperature for Cape Hatteras in December, and perhaps January, does not prove to be more than 50°.

Savannah is at least 120 miles from the Gulf Stream, and its means for December and January, 1876–1877, as well as those of Charleston, are below 50°. Charleston water appears to be uniformly warmest. In

1874, December in Charleston averaged 48°.8; in 1875, January averaged 50°.2.

The movements of the menhaden in this region have not been observed, but since in the north it is not more hardy than the shad, and since the shad do not venture into the Georgia and Carolina rivers in December, it is safe to predict that the habits of the menhaden are similar.

Jacksonville, Fla., is the only point on the east coast from which there are observations showing a temperature unformily above 51°, and here the menhaden remain throughout the winter.

Maximum limits of temperature.—On the coast of Eastern Maine we are told that the menhaden schools keep passing to the eastward until about the middle of July, when their impetus is apparently checked and their movements for thirty or forty days seem to be local only. During this period the temperature at Portland ranges from 60° to 70°, this being the height of mid-summer. The monthly means for July and August, 1876, were 66°.7 and 63°.9. The same months at New London are placed at 73° and 73°.3; at Norfolk, 84°.1 and 78°.3. Wilmington, Charleston, and Savannah do not range much above Norfolk; June, July, and August at Jacksonville average above 85°, and we have no satisfactory evidence that the menhaden are seen there in mid-summer. At Key West the lowest monthly mean is December, at 66°.4, in an unusually cold winter.

Preferred range of temperature.—These facts appear to indicate that under ordinary circumstances the menhaden prefers a temperature of 60° to 70° Fahrenheit. When the rising temperature of spring has passed the limit of 50° to 51° the fish are certain to appear, and when the falling temperature of autumn reaches that point their departure is equally sure, though a few individuals may linger in waters not congenial to them. The opposite limit seems to be marked by the line of 80° or perhaps 75°. An easterly or northerly wind, lowering temporarily the surface temperature, causes the schools to sink below the surface, as is shown in paragraph 95. The chill of night also drives them down.

These conclusions are not to be regarded as final. The movements of the fish about Cape Hatteras are very puzzling and need to be interpreted by a series of careful temperature observations.

It is a well-established fact that the summer of 1877 was not so warm as that of the preceding year. It is also known that the catch of menhaden in Maine for that year was much smaller than in 1876, when it was unusually large. There may be a connection between these circumstances, though the observations of water temperatures at my disposal are not sufficient to warrant decided generalization. The means for the summer months of 1876 were, at Eastport, 45°.5; at Portland, 57°.9; at Wood's Holl, 70°.4; at New London, 68°; at Norfolk, 78°.7. The corresponding means for 1877 were, at Eastport, 42°.8; Portland, 57°.6; Wood's Holl, 67°.7; New London, 66°.9; and Norfolk, 77°.2. The summer of

1877 was then colder than that of 1876 by 2°.7 at Eastport; by 0°.3 at Portland; by 2°.7 at Wood's Holl; by 1°.1 at New London; and by 1°.5 at Norfolk. July, 1877, was colder than July, 1876, at Eastport by 2°.8; at Portland by 2°.2; at Wood's Holl by 5°.9; at New London by 1°.2. August, 1877, was colder than August, 1876, at Eastport by 0°.3; at Portland by 0°.6; at Wood's Holl by 0°.9; at New London by 3°.1. September and October of 1877 were warmer than the corresponding months of 1876 at Portland, and this agrees with the fact that the catch of menhaden in Maine was entirely made in the fall months.

General discussion as to the winter habits of summer fishes.

86. The relations of the temperature of the water to the movements of the menhaden schools having been studied, a new question is at once suggested. When the schools disappear from our coast, driven by falling temperature, where do they go? The answer must be in the form of a theory, for no one has seen them during their winter absence; at least no one has been able to identify the New England and Middle States fishes after their departure in the autumn. It is evident that there are but three courses open to our coast fishes when it becomes necessary for them to leave inshore—

(1.) They may swim out to sea until they find a stratum of water corresponding in temperature to that frequented by them during their summer sojourn on our coast.

(2.) They may swim southward until they find water of the required warmth.

(3.) They may descend into the abyssal depths of the ocean, there to remain for a season in partial or total torpidity.

The last of these theories is the least plausible, from the fact that it necessitates the greatest change in habits. The susceptibility of the menhaden to slight changes of temperature has been pointed out. Hibernation in the oceanic depths involves a change to a temperature 10° to 25° colder than that preferred by them in summer, as well as other important changes in respect to specific gravity and pressure.

The theory of hibernation discussed with special reference to the habits of the mackerel.

87. The hibernation theory is a favorite one with the fishermen of the British Provinces, and has recently received strong support from Professor Hind, in his treatise on the fisheries of North America. His arguments refer to the mackerel, although the scup, tautog, and herring are included by implication. He refers to the appearance of the mackerel "with scales on their eyes and blind," and suggests that the winter sleep of fishes is probably much more general than is usually supposed. He takes the position that there are only two alternatives possibly open to fishes which cannot live in cold water. They must migrate south or

hibernate. His arguments naturally fall into two categories—those against migration and those in favor of hibernation. Those in favor of hibernation may be summed up as (1) the testimony of fishermen and travelers; (2) the quoted opinions of theorizers; (3) the alleged hibernations of other fishes; and (4) peculiarities in early and late fish.

(1.) The statements of one M. Pleville le Peley, "an eye-witness," are quoted both from Lacepede and H. de la Blanchere. M. le Peley gravely states that he had observed about the coasts of Hudson's Bay "the mud at the bottom of the small clear hollows incrusted with ice round their coasts, entirely bristled over by the tails of mackerel imbedded in it nearly three parts of their length,"* and again "affirms having seen in the middle of winter, in deep muddy bottoms, myriads of mackerel, packed close one against the other, with one-half of the body plunged in the mud, where they remained during the winter. As soon as spring came they aroused themselves from their torpor, and appeared always on the same day on the same coast at the surface of the sea, and repaired to favorable spots to spawn."† The absurdity of these statements renders it unnecessary to criticise them. The other testimony is less definite. A Newfoundland fisherman remembers to have heard his father say that forty years before "he had often seen mackerel in White Bay come on shore like squid, with scales on their eyes and blind, about Christmas."‡ And, again, a statement quoted from the Rev. John Ambrose, that "mackerel have been brought up from the muddy bottoms of some of our outer coves by persons spearing for eels through the ice,"§ which statement is not supported by the personal evidence of Mr. Ambrose, being merely a hearsay story. And this is all.

Professor Hind, in Part II of the same work‖ remarks confidently: "That the mackerel spends the winter months in a torpid condition near to the locality where the schools first show themselves on the coast has already been adverted to," and again refers to "the fact, already noticed, that it is taken in winter from muddy bottoms." I submit that no such fact has been established and that Professor Hind's generalizations are without foundation. There is much better evidence to prove that swallows hibernate in the mud of ponds, a theory which has had numerous advocates since the time of Gilbert White, of Selborne.

(2.) Professor Hind first quotes from "La Peche et Les Poissons" of M. H. de la Blanchere. The statement, printed as it is in a single paragraph instead of two and not given in full, conveys the impression that M. de la Blanchere indorses the views of Pleville le Peley, already quoted. On the contrary, he states explicitly: "The question of the annual and

* Hind, *op. cit.*, Part II, p. 10, note.
† Part I, p. 78.
‡ Part I, p. 78.
§ Observations on the Fishing Grounds and Fish of St. Margaret's Bay, N. S., by Rev. John Ambrose. <Proceedings and Transactions of the Nova Scotian Institute of Natural Sciences, 1866-'67, quoted by Hind, *op. cit.*, Part I, p. 79.
‖ P. 10.

regular appearance and disappearance of this fish is still unsolved." He then proceeds to contrast with M. le Peley's views those of Duhamel de Monceau, Anderson and others, who represented that the mackerel pass the winter in the northern seas, and in spring, beginning their migrations, pass southward visiting first Iceland, then Jutland, then Scotland, and Ireland, and the coasts of Continental Europe, in autumn assembling together for a return to the polar regions. Then he quotes Pleville le Peley, and remarks: "This theory associates the mackerel with many other sedentary fishes which pass the winter at the bottom of the sea, stupefied by the cold into a kind of lethargy, and would serve to explain why, in October, young mackerel of 10 and 15 millimeters are taken, why in winter others of larger size are taken, not with a line, but with nets, which entangle those which had not already buried themselves in the mud or the sand."*

Another quotation is made† from Shaw's "General Zoology, or Systematic Natural History," published in 1803. Professor Hind says that "the four disputed points in relation to the natural history of this fish are there asserted, namely, its local habits, its torpidity during hibernation, the film over the eye, and the fact of its being partly imbedded in the soft mud or sand during its winter sleep."

I admit that Shaw asserts the presence of a film over the eye. He does not, however, even give the theory of hibernation his personal indorsement, but remarking that the long migration of the mackerel and herring seems at present to be called in question, continues, "It is thought more probable that the shoals which appear in such abundance round the more temperate European coasts, in reality reside during the winter at no very great distance, immersing themselves in the soft bottom, and remaining in a state of torpidity, from which they are awakened by the warmth of the returning spring, and gradually recover their former activity."

Even if Shaw could fairly be quoted as a supporter of this theory, his opinion is of little value. He was not a naturalist, but a bookmaker, and his compilations are acknowledged to be inaccurate.‡

The opinions of Dr. Bernard Gilpin and the Rev. John Ambrose, two excellent Nova Scotian observers, are quoted,§ though with no apparent reason, for the latter remarks only that "it is the opinion of some" that the third run of mackerel, which takes place at St. Margaret's Bay about the first of August, are not returning from the Gulf of Saint Lawrence, but from sea, and "it may be that a portion of the immense schools passing eastwardly in the spring strike off to some favorite bank

* Nouveau Dictionnaire Général des Peches, &c., par H. de la Blanchere. Paris, 1868, p. 183, article *Maquereau*.

† Hind, *op. cit.*, Part II, p. 10.

‡ See a criticism upon Shaw's General Zoology in Gill's Arrangement of the Families of Fishes, &c., 1872, pp. 40, 41.

§ Part I, p. 79.

outside to deposit the spawn. Or there may be a sort that never go as far east or west as the others, but winter along our shores," &c.; while Dr. Gilpin expressly remarks that though the *asserted torpidity and blindness* favor the idea of hibernation, he does not think that we have yet sufficient proof to assert them as facts.

The authorities quoted in support of the hibernation theory do not in fact support it, and the testimony cited by Professor Hind is merely tradition and popular opinion, some obtained directly, the remainder at second-hand.

(3.) Still another set of arguments is based upon the supposed hibernating habits of other species of fishes. Professor Hind remarks: "In seas which are not ice-encumbered the winter torpidity (of the mackerel) may be of very short duration; in ice-encumbered seas it may extend over several months. In this particular the mackerel resembles the sturgeon of the Caspian Sea, whose torpidity during winter is well known, and this winter sleep is not confined to these fish, but is probably much more general than is usually supposed." *

Here we have a definite statement. The mackerel hibernate, and the winter sleep is not confined to the mackerel.

The only hibernation which is definitely known to occur among fishes takes place in the fresh-water lakes and streams of cold regions. The fish are driven by cold into the deeper waters, and there remain in a state of torpor proportionate in degree to the amount of cold which they experience. They may even be frozen up in the midst of a mass of ice and recover their vitality when the ice is melted. †

In warm regions an analogous phenomenon takes place which has been called æstivation. When the lakes and streams are dried up by the heat the fish seek refuge in the deepest pools, and when these too are dry they bury themselves in the mud at the bottom and remain torpid until the rainy season refills the reservoirs and revives them.

Fishes in the extreme north doubtless undergo similar experiences, though I am not aware that any record of such a phenomenon has ever been published.

Hibernation and æstivation do not appear to be in any case voluntary acts. The fish do not become torpid of their own volition. They avoid it as long as they can, and only succumb when they are deprived of means of escape. They never become torpid when there are greater depths to which they can retreat. ‡

* Part II, p. 11.

† Mr. Milner had a mud-minnow (*Umbra limi*) which was frozen in solid ice in the middle of an aquarium globe three or four times, and each time recovered its vitality upon thawing out.

‡ "A curious phenomenon in Indian fresh waters, and one which has never been satisfactorily explained, is the sudden appearance of healthy adult fishes after a heavy fall of rain, and in localities which for months previously had been dry. When pieces of water inhabited by fish yearly dry up, what becomes of them? On January 18, 1869, when examining this question, I was taken to a tank of perhaps an acre in extent, but

(4.) Professor Hind lays much stress upon the presence of a "film" over the eyes of the spring and autumn mackerel and upon their alleged capture in winter in the waters of the Dominion, and also quotes arguments for hibernation based upon the resemblance of the mackerel to the batrachians (which are known to be capable of hibernation) in color, and upon its resemblance to embryonic forms of other fishes which is supposed to "prove him low in the scale of intelligence."* To the latter it is needless to refer. The so-called "film" on the eye is not peculiar to the mackerel. Many fishes, such as the shad, the alewife, the menhaden, the bluefish, the mullet, the lake whitefish, and various cyprinoid fishes have a thick, rough membrane covering the anterior and posterior angles of the orbits narrowing the opening to the form of an ellipse with a vertical major axis. This possibly becomes somewhat more opaque in seasons of decreased activity. It

which was then almost dry, having only about four inches of water in its center, while its circumference was sufficiently dried to walk upon. The soil was a thick and consistent bluish clay, from which, and not nearer than thirty paces to the water, five live fish were extracted from at least two feet below the surface of the mud. They consisted of two of *Ophiocephalus punctatus* and three of the *Rhynchobdella aculeata*. All were very lively and not in the slightest degree torpid. They were covered over with a thick adherent slime. Among the specimens of fish in the Calcutta museum is one of the *Amphipnous cuchia*, which was dug up some feet below the surface of the mud when sinking the foundation for a bridge. If when the water failed fish invariably died, the tank would be depopulated the succeeding year unless a fresh supply was obtained from some other source, while the distance from other pieces of water at which they reappear excludes, in many instances, the possibility of migration, which must always, to a certain extent, be regulated by distance, time, and other local circumstances. Some species, especially "compound breathers," are unable to live in liquid mud, which they cannot employ for purposes of aquatic respiration.

"The practical question is, whether, when food and water fail, some fish do not æstivate until the return of a more favorable season. Natives of India assert that they do thus become torpid in the mud. As the water in tanks becomes low, the fishes congregate together in holes and places in which some still remains, where they may be frequently seen in numbers huddled together with only sufficient water to cover their dorsal fins.

"If disturbed they dive down into the thick mud, so that a net is often found ineffectual to take them. The plan employed to capture them is for the fisherman to leave the net in the water, and to walk about in the surrounding thick mud; in time they come to the surface to breathe, and fall an easy prey.

"As the water gradually evaporates, the fishes become more and more sluggish, and finally there is every reason to believe that some at least bury themselves in the soft mud, and in a state of torpidity await the return of the yearly rains. In Ceylon, Mr. Whiting, the chief officer of the western province, informed Sir Emerson Tennent that he had accidentally been twice present when the villagers had been engaged in digging up fish. The ground was firm and hard, and "as the men flung out lumps of it with a spade, they fell to pieces, disclosing fish from 9 to 12 inches long, which were full-grown and healthy, and jumped on the bank when exposed to light. Many other animals which possess a higher vitality than fish æstivate during the hot months, as *Batrachians*, the *Emys*, the *Lepidosiren annectens*, and some of the *crocodiles*. Mollusks and land-snails are commonly found in this state during the hot and dry months. (Day's Fresh-water Fish of India, p. 28.)

* Part I, p. 79.

never has been observed to cover the whole eye. Until the fact has been established that "a skin forms over the eye in winter" it is quite unnecessary to propose the theory that such a skin "is probably designed to protect that organ from the attacks of the numerous parasitical crustaceans and leeches which infest the external portions of the bodies of fishes, and are also found internally, as in the gills of codfish"*

Criticism of the argument based upon the presence of mackerel in northern waters late in the season.

A number of instances are cited to prove that the mackerel schools remain on the coast of the Dominion throughout the winter season. If this can be well established it is a very strong argument in favor of hibernation. Let us analyze the testimony.

Dr. Gilpin is quoted to the effect that during some seasons they linger on the Nova Scotian coast until December, and allusion is made to a mackerel obtained by him at Halifax, October 27, 1875.†

Mr. John Rice remembers that his father used often to speak of mackerel "coming on shore like squid with scales on their eyes and blind about Christmas," about 40 years ago.‡

Mr. Jabez Tilley states that they have been taken in November in Trinity Bay.

Professor Hind also states that they are to be found on the whole coast from Quirpon to Cape Spear during November and December. He gives no authority for this statement, and it is to be inferred that it is founded upon personal observation.

Then there is the vague statement of Mr. Ambrose, already quoted, that mackerel have been speared on muddy bottoms under the ice.

Now this testimony does not, by any means, tend to prove that the mackerel remain near the coast in winter.

In the first place there is no satisfactory proof of their occurrence later than October 25, since that is the only evidence fortified by a memorandum of date, and the memories of fishermen are not more certain than those of other men.

In the second place it is not impossible that mackerel linger in these waters until November or even December in the case of a very warm autumn. The temperature necessary for the menhaden cannot be many degrees below 50°, while the mackerel appears to endure a temperature of 41° or less. Menhaden linger in Maine waters till November and in Massachusetts Bay and the Vineyard Sound till December.

Finally, the undoubted capture of many individuals in winter on the coast of Newfoundland would by no means prove that the great schools were there throughout the season. Disabled, blind, or diseased individ-

* Hind, *op. cit.*, Part II, p. 11.
† Part I, p. 79.
‡ Part I, p. 78.

uals would naturally be unable to accompany the departing schools. Such fish would naturally grovel on the bottom in a helpless state and might easily become impaled on the eel-spears, or might be thrown on shore by the waves, as the Newfoundland fishermen relate. Even healthy fishes might occasionally be accidentally detained. Mr. Peter Sinclair a well-known fisherman of Gloucester, stated to Professor Baird that some years ago a school of mackerel were detained all winter in a small river in Nova Scotia, and were speared out of the mud. This is doubtless hearsay testimony and is given for what it is worth. I do not doubt that there have been individual cases of this kind, but I maintain that no generalization should be founded upon them.

The theory of extended migration discussed with reference to the habits of the mackerel.

88. The preceding paragraph is devoted to the refutation of the idea that sea-fish hibernate. This is regarded as the least probable of the three hypotheses stated in paragraph 85. In paragraph 84 it is stated that the sea-herring and many other fishes have two kinds of migrations: one bathic, or from and toward the surface; the other littoral, or coastwise. Now, in some species the former is most extended; in others, the latter. The anadromous species very probably strike directly out to sea without coasting to any great degree, while others, of which the mackerel is a fair type, undoubtedly make extensive coastwise migrations, though their bathic migrations may, without any inconsistency, be quite as great as those of the species which range less.

Upon this point I cannot do better than to quote from a manuscript letter from Professor Baird to the Hon. Hamilton Fish, Secretary of State, dated July 21, 1873. Having expressed the views concerning the migration of the herring and shad already quoted in paragraph 84, he continues:

"The fish of the mackerel family form a marked exception to this rule. While the herring and shad generally swim low in the water, their presence being seldom indicated at the surface, the mackerel swim near the surface sometimes far out to sea, and their movements can be readily followed. The North American species consist of fish which as certainly, for the most part at least, have a migration along our coast northward in spring and south in autumn, as that of the ordinary pleasure-seekers, and their habit of schooling on the surface of the water enables us to determine this fact with great precision. * * * Whatever may be the theories of others on the subject, the American mackerel-fisher knows perfectly well that in the spring he will find the schools of mackerel off Cape Henry, and that he can follow them northward day by day as they move in countless myriads on to the coast of Maine and Nova Scotia."

It is difficult to estimate to what extent the advocates of the hibernation theory have been influenced by patriotic motives in their efforts

to prove that the mackerel remain in the waters of the Dominion of Canada throughout the entire year. It is certain that all recent treatises on ichthyology by Canadian writers have appeared in the form of campaign documents apparently intended to influence the decisions of diplomatic commissions.

I am by no means prepared to maintain that mackerel do not pass the winter in the American domain of Her Imperial Majesty. It seems important, however, that the subject of the migration of fishes should be restored to its proper position as a question of abstract scientific importance. Let us glance at the arguments of Mr. Whitcher and Professor Hind against what the former is pleased to style the "American theory."

In the report of the Minister of Marine and Fisheries for the year ending the 30th of June, 1871, Mr. W. F. Whitcher, Commissioner of Fisheries, published a paper entitled "American theory regarding the migration of the mackered refuted".*

Mr. Whitcher opens his letter by claiming that the theory of north and south migration was invented solely in support of a claim advanced by citizens of the United States to participate in the Canadian inshore fisheries. "This ingenious but traditional theory of annual migration having gained local credence among some of the Nova Scotian fishermen engaged in United States fishing-vessels, has been sagaciously indorsed and circulated by American authors." He also refers to evidence "supposed to have been procured among the fishing population of the New England States."

I need only say that these claims are unjust, and that the theory of the annual north and south migration of the mackerel is time-honored, and was held conscientiously by ichthyologists of the United States and the provinces long before the question of fishery treaties assumed its present aspect. It is manifestly unfair to state that, while the theories which prevailed respecting the habits of herring and mackerel were formerly similar, that "in the former case it is probable that traditionary and imperfect information formed the basis of error, while in the latter instance it is most probably founded on misinformation dictated by sectional interests." Mr. Whitcher's own paper upon migration is the only one of American origin in which I have seen scientific method sacrificed to partisan spirit.

Having read Mr. Whitcher's introduction, one might readily predict what sort of an argument he will wrench out of the statements of "such disinterested authorities as may be readily quoted." First he gives extracts from Mitchell and the Edinburgh Encyclopædia regarding the habits of the herring. Granting all that is claimed about the herring, without reference to the liability of these authorities, what do we find? Merely a begging of the question. The habits of the herring and the mackerel are not known to be the same. In many particulars they are

* Pages 186–189.

diametrically different, for the former loves cold water, the latter warm water.

Various provincial writers are now quoted; Mr. Perley, who says that "naturalists now tell us" and "it is now considered settled" that the mackerel is not migratory, but draws off into deep water at the approach of winter, and Mr. Knight and Mr. Fortin, though the reason for these quotations is not apparent, since no reference to the winter habits of the fish can be found therein. He does not refer to the writings of Mr. Ambrose and Mr. Johnson, Canadian writers, who advocate the migratory theory.

Yarrell and Couch are next quoted, though neither of them has ventured to give a decided opinion.

Finally, we have a paragraph compiled from five French encyclopedias, good and bad, no means being afforded of distinguishing the opinions of Cuvier from those of Chenu's literary staff.

Mr. Whitcher's conclusion is this: that "it is clearly neither necessary nor accurate that mackerel should perform the migrations ascribed to them by American writers."

The migrations of the mackerel are neither proved nor disproved by special pleadings of this description. The spirit of Professor Hind's writings is very different. He writes from the stand-point of an investigator, and his book is an important contribution to our knowledge of the habits of fishes in relation to temperature and currents. I feel obliged, however, to call attention to a very serious flaw in his chief argument against the annual migration of the mackerel.

In the chapter on the "Relation of the Supposed Migratory Movements of Mackerel to Isothermal Lines,"* it is claimed that a migration to the north in the spring "presupposes the movements of bodies of the same great schools of mackerel which are alleged to pass Massachusetts Bay from the waters of the coasts of Virginia and New Jersey, not only through from ten to twelve degrees of latitude, but it assumes that they are able to cross in the early summer, and frequently before spawning, numerous isothermal lines in descending order."

He then refers to the article upon the Gulf Stream in Petermann's "Mittheilungen" for 1870, in which the marine isothermals for the different months are shown by means of a chart. A table is given showing the isothermals for July. That of 68° would touch the coast at Delaware Bay, that of 63°.5 at Long Island, that of 59° at Boston, that of 54°.5 at Cape Sable, Nova Scotia, that of 50° at Cape Race, and that of 45°.5 at the Straits of Belle Isle.

From this he concludes that a "a school of fish, moving rapidly from Delaware Bay to the Straits of Belle Isle, would pass in July from a mean temperature of 68° to a mean temperature of 45°, a difference of more than 22° Fahrenheit.

This theory would be very satisfactory if it could be admitted that the

*Hind, *op. cit.*, part ii, pp. 15–17.

isothermals for July indicate the actual temperature of the sea from day to day. In reality the marine isothermals are constantly varying, and, in this respect are different from those printed upon a chart. A glance at the tables in Appendix F, and the conclusions deduced from them in regard to the menhaden (paragraph 85), will show that schools of fish do not find it necessary to force their way through walls of sea temperature, but that their movements from south to north are exactly correlated with the seasonal rise of temperature. As soon as the water at a given point reaches the necessary temperature, which for the mackerel on our own coast appears to be as much as 45°, the fish make their appearance, and with the advance of the season they appear farther and farther to the north. Mackerel do not appear on the coast of Maine until the water is as warm as it was off Cape Hatteras at the time of their first arrival. This is the case whether we suppose their general movement to be parallel with or vertical to the coast line.

I have entered the discussion of this question not with any idea of attempting to prove that mackerel migrate south from the Gulf of St. Lawrence, but to show that a comparatively rapid northward movement in May and June does not necessitate a "sudden plunging from high to low zones of temperature."

Arguments against extended migrations of menhaden.

89. There is no satisfactory evidence that the menhaden pursue extended migrations north and south. The same evidence which tends to show that the shad, salmon, and alewife do not follow this course will will apply, with modifications, to the menhaden.

The menhaden schools at different points along the coast appear to have individual peculiarities, corresponding to those of the shad in the different rivers. A Maine menhaden may easily be distinguished from a Long Island menhaden, a Chesapeake or a Florida one, by certain indescribable characters, easy to perceive but difficult to define. The presence of the crustacean parasite in the mouths of southern menhaden, and its constant absence from those of the north is a very strong argument in favor of local limitation in the range of menhaden schools.

That the same schools of menhaden return year after year to the same feeding grounds is rendered very probable by the statements of Mr. Miles in paragraph 72.

The schools in the southern waters do not receive any apparent increment at the time of desertion of the north coast, nor are the southern waters deserted at the time of abundance in the north. There is, however, a limited north and south migration. The Maine schools on their departure in the fall appear to follow the southward trend of the coast until they strike the hook of Cape Cod, where they are detained for some days; they then round the cape and are again detained by the hook of Montauk Point. They first strike the shore at Point Judith and are

turned over into Peconic Bay by the line of islands stretching across the eastern end of Long Island Sound.

In this same way the Chesapeake schools are said to be detained for some days by the projection of Cape Henry.

The hypothesis of oceanic sojourn of the menhaden.

90. The questions of hibernation and extended migration having been considered, it only remains to discuss the third alternative, that of the possibility of sojourn in the warm strata of the open ocean.

In plate XII is given diagram sections of the North Atlantic Ocean between New York and Bermuda, showing the soundings and isothermal lines obtained in Her Majesty's ship "Challenger", April 24 to May 8, 1873. The vertical scale is necessarily enormously exaggerated, but the diagram shows the presence of strata under the Gulf Stream, and between it and the American coast, the temperature of which exactly meets the requirements of the menhaden. At a depth of 50 to 100 fathoms there is a shoreward extension of the warm stratum of 50° to 55° which extends inward one hundred and twenty miles. There are no means of determining the corresponding isothermal lines on the coast of North Carolina, but an extension of much less degree would approach very near the shore in that region. The diagram represents the condition of the sea temperature near New York at the very period when the menhaden are approaching the coast in April, and a similar relation not improbably exists in November, at the time of their departure. The schools of fish swimming out to sea when the shore waters become too cold for them, and driven below the surface by the winds of November, would naturally strike these temperate strata, and being kept from descending deeper by the uniform coldness of the waters below, as well as by the increasing pressure, and their efforts to approach the shores being also opposed by a temperature barrier, they would remain in the temperate strata until they were enabled by the warmth of spring to regain their feeding grounds near the shores.

No authorities can be quoted in support of this hypothesis, but, in the case of the menhaden at least, it appears to explain more of the difficult questions in relation to periodical movements than that of hibernation or that of extended migration.

(1.) It presupposes less sudden changes of temperature than that of hibernation. It has been shown that hibernation of fishes is never voluntary, but is a state of torpidity induced like that of æstivation by a change of temperature and surroundings which they have no power to avoid. Before entering upon hibernation or æstivation fishes retreat to the deepest water, and only become completely torpid when they are followed thither by the changed conditions of existence. In the fresh waters of temperate regions fishes do not become entirely torpid in cold weather, but are sufficiently active to be taken with hooks from under the ice. This is also the case in very deep waters in subpolar regions. The

kalleraglitz or American turbot (*Reinhardtius hippoglossoides*) is taken with hooks, in the dead of winter, under the floe ice of North Greenland at a depth of 300 fathoms; in South Greenland, on the oceanic banks, at 60 and 80 fathoms; and at Fortune Bay, Newfoundland, it is captured in the shore herring-seines at the same season.

So long as the menhaden can avoid the extremes of temperature which they so carefully avoid in the summer by seeking congenial warmth in the ocean strata under the Gulf Stream, need we suppose that they will plunge into the colder strata below?

(2.) It involves less radical changes than hibernation in the habits of the fishes. Some fishes, like the mud-minnow (*Umbra limi*) of the Eastern United States, are peculiarly adapted for life in the mud; others, such as the "compound breathers" (*Labyrinthici*) of India, are said to respire with ease with their heads covered by liquid mud. Such fishes, however, are totally different in organization from the free-swimming species of the open seas. All free swimmers are especially heedful to avoid contact with the bottom. This is especially so in the case of the herring family, of which the menhaden is a member. They are provided usually with deciduous scales, and never suffer themselves to come in contact with the bottom. If one of the herring or mackerel tribe is placed in an aquarium, it will be noticed that it keeps itself always free from the bottom. Other fishes in the same tank, such as the sea-bass, tautog, or king-fish, will be seen to rest on the bottom, and even to take refuge under the stones.

It is improbable that mackerel ever voluntarily sink into the mud of the ocean bottom; still more so in the case of the menhaden.

(3.) It accounts better than the other theories for the early appearance of the fish in the spring.

Admitting the possibility of a winter's sojourn in the mud, we are met by a difficulty when we try to account for the prompt appearance of the fishes in the spring. The deeper strata of the ocean are now known to preserve throughout the year the uniform temperature of 22° to 40°. The fish, once mummified in the depths of the ocean, would remain so forever, unless they possess powers unknown to exist in other animals.

On the other hand, if we suppose the fish to be swimming in the strata of mid-ocean, we know that they are in just the position to be susceptible to all the daily variations of temperature. Following, with the advance of the season, the inward curving of the Gulf Stream, the warm strata below it gradually approach the shore. The schools of fish are thus enabled gradually to draw nearer to the coast line, and when the strata of 50° to 55° in temperature touch the coast the menhaden are at hand.

(4.) It explains, as well as the hibernation theory and better than the migration theory, the peculiarity of the schools at different localities along the coast. This was discussed in paragraph 88.

(5.) It explains better than the other theories the appearance of the fish at the time of their arrival in the spring.

The menhaden appear to be bottom feeders. If they migrated coastwise to the south, they would there find feeding-grounds; if they sank to the bottom, they would there find food if they had sufficient vitality to resurrect themselves in the spring; if they passed the winter in the mid-ocean strata, they could obtain no food and would naturally become emaciated, the accumulated fat of the preceding summer being absorbed.

Rimbaud's classification criticised and a new one proposed.

91. Rimbaud's classification, which is a modification of one recognized in the markets of South France, is very suggestive, but it does not appear to me to be entirely applicable to the fishes of our coast, at least not in the way in which it has usually been adopted.

Rimbaud makes four divisions, viz:

I. Wandering fishes (*Poisson nomade*).

II. White fishes (*Poisson blanc*).

III. Bottom fishes (*Poisson de roche* or *Poisson de fond*).

IV. Alien or outside fishes (*Poisson forain*).

The distinction between Classes I and IV does not appear to be very clearly marked. In the Western Atlantic, some of the fishes making up Class IV belong to each of the other classes.

A more natural classification would be in three divisions, which might readily be correlated with the three kinds of migration mentioned in the preceding paragraph.

The first group would include the wandering fishes, the *Poisson nomade* of Rimbaud, whose migrations are entirely oceanic and confined to the surface zones. The second group would include the bottom fishes of restricted range, the *Poisson de fond* of Rimbaud, which move to and from the shore or the shallows, and which do not range. The third group would include the middle classes, those which take advantage of both methods of migration, and corresponds approximately to Rimbaud's second division. "White fishes" seems hardly an appropriate name: "coast fishes" would perhaps be more expressive.

Colonel Lyman, in his report "On the Limits of Artificial Culture, and the Possible Exhaustion of Sea-fisheries"* (p. 67), speaks of the first class as "the wandering or schooling fishes of the high seas." The term "schooling" is liable to mislead, for the "white fishes" also school. Among the wandering fishes he mentions only "the herring (*Clupea elongata*), mackerel (*Scomber vernalis*), menhaden (*Alosa menhaden*), cod (*Gadus morrhua*)," &c. The cod and herring most certainly are "white fishes," and the menhaden and mackerel are certainly not to be ranked with "those which appear on the coast only when 'migrating,' and then in vast but uncertain troops" (p. 63).

* Report of the Commissioners of Fisheries (of Massachusetts) for the year ending January 1, 1870, pp. 58–67.

A provisional classification, by habits, of the fishes of our eastern coast might stand somewhat as follows:

I. *Wandering or surface fishes.*—These remain in our waters only for a short time, their movements being capricious or accidentally directed by the ocean currents, or else in search of food. They do not spawn on our coast, and their young are never seen in our waters.

The best-known examples are the sword-fish (*Xiphias gladius*), the spear-fish (*Tetrapturus albidus*), the bonito (*Pelamys sarda*), the tunny (*Orcynus thynnus*), the dwarf tunny (*Orcynus alliteratus*), the ceroes and Spanish mackerel (*Cybium maculatum*, *C. caballa*, and *C. regale*), the rudder-fishes (*Seriola zonata*, *Naucrates ductor*, and *Palinurichthys perciformis*), the dolphins (*Coryphæna*, two or three species), the remoras (*Echeneididæ*), the barracuda (*Sphyræna borealis*), the lady-fish (*Albula vulpes*), the tarpum (*Megalops thrissoides*), the oceanic sharks, such as *Galeocerdo tigrinus*, and the numerous waifs from the West Indian fauna.

Of these only the sword-fish, bonito, and the ceroes and Spanish mackerel are of economic importance at present.

II. *Local or bottom fishes.*—These remain in our waters throughout the year, their movements being chiefly to and from the shores, though many of the species move for long distances up and down the coast. They prefer a somewhat uniform temperature, which they secure by going into the shallows in summer and deeps in winter in the northern districts of their distribution, while in their southern districts of distribution these movements are reversed. They spawn on our coast, usually in shallow water and during their shoreward sojourn.

The principal representatives of this group are the goose-fish (*Lophius piscatorius*), the flounders and flat fishes, the halibut (*Hippoglossus vulgaris*), of whose spawning habits little, however, is known, the lump-fish (*Cyclopterus lumpus*), and the two species of *Liparis*, the cod (*Gadus morrhua*), haddock (*Melanogrammus æglefinus*), pollock (*Pollachius carbonarius*), and the hakes (*Phycis chuss* and *P. Americanus*), the gurnards and sculpins (*Prionotus*, sp. and *Cottus*, sp.), the rose-fishes (*Sebastes*, sp.), the tautog (*Tautoga onitis*), and the chogset (*Ctenolabrus chogset*), the skates, the rays, and the ground-sharks.

III. *The coast or ranging fishes.*—These are in our coast waters for a portion of the year, and when absent from them are supposed to retreat to the depths of the ocean. When near the shores their movements are a combination of those of the two previous classes, and they wander widely up and down the coast. They spawn upon our continental slope, some entering the rivers, some upon the inshore shallows, and some upon the off shore shoals, their young coming to the shores with the parents. They all are summer visitors in the northern districts of their distribution, though some, like the herring, only appear in New England in the winter.

The best-known examples of this group are, among the river-spawning or anadromous species, the salmon (*Salmo salar*), the shad (*Alosa sap-*

idissima), the alewife (*Pomolobus pseudoharengus*), the mattowacca (*Pomolobus mediocris*), and perhaps the striped bass (*Roccus lineatus*) and the smelt (*Osmerus mordax*); among the shore-spawning species, in the north, the capelin (*Mallotus villosus*), the launce (*Ammodytes lanceolatus*), and the herring (*Clupea harengus*); in the south, the scuppaug (*Stenotomus argyrops*), sheepshead (*Archosargus probatocephalus*), the sea-bass (*Centropristis atrarius*), the atherines (*Chirostoma notatum*), the mullet (*Mugil*, sp.), and the mackerel (*Scomber scombrus*); and among the offshore spawners the pompano (*Trachynotus carolinus*), the squeteague (*Cynoscion carolinensis* and *C. regalis*), the menhaden (*Brevoortia tyrannus*), and probably the bluefish (*Pomatomus saltatrix*).

14.—THE MOVEMENTS OF THE SCHOOLS.

Habits of the schooling fish.

92. Making their appearance in our waters in the early spring, they rapidly increase in abundance until the sea appears to be alive with them. They delight to play in inlets and bays, such as Chesapeake Bay, Delaware Bay, Great Egg Harbor, Long Island, Block Island and the Vineyard sounds, Narragansett Bay, Buzzard's Bay, and the numerous narrow fiords on the coast of Maine. They seem particularly fond of shallow waters protected from the wind, in which, if not molested, they will remain throughout the season, drifting, with the tide, in and out of the shallow indentations of the shore and into the mouths of creeks and rivers. Brackish water attracts them, and they abound at the mouths of streams, especially on the Southern coast. They ascend the Saint John's River more than thirty miles, the Saint Mary's, the Neuse, the York, and Rappahannock. The Potomac they ascend nearly to Washington, a distance of sixty miles, and the Patuxent to Marlborough. In these rivers they come soon after the shad, and are so troublesome to the fishermen that their presence is easily determined.

I am not aware that this difficulty occurs in northern rivers. Professor Baird found them in the Hudson and its tributaries in the summer of 1854.*

They enter the Housatonic late in the summer. I am not aware that they ascend the Connecticut to any considerable distance from its mouth.†

They are found in the Mystic, Thames, and Providence Rivers, in the creeks on Cape Cod, in the mouth of the Merrimac River, and in some of the large rivers of Maine, such as the Kennebec and Penobscot.

Boardman and Atkins state that fish caught in the brackish water of the rivers are generally inferior as to fatness, "a fact indicating that they find there a poor feeding ground, and also that their stay there is long enough to affect their condition."

*Fishes of the New Jersey Coast, 1855, p. 34.

†This is perhaps due to the swift current of the river. Sea-going vessels fill their water-barrels at Essex, six miles from the bar.

Movements to and from the surface.

93. The arrival of the menhaden is announced by their appearance at the top of the water. They swim in immense schools, their heads close to the surface, packed side by side, and often tier above tier, almost as closely as sardines in a box. A gentle ripple, caused by the motion of the vertical fins, indicates the position of the school, and this may be seen at the distance of nearly a mile by the lookout at the masthead of a fishing-vessel, and is of great assistance to the seine-men in setting their nets. At the slightest alarm the school sinks toward the bottom, and in this way often escapes its pursuers. When sailing over a school of menhaden, swimming a short distance below the surface, one may see their glittering backs beneath, and the boat seems to be gliding over a floor inlaid with blocks of solid silver. At night they are phosphorescent and their backs glow like fire. The motions of the schools seem capricious, and without a definite purpose; at times they swim around and around in circles, at other times they sink or rise. Why they swim at the surface so conspicuous a prey to men, birds, and other fishes, is not known; it does not appear to be for the purpose of feeding; perhaps the fisherman is right when he declares that they are "playing." When they are pursued by other fish they fly in confusion like a flock of frightened sheep, and are often driven in great masses upon the shores.

The swimming habits of menhaden and mackerel.

94. An old mackerel-fisherman thus describes the difference in the habits of the schools of mackerel and menhaden:

"The pogies school differently from mackerel. The pogy slaps with his tail, and in moderate weather you can hear the sound of a school of them as first one, then another, strikes the water. The mackerel go along 'gilling'—that is, putting the sides of their heads out of the water as they swim. The pogies make a flapping sound, the mackerel a rushing sound. You can sometimes, in calm and foggy weather, hear schools of mackerel miles away."

Birds attracted by the schools.

95. They do not attract terns, as do the schools of predaceous fish, for they are too large to be an easy prey for those birds, and they are not in pursuit of crustaceans or smaller fish, which might also serve as food for the small birds. The bluefish and bonitos are attended by eager flocks of gulls and terns, which find a bountiful supply in the remnants of their voracious feasting, floating on the surface in their wake. The fish-hawk (*Pandion carolinensis*) often hovers over the schooling menhaden, and some of the larger gulls occasionally follow them in quest of a meal. About Cape Cod one of the gulls, perhaps *Larus argentatus*, is known as the "pogy-gull."

The influence of wind and weather.

96. On warm, calm, sunny days they may always be seen at the surface, but cold or rainy weather, and prevailing northerly or easterly winds, quickly cause them to disappear below the surface. In rough weather they are not so often seen, though schools of them frequently appear at the surface when the sea is too rough for the fishermen to set their nets.

Mr. Atkins and Mr. Dudley agree that the best days for menhaden-fishing is when the wind is northwesterly in the morning, dying out in the middle of the day, and then springing up again in the afternoon from the southwest, with a clear sky. At the change of the wind on such a day the menhaden come to the surface in large numbers.

A comparison of the influences of the weather upon the movements of the menhaden and its allied species, the herring, gives some curious results. The herring is a cold-water species. With the advance of summer it seeks the north, returning to our waters with the approach of cold weather. The menhaden prefers a temperature of 60° or more, the herring of 55° and less. When the menhaden desert the Gulf of Maine they are replaced by the herring. Cold weather drives the menhaden to the warmer strata below, while it brings the herring to the surface.

The observations of Herr von Freedon, of Hamburg, director of the German See Warte,* are important in this connection. Herr von Freedon made a thorough analysis of the log-books of the luggers engaged in the German herring fishery, and made an elaborate report to the Fishery Commission at Embden upon the influences which affect this fishery, especially the influence of winds and the temperatures of the sea. He has come to the conclusion that northwest winds are the best for large catches, and northerly winds better than southerly, westerly better than easterly; also that moderately strong winds, sufficient to ruffle the surface of the sea, are better than calm weather, and light winds almost as unfavorable as stiff breezes; a ruffling of the sea being, in his opinion, of considerable importance to success in fishing. For the temperatures of the sea, he regards a temperature from 53° to 57° as most favorable, the chances of success diminishing with higher or lower temperatures.

The conditions most favorable, then, for the appearance of herring at the surface are least so for menhaden, it being borne in mind that northwesterly and westerly winds on the east side of the Atlantic correspond to northeasterly and easterly winds upon the west side.

The movements of the herring as influenced by weather.

97. In the "Scotsman" of August 25, 1876 (quoted in "Nature"), is an interesting observation regarding the movements of the herring on the Scottish coast. The surface temperatures of the sea, as determined by the sea-thermometer furnished to the fishermen by the Scottish Meteorologi-

* See Report of the Commissioner of the Fishery Board of Scotland, 1875.

cal Society, is regarded to have been from 58° to 59° during the week ending August 19, but on the 21st, when the nets were shot, the temperature had fallen to 55°, and this was the first night the herring were caught. They were found low in the nets during the prevalence of warm weather between Northumberland and Peterhead.

"The Meteorological Society of Scotland have for two or three years had this capriciousness in the movements of the herring under special investigation, and in the past year the deep-sea thermometers provided to the society by the Marquis of Tweeddale, its president, for testing the temperature of the sea, were again sent out by the Fishery Board to their officers, and the temperature obtained at different periods of the herring fishery. Daily registers of the weather were kept and other particulars furnished to the society, both by the district fishery officers and by Samuel McDonald, esq., commander of the "Vigilant," fishery-cruiser. From the registers and the information thus supplied, the following conclusions have in the mean time been drawn by the committee of the society:

"From the observations of the catch of herrings and the temperature of the sea off the east coast of Scotland, during the two seasons of 1874 and 1875, it is seen (1) that the temperature of the sea from the middle of August to the close of the fishing season was continuously and considerably higher in 1875 than 1874; and (2) that the catch of herrings was continuously and considerably lower during 1875 than during the same period of 1874.

"Another result is this: If there be a district where, from any cause, the temperature of the sea is lower than in surrounding districts, in that district the catch of herrings is heavier; and conversely, if there be a district where, from any cause, the temperature of the sea is higher than in surrounding districts, in that district the catch of herrings is less. Among the causes which bring about a local increase or decrease of sea-temperature, the chief are clouded or clear skies in respective districts, according as these occur during the day or during the night. These local variations in the temperature of the sea in their bearings on the catch of herrings have been shown by the observations both of 1874 and 1875.

"Another important point is the relations of surface temperature to bottom temperature, and the relations of the deepest parts of the sea to the positions of the fishing grounds. It is found, for instance, that when the surface temperature is high—higher than lower down—the fish, if any be caught, strike the nets far down, in such a way as to lead to the supposition that a good deal of failure may often arise from the nets not going deep enough. The fish prefer, apparently, so far as the inquiry has gone, the lower to the higher temperature. The herring committee are most desirous of carrying out this line of inquiry into greater detail, if some of the fishermen could be induced to take the trouble of observing the temperature of the sea at the surface and also at the depth at which the fish strike the nets.

"The influence of thunder-storms was equally seen as in former years. If there is a thunder-storm of some magnitude extending over a large portion of Scotland, good takes may be made on that day; but on the following day few, if any, fish are caught over that part of the coast *unless at the extreme verge of a deep part of the sea*, as if the fish were retreating thither.

"Owing to the shortness of the time over which the inquiry has extended, the committee wish these results to be considered only as provisional. The results are, however, of the greatest value, not merely as indicating the lines of inquiry to be followed in further carrying on this large investigation, but also as indicating, in some cases not obscurely, the nature of the results which will ultimately be established—results which, since they lead directly to a knowledge of the localization of the herring, will serve as a guide to the fishermen where to set their nets with the highest probability of success."

The influence of the tides on the menhaden.

98. There has been no decided relation observed between the movements of the schools and of the tide.

Following the coast in its northward trend they crowd into the bays and sounds, and breaking up into smaller schools the detachments find their way into the shallows. In outside waters they do not appear to be affected by tides, and when they are migrating they seem independent of its influence. Mr. Dudley states that they often rise to the surface when the tide changes near the middle of the day. This is doubtless in waters near the shore, where the change of tide would be accompanied by some slight change of temperature. Mr. Simpson feels certain that more enter the inlets of North Carolina on the ebb than on the flood. It seems to be true, however, that throughout their halt during the summer, many schools drift lazily with the tide into the bays and creeks, coming in with the flood-tide, going out with the ebb-tide. In Southern waters they appear to hug the shore as closely as they can, and at high water thus gain access to waters too shallow for them at any other time.

15.—ALLEGED CHANGES IN HAUNTS AND HABITS.

The alleged changes of habit caused by the fisheries.

99. Many of the remarks in the preceding chapter are applicable to the menhaden only when they are left to enjoy their favorite haunts undisturbed. On the coast of Maine their habits are said, temporarily at least, to be greatly modified through the influence of man. They no longer hug the shores, but are found many miles out at sea, where they are followed by the fishing-vessels. The introduction of steamers into the fisheries is an evidence of this change of habit, and indeed the almost unanimous testimony of the Maine fishermen, from whom letters

have been received, is that the use of nets and seines tends to scare the fish farther out to sea. The purse-nets are set generally at a distance of from five to twenty-five miles from land.

Off Penobscot Bay menhaden are frequently caught by Brooklin fishermen outside of Isle au Haut and Great Duck Island.

According to Mr. W. H. Sargent the fish are much less numerous in the creeks, coves, inlets, and rivers, though outside no decrease is perceptible.

Capt. William S. Sartell, keeper of Pemaquid Point Light, writes: "The menhaden come regularly every summer into the bays, but the seining draws them off out of sight of land so that the fishermen here can't get bait to put on their hooks. They get some fish in their nets on Sundays when the seines are laid by."

Mr. Babson writes: "Since they have been taken in large quantities for their oil, they have gradually avoided the bays, creeks, harbors, and rivers to which they once resorted in immense numbers, and are now principally taken from one to ten miles from the shore. (Some of the fishermen maintain that since the advent of the bluefish, some twenty years ago, the pogies have sought deeper water for their own safety, while others maintain that the bluefish drive the pogies into shoal water; both statements are doubtless at times true.)"

Mr. Kenniston states that the fish are now farther off shore than in former years, and in this he is confirmed by Mr. Phillips, who states that they are taken better off shore where the seines cannot touch bottom. On the other hand, Mr. Washburne and Mr. Brightman are of the opinion that the use of the seine does not influence the movements of the fish.

Mr. Church, who has had much experience in the fisheries of Rhode Island, is very positive in his opinion. He writes: "The nets and seines do not scare the fish from the shore, for Narragansett Bay has been the theater of their greatest capture for forty years or more, and they have been more plenty than ever before known for the last ten years. I have seen a school of fish set at ten times in succession in deep water, and they would dive under the seine each time, but when they came to the surface they would not be ten feet from the seine, and they would lie still until we got ready to set, and when the seine was around them they would dive again. Fish will drive menhaden but man never does, except by use of powder; the menhaden are sensitive to a jar, such as is caused by striking the deck of a vessel with an ax. Even so slight a jar as the dropping of an oar or the careless slat of a rung on the gunwale has sent a school of fish off at top speed." Mr. Dudley confirms this. Steamers must carry low-pressure engines and run as noiselessly as possible.

Fishermen on Long Island Sound and about its eastern entrance seem to be divided in opinion. Messrs. Sisson, Havens, B. Lillingston, Washington, Crandall, and Dodge incline to think that fishing with nets

drives the fish away, while Messrs. Whaley, Potter, Wilcox, Beebe, Ingham, Miles, F. Lillingston, and Hawkins Brothers share the opposite belief. It should be noted in this connection that in Long Island Sound and vicinity purse seines worked off shore have almost superseded the haul-seines used twenty or thirty years ago, which were worked from row-boats and drawn up on the beaches. Does not this point to a change in the habits of the fish? In this district, where the fisheries are mostly prosecuted in waters more or less land-locked, the fish are not so apt to be driven out to sea as in Maine, where the fishing is prosecuted on an open coast. The timid fish may easily be crowded out into deep water by the vessels, which, working from the shore, usually approach them from that direction. If the fisheries of Maine were to be suspended for a short time the fish would doubtless return in full force to their former haunts. It appears from the statement of Mr. Sartell, already quoted, that they appear inshore in considerable numbers if the large seines are laid up for a single day. Mr. Simpson thinks that a school which is frightened away by nets returns to the same place in the course of two or three hours. South of Long Island, menhaden fisheries have not been carried on to such an extent as to exert any modifying influence upon the habits of the fish.

The opinion of Mr. Atkins.

100. There is room for difference of opinion on this subject. Boardman and Atkins do not accept this view, and after the thorough study they have made, their views are entitled to much respect. They remark:

"In general, it is safe to say that the surface movements of the menhaden are characterized by nothing so much as by capriciousness. They appear suddenly in the most unexpected spots, and, after a stay whose length nobody can foretell, all at once they disappear. One day they may be found at the mouth of the Kennebec, the next at Pemaquid, and the third all along the shore. Occasionally they reappear daily in the same spot for weeks at a time. Such was the case in the latter part of the season of 1874, over the sandy bottom off the Phipsburg beaches. Then it will sometimes happen that a whole season will pass without their appearance in bays where they have previously swarmed. Again, in some seasons they crowd the harbors and coves; in others they seem to avoid them altogether. For some years past they have so generally absented themselves from these places as to excite a good deal of speculation as to the cause."*

And again:

"Of the desertion of the harbors and coves there seems to be abundant testimony. An observer in Boothbay says: 'Menhaden can be driven out of small bays so that they will not come in.' 'Certain it is that they do not come into the bays as they used to.' In Bluehill we are

*Op. cit., p. 11.

told the same story. In Jonesport it is said, 'Pogies used to run into all the coves and creeks. Of late years they do not appear to frequent the shores as formerly.' Testimony of this sort might be multiplied; but it is unnecessary. The fact is notorious. During the past season (1874) they returned to some of their old haunts in great numbers, but have by no means resumed their former habit in this respect. Of this singular change of habit there are various explanations offered. According to some persons it is caused by the practice of seining; others lay it to the oil and decaying matter from the oil-factories. Neither of these causes appears sufficient to produce such a result. The desertion of the coves is observed in localities far removed from those where the alleged causes have operated. Perhaps, after all, the thing to be accounted for is why the menhaden ever crowded into small bays as they used to. Were they there in search of food, were they simply obeying blind instinct, or were they driven in by hordes of hungry foes outside? The latter supposition seems quite as probable as the others. We know that small fishes sometimes rush ashore to escape pursuit; we know that this happens with herring when flying from the pollock, and with menhaden when flying from the bluefish and horse-mackerel. The presence, outside, of a large number of predaceous foes, of whatever species, would be ample to drive the menhaden in. This might happen year after year; while with the cessation of the cause the result would cease too, and the menhaden would no longer crowd into the coves as before. If this view be correct, then the recent absence of the menhaden from the shores indicates an improvement in its chances of life, by the removal of its destroyers. Lack of information forbids an attempt to point out the species that have been most active in producing these movements of the menhaden; and indeed the theory itself is not proposed as one that has much of positive evidence in its favor, but just to show the possibility of accounting for the absence of the fish from shore on the hypothesis of the operation of causes purely natural, and not inimical, but positively favorable."

The opinion of Mr. Maddocks.

101. Still another view is advanced by Mr. Maddocks: "The menhaden, it is believed, does not of its own preference visit the coves and inner harbors, for its food seems to be less abundant in such localities, but to be driven into them by predaceous enemies. Upon the withdrawal of these, either in part or in full, the menhaden may reoccupy their former haunts at a remove from the shore, and thus disappear from inner waters."

I hardly think that the facts support this opinion. The habits of the fish when undisturbed, as they may be studied on the thousand miles or more of coast south of Cape Cod, are a safer guide than their habits on the much-seined coast of Maine.

102. Boardman and Atkins record some very interesting facts regarding

the change in the northern limits of the range of the menhaden within the past thirty years.

At Jonesport, Me., menhaden used to be very plenty. They were commonly caught in gill-nets two and one-half fathoms deep, but it was practicable, almost any time, to get enough to go fishing with by spearing. They became scarce seven, eight, or ten years ago, and now very few are caught, although some come as far as this every year.*

At Lubec, thirty years ago or more, menhaden were so plenty during their short season (July and August) as to be a nuisance. They have not been plenty since 1840 or 1845, and now none are found east of Jonesport. They left suddenly, and since the date mentioned have been rarely seen. Mr. E. A. Davis, of Lubec, a man of long experience in the herring fishery, has not seen a single specimen for ten years. Mr. E. P. Gilles, also of large experience, in 1860, or thereabouts, got three hogsheads of them one afternoon tide, and since then has seen none.

At Pembroke, says Mr. Moses L. Wilder, "twenty years ago, and always before that, the menhaden used to come here every year in great numbers, filling every cove and creek; but for the past twenty years none whatever have been seen. Little use was ever made of them except for bait, and of that but little was needed here."†

There is also evidence to show that the waters of Nova Scotia and New Brunswick have of late years been entirely deserted by them.‡

E.—ABUNDANCE.

16.—ABUNDANCE IN THE PAST.

The testimony of early writers.

103. Of the abundance of menhaden in times gone by we can know very little, for they have never been considered an important species, and might easily escape the observation of writers. We infer that they were abundant the time of the Dutch colony on New York Island, two hundred years ago, from the name given to it by the New Netherlanders; in fact we have the statement, already quoted, of Dankers and Sluyter, who before 1679 saw in the bay of New York "schools of innumerable fish, and a sort like herring, called there *marsbanckers*." L'Hommedieu speaks of their abundance at the close of the last century.§

Professor Mitchill, writing in 1814, states: "They frequent the New York waters in prodigious numbers. From the high banks of Montock, I have seen acres of them purpling the waters of the Atlantic Ocean. The waters of Long Island Sound and its bay are often alive with schools of them."¶

* Statement of Z. D. Norton.

† Boardman & Atkins, *op. cit.*, p. 21.

‡ See below, paragraph 222.

§ Agricultural Transactions of New York, I, p. 65. See Appendix O.

¶ Transactions of the Literary and Philosophical Society of New York, 1815, I, p. 453.

In his deposition to Professor Baird, August 3, 1871, Capt. Nathanael Smith, an aged Newport fisherman, gave the following testimony: "Menhaden are decreasing too. In 1819 I saw a school of menhaden out at sea, when I was going to Portland, that was two miles wide and forty miles long. I sailed through them. We were out of sight of land. They appeared to be all heading southwest. There were no fish near them. I have seen a school on this coast three miles long. I think they spawn in April and May."*

Dr. DeKay, in his "Natural History of New York," says of this fish that, "although it is seldom eaten, as it is dry, without flavor, and full of bones, yet it is one of the most valuable fish found in our waters. They appear on the shores of Long Island about the beginning of June, in immense schools; and as they frequently swim with a part of the head above or near the surface of the water, they are readily seen and captured. They are commonly sold on the spot at the rate of $2 the wagon-load, containing about 1,000 fish. The largest haul I remember to have heard of was through the surf at Bridgehampton, at the east end of the island. Eighty-four wagon-loads, or, in other words, 84,000, of these fish were taken at a single haul."

Mr. George H. Cook, writing in 1857, thus speaks of the abundance of menhaden on the coast of New Jersey:

"The moss-bonker (the *Alosa menhaden*, or *Clupea menhaden*), or, as it is sometimes called, bony-fish, menhaden, and other names, is an abundant fish in all the waters of this part of the State. It is frequently seen in immense shoals, fairly blackening the water for many miles. It is easily caught, and in large quantities at once. Mr. John Stikes, sen., of Beesley's Point, with his brother, some years since, caught, in a ninety-fathom net, thirty two-horse wagon-loads, at four hauls, taking fourteen of the loads at a single haul. Last summer, in a trip through the sounds from Beesley's Point to Cape Island, we passed through water filled with these fishes. Many of them swam so near the surface that their back fins projected above it; and the appearance of the water was entirely changed by the slight ripple they made in moving. They were most abundant then in the vicinity of Hereford inlet; but they are found near all the shores; and the only limit to the amount which can be taken is in the ability to take care of them when caught. Sixty wagon-loads, of at least 2,500, fish each, were taken at one haul in Raritan Bay this season."

17.—Abundance in the present.

On the coast of Maine.

104. Mr. W. H. Sargent considers the pogy the most numerous fish on the coast of Maine. Their capture affects their abundance in the coves and rivers and along the shore, though not outside. In 1873, Friend & Co.,

* Report of the Commissioner of Fish and Fisheries, 1871-'72, p. 21.

of Brooklin, took 25,000 barrels; Allen & Co., 15,000; others in the vicinity, 85,000. In 1874, about 15,000 were taken, the larger portion by Friend & Co. Between 1863 and 1868, some years 500,000 barrels have been taken. In 1877, Mr. Sargent estimates the total catch in his district at 100,000 pounds, or less than 400 barrels. Mr. J. C. Condon states that the fish are quite abundant about Belfast, Me.; 2,000 barrels were taken in the Belfast customs district in 1873; 3,000 in 1874. Seining does not appear to diminish their number. According to Mr. R. A. Friend, the pogies are much more numerous about Brooklin, Me., than any other fish; their numbers are not apparently diminished. About 14,000 barrels were taken in that vicinity in 1873, and 23,000 in 1874.

Mr. John Grant writes that, though pogies are more numerous about Matinicus Rock than any other fish except the herring, their numbers are decidedly diminished, probably on account of their wholesale capture.

Mrs. B. Humphrey states that at Manhegin Island these fish are more numerous than any other, but that seining has greatly affected their abundance.

Captain Coombs, of Esterbrook, who fishes for the Brightmans at Round Pond, Bristol, Me., recently caught with his seine, at one haul, 1,300 barrels of menhaden, and saved 1,179 barrels, made and valued as follows: Thirty tons scrap, at $10 per ton, $300; 3,650 gallons of oil, at 60 cents per gallon, $2,190; total, $2,490.*

At Sargentsville, Me., according to Mr. W. G. Sargent, 1,500 barrels of pogies were captured, in 1877, by Herrick & Bayard's boats. These were taken to the factories in the adjoining township of Brooklin.

Capt. Frank A. Chadwick, of New Harbor, Me., states that seven purse-seines are used in that vicinity, which catch an average of 15,000 barrels of menhaden annually, and a total amount of 125,000 barrels.

Mr. William P. Sprague, of North Isleborough, Me., writes that pogies are extremely abundant in that vicinity. A fleet of menhaden steamers, some twenty in number, has fished much here.

Mr. Lewis McDonald, of North Haven, Me., estimates the catch of menhaden for 1877 at 400 barrels.

The number of fish taken about Booth Bay and Bristol is given in the report of the Maine Oil and Guano Association, cited elsewhere. Mr. Sartell thinks that the fish are driven away by the seines. Mr. Kenniston and Mr. Brightman think that there is no perceptible diminution, as they continue by far the most numerous species. Mr. Washington Oliver thinks that they have been diminished by the fisheries about Booth Bay.

Mr. Kenniston states that in the town of Booth Bay, in 1873, 152,000 barrels were taken by five factories, as follows: Kenniston, Cobb & Co., 17,000; Gallup & Holmes, 17,000; Gallup & Manchester, 25,000; Suffolk Oil Works, 48,000; Atlantic Oil Works, 45,000. In 1872 the aggregate reached 110,000 barrels; in 1871, with six factories, about 95,000; in

* Boston Semi-Weekly Advertiser, August 27, 1872.

1870, less than 75,000; while in 1866, the first year of the work, only about 35,000 barrels were taken. Judson Tarr & Co. think that they are more plenty than ever before, but not so numerous inshore.

Mr. Edward E. Race, of East Booth Bay, Me., reports, November 5, 1877, the total catch for the season in that vicinity at 156,000 barrels, or 51,948,000 fish.

Mr. W. A. Abbe, manager of the Pemaquid Oil Company, states that the season of 1877 was a poor one, both in the number and quality of the fish taken. The company's fleet of five steamers took during the season over 61,000 barrels (20,000,000 of fish), yielding about 127,000 gallons of oil and 1,800 tons of guano. The fishing began off Gloucester, thence extended to the coast of Maine, and ended off Provincetown. Some of the steamers fished for other parties after the close of the Provincetown season off Newport and Sandy Hook, but the catch was insignificant.

The three steamers owned by Edward T. Deblois took, in 1877, on the coast of Maine, 26,649 barrels (9,000,000 of fish).

Mr. George Devoll, of Fall River, Mass., fishing in 1877 for the Narragansett and Atlantic Oil Works in Maine, caught from his steamer, the Chance Shot, about 12,000 barrels of menhaden.

In 1877, Gallup & Holmes took 52,000 barrels of fish on the coast of Maine and at Provincetown, besides 8,000 barrels caught and sold further west. These fish yielded 120,000 gallons of oil and 1,500 tons of guano.

On the coast of New Hampshire.

105. Mr. Chandler Martin, of Whale's-Back Light, near Portsmouth, N. H., in his communication of February 23, 1874, reported that the fish were diminished January 9, 1875; he writes that they were more abundant in 1874 than for ten years previous, and that they are probably not affected by the fisheries.

Mr. Winslow P. Eayrs, of Nashua, N. H., calls attention to the rapid diminution of the pogies in that vicinity, attributing it to the extensive operations of the oil-factories and to the pollution of the waters by the refuse dye-stuffs and chemicals from the factories.*

On the coast of Massachusetts.

106. Mr. W. W. Marshall estimates the catch of gill-nets at Rockport, 1877, at 1,000 barrels. The fisheries at Newburyport are described below.

According to Mr. Babson the pogies are more numerous about Cape Ann than any other fish except herring and mackerel. He thinks they have decreased somewhat during the past ten years and keep more off the shore. Statistics of capture are given elsewhere.

* Report of the Commissioner of Fish and Fisheries for 1871–'72, p. 136.

About Marblehead, Mass., says Mr. Dodge, they are greatly diminished and are less numerous than most other species.

Mr. Horatio Babson states that the value of the catch of menhaden off Gloucester in 1876 was nearly $800,000. Mr. George W. Plumer estimates $750,000 for the New England coast. George Norwood estimates its value at from $300,000 to $500,000.

Capt. Charles C. Pettingell estimates the number taken in Salem Harbor at 2,000 barrels. This is probably below the actual figure.

Mr. Horace M. Merchant, of Lanesville, Mass., estimates the catch in that vicinity at 750 barrels. They are taken mostly by gill-nets, 300 of which are in use, and are sold for bait.

Mr. J. G. Pond, of Provincetown, estimates 1,000 barrels for that port.

At Plymouth, Mass., according to Mr. Thomas Loring, the menhaden are very few and are diminishing.

About Wellfleet, Mass., states Mr. Dill, the number is greatly diminished on account of the bluefish; they are not so numerous as the mackerel; the capture for the past eight years (in 1873) has been about $500 worth a year. In 1874 about 6,000 barrels were taken in the bay. Fishing does not appear to diminish their numbers.

Capt. Hanson Graham and Capt. Zephaniah P. Lanman estimate the catch of Wellfleet for 1877 at 20 barrels. This is far too small.

Capt. Henry E. Hatch, of North Eastham, Mass., states that many menhaden are taken in the pounds of that neighborhood.

Capt. Solomon Dinnel, of East Orleans, thinks that 100 barrels are taken in the gill-nets belonging in that town.

At Provincetown and Truro, Mass., according to Mr. David F. Loring, the fish are greatly diminished; they are more numerous than any other fish in late April and May. Only 1,000 to 2,000 barrels were taken in 1873.

At Chatham they are more numerous than any other fish, though they do not enter the bay so plentifully as in former years. From 3,000 to 5,000 barrels have been taken annually for the past six years. Captain Hardy does not think that their abundance is affected by the fisheries.

Mr. Kenney states that at Nantucket pogies are the most numerous fish. They vary in abundance from year to year but for the past ten years, as a whole, their numbers remain about the same. Fishing does not affect them. On the other hand Capt. S. H. Winslow, line fisherman, testifies: "The menhaden are very scarce now (July 19, 1871), and I think we shall lose them too very soon, because they are using them up for oil.* In this month and from the 20th of June the ocean used to appear to be literally covered with menhaden. Now there are not a quarter as many as there used to be. People think they are plenty because by using a purse-net one or two hundred fathoms long they can purse several hundred barrels at a haul."

* Report of United States Commissioner of Fish and Fisheries, 1871–'72, p. 46.

N. B. Tower, of Cohasset, states that menhaden are taken in the weirs located in that town. Mr. A. J. Hathaway estimates the annual catch at 10 barrels.

John W. Cook, of South Dartmouth, estimates the catch for 1877 at 30,000 barrels or 9,990,000 fish.

Warren A. Gifford, of Dartmouth, puts the catch of that town at 465 barrels.

Capt. Darius F. Weekes, of South Harwich, reports "thousands of barrels."

Capt. Remark Chase, of West Harwich, who sets a small weir for shad, herring, and pogies, reports about 2,000 barrels of the latter.

At South Westport, according to Capt. John W. Gifford, there are five seines 120 fathoms long and 20 feet deep used in the capture of menhaden. Their average annual catch is about 300 barrels. Mr. Gifford thinks that 1,500 barrels are taken annually in Westport.

Capt. Eldad Gill, of North Eastham, estimates the catch for that place at three or four barrels.

Mr. Alonzo F. Lathrop, of Hyannis, Mass., thinks that the number of pogies is increasing, though it was not so great in 1873 as in 1874 or the preceding years. They are quite as numerous as other fish, and are not perceptibly affected by fishing. Alexander Crowell testified June 29, 1871, that menhaden were more scarce.*

At Edgartown, Mass., and about Martha's Vineyard, they are more numerous than any other species.' Five thousand barrels were taken in 1873 by the pounds; 10,000 in 1872. Fishing is not thought to affect their abundance. According to Mr. Marchant and Mr. Luce, they are not more or less abundant than they were ten years ago.

In the weir at Menemsha Bight, owned by Jason Luce & Co., the number of barrels of menhaden taken in 1869 (April 4 to June 7) was 1,590; in 1870 (April 14 to June 8), 1,375; in 1871 (April 14 to June 9), 3,200; in 1872, 3,800.

At a conference on the subject of fisheries at Edgartown, Martha's Vineyard, September 27, 1871, Captain Rease, acting as spokesman for a number of other fishermen, gave the following testimony:

"The law ought to be uniform. One reason why the pounds were not stopped by the legislature of Massachusetts was, that the Provincetown people made a statement that they could not fit out their vessels with bait unless they had pounds to catch it for them.

"Question. Could they?

"Answer. How did they do it before? They had the same facilities then as now. They used to send to Nova Scotia for bait; now they use only menhaden and herring for bait. Menhaden are getting scarce. The harbor used to be full when I was a boy; but it is a rare thing to find any here now, because they are caught up. They don't catch them at Saughkonet Rocks as they used to. If they keep on catching them up

* Report of United States Commissioner of Fish and Fisheries, 1871–'72, p. 49.

as they have done, we shall have to send to California to get a mess of fish." *

At Waquoit weir, near Wood's Hole, Mass., the number of menhaden taken in 1865 was 211,100; in 1866, 318,510; in 1867, 203,740; in 1868, 124,726; in 1869, 145,710; in 1870, 407,930; in 1871, 235,270.†

On the north side of Cape Cod, in Massachusetts, there are 19 weirs; 10 of these were estimated to have yielded in 1876 16,236 menhaden, giving an average of 1,624 to a weir, making an aggregate for the whole of about 32,480. On the south side of Cape Cod, in 1876, were 22 weirs; 10 of these yielded 1,827,729, and the total yield is estimated at 4,000,000. The number of weirs in Martha's Vineyard Sound is 9; 6 of these yielded 1,395,270, and the total yield is estimated at 2,093,000. The number of weirs in Buzzard's Bay is 30; the yield of 11 in 1876 was 54,878,000, and the total yield is estimated at 162,000,000. The total amount taken in the weirs of Massachusetts is estimated at about 170,000,000.

The returns of the catch of these same weirs in 1877, as given in the Report of the Commissioners of Inland Fisheries, is as follows:

Weirs	1,770,136
Gill-nets	81,256
Seines	600,198

While the estimate given above is perhaps too large, the returns cited are probably much too small.

On the coast of Rhode Island.

107. Mr. Edwin A. Perrin, postmaster, Pawtucket, R. I., puts the catch of the five drag-seines there owned, at 2,500 barrels.

Mr. Daniel T. Church writes: "There are no fish in Narragansett Bay so plenty as menhaden if we take several years as the standard, but if we should take years as they come and name each year separately it would be different. For instance, during 1871, 1872, and 1873, scup appeared in Narragansett Bay in immense quantities. There is no doubt in my mind that there has been, during the years named, more of them than menhaden. But, for a number of years preceding, scup were scarce. A few years since squeteague were more plenty than menhaden, for the bay seemed to be full of them from near Providence to Point Judith, and from Seconnet to Somerset. Menhaden, as an average, have been plenty in Narragansett Bay for the last ten years; but not far from ten years back they were scarce, and some of the fishermen left the business on that account. It is my opinion that the blue-fish were so plenty as to destroy the menhaden in large numbers. It was seriously feared that they were to disappear; but since blue-fish, sharks, and horse-mackerel,

* Testimony in regard to the present condition of the fisheries, taken in 1871. <Report of U. S. Commissioner of Fish and Fisheries, 1871, pp. 39, 40.

† Report of Massachusetts Commissioners of Inland Fisheries for 1871, and Report of United States Commissioner of Fish and Fisheries, 1871-'72, p. 176.

have become, for some unknown reason, scarce, menhaden have grown plenty, and 1871, 1872, and 1873 have been great years in the business. Taking for a basis of estimate that there are eight menhaden factories in Narragansett Bay that use about 20,000 barrels each, it would make the number of barrels caught during the year 1873 about 160,000. We do not think fishermen have any perceptible effect on menhaden, for it is a fact well known that a few years back they were so scarce that boats and seines were in the market at less than half their value. The year 1873 has been the year of surprise and wonder of all years, for the sea has been one blanket of menhaden from the Chesapeake to the Bay of Fundy."

Lieutenant-Governor Stevens, of Rhode Island, who owns a pound in Narragansett Bay, found menhaden more plentiful in 1871 than for many years before.*

Mr. Joshua T. Dodge, of New Shoreham, R. I. (Block Island), writes that menhaden are very plenty, though they are scarce in particular seasons; 1873 was a very good year for them. The fish do not seem to be less numerous, but they are wilder than formerly.

Captain Crandall is of the opinion that about Watch Hill, though still more numerous than other fish, they are considerably diminished in number by the use of seines. The catch of 25 drag-seines, owned in that vicinity, was estimated for 1877 at 100 barrels.

On the coast of Connecticut.

108. Captains Wilcox and Potter, of Mystic Bridge, Conn., think that there is no perceptible decrease in the numbers of bony fish on account of the fisheries, and that they are on the increase. They estimate the amount taken in the neighborhood (from Stonington to Poquannock) in 1873 at 6,500; in 1874 at 109,000 barrels.

Captain Washington, of Mystic River, Conn., is unable to see any decrease of late years.

Capt. S. G. Beebe, of Niantic, thinks that the fish are on the increase, and are more abundant than any other species. He estimates the number taken by Luce Brothers in 1873, three seines, 9,000,000; in 1872, four seines, 13,000,000; 1871, four seines, 17,000,000.

At Saybrook, according to Mr. R. E. Ingham, there is no decrease, and the fish are more abundant than any others.

It is the opinion of Mr. H. L. Dudley that there has been no actual decrease. The wears in the vicinity of New Haven have been as successful in 1877 as in any previous year. In 1871, when the Pine Island fishermen captured 10,000,000 they thought the climax had been reached, but in 1876 the quantity was increased to 18,000,000. The catch for seven years is approximately as follows:

1871	10,000,000
1872	13,000,000

* Report of Commissioner of Fish and Fisheries, 1871-'72, p. 19.

1873	11,000,000
1874	10,000,000
1875	12,000,000
1876	18,000,000
1877	14,000,000

In 1869, Miles Brothers, of Milford, Conn., are said to have taken 8,000,000 or 10,000,000 of fish; a season's catch which has not yet been exceeded, although their facilities for fishing have been greatly increased.

A correspondent of the American Agriculturist wrote to that paper in 1873,† that during the season of 1872 the factories between New London and Stonington caught 40,800,000 fish, which yielded about 142,000 gallons of oil and 4,080 tons of scrap.

The season of 1877 has been an eminently successful one for the fishermen of Long Island Sound. From Pine Island Mr. Dudley counted at one time 30 schools of fish. This year, however, the fishing has been most successful around and outside of Montauk Point.

Gurdon S. Allyn & Co., with three seines worked from sloops took in 1877, 13,000,000 of fish, yielding 42,000 gallons of oil.

Luce Brothers, of East Lyme, Conn., with one steamer and nine sloops, with 48 men, took in 1877, 3,800,000, fish producing 103,200 gallons of oil.

There are eighteen weirs in the harbor of Westbrook, Conn., which take, according to Capt. J. L. Stokes, about 8,000 shad and 500,000 menhaden each, giving an annual yield of 144,000 shad and 9,000,000 menhaden. This is probably rather an overestimate. The Westbrook weirs have leaders of 250 to 500 fathoms, and are managed by four men each. The menhaden taken in them are sold to farmers.

The following are the returns of George Stannard & Co.'s pound at the mouth of the Connecticut:

Year.	Shad.	Small shad.	Whitefish.	Alewives.
				Barrels.
1858	1,200	.....	446,090	15
1859	1,032	.....	990,600	11½
1860	1,294	.....	549,650	25½
1861	4,381	602	771,930	10½
1862	4,056	667	1,144,410	4*
1863	9,400	1,655	678,070	12
1864	8,305	1,248	569,040	11½
1865	7,069	1,320	642,107	10½
1866	8,891	892	855,575	12½
1867	9,469	1,214	1,113,158	27
1868	8,781	2,212	219,070	9½

Captain Stokes, with a shore-seine of about 400 fathoms, took during the season of 1877 about 1,000,000 menhaden, which were chiefly sold to farmers at $1.25 the thousand.

Mr. Miles, of Milford, Conn., states that there are no fish in the waters of the western part of Long Island Sound to be compared in numbers

* In 1875 the steamer was first used by the Quinnipiac Fertilizer Company.

† American Agriculturist, 1873, vol. xxxii, p. 139.

with the whitefish, and that so far from being diminished by capture they appear to be on the increase. The men in the employ of the George W. Miles Company, took 12,000,000 fish in 1873, 10,000,000 in 1872, 8,000,000 in 1871, and 8,000,000 in 1870.

Mr. F. Lillingston, of Stratford, states that the propotionate abundance of whitefish to any other species is about 1,000 to 1. About 5,000 barrels are taken each year. Fishing has no effect on their numbers, though previous to 1874 they were growing scarce close to the shore.

On the coast of New York.

109. In the eastern district of Long Island, according to Captain Sisson, the mossbunkers are, and seem likely to be, the most numerous species. He estimates that the number taken by purse-nets in 1873 was 50,000,000, by other nets 10,000,000. Captain Sisson.

Mr. Joseph D. Parsons, of Springs, Suffolk County, New York, estimates the total catch of 1877 at 150,000,000 of fish; 1,150,000 of these he credits to the 50 pounds and traps.

During the three months ending June 30, 1872, there were 20,000.000 of menhaden caught in Gardiner's and Peconic Bays. These fish were rendered into 14,400 gallons of oil and 1,500 tons of guano, and yielded $80,000. The business of the year it is stated will be a failure. In 1871 the receipts of the season amounted to $456,000.*

New York papers of August, 1872, stated that during the two weeks ending on the 17th of the month, the waters of Long Island Sound swarmed with menhaden. One fishing company took 1,300,000, realizing $1 per thousand; another took 3,000,000. One company had rendered 5,000,000 into oil and guano during the season, not running to its full capacity. The price of the fish, formerly 60 cents per hundred, had been reduced to $1 per thousand; yet the fishermen asserted that they could make money at the latter rate if they could sell their whole catch, but only one-third had been taken by the factories.

During 1871 24,520,000 menhaden were taken in the Eastern Long Island Bays. In less than one week, in 1872, six companies took 1,650,000. The "Cove Company" was said to have surrounded with its nets 1,000,000 at a time, but through a fault of the nets only 400,000 were taken. One of the pound nets became so full that the crew could not haul it, and the fish succeeded in breaking it loose from the stakes; it was afterward washed up on the bar. By actual count it contained over 800,000. In two weeks, in 1872, the seines took over 2,000,000.

The two steamers and three sloop-yachts of Hawkins Brothers, Jamesport, N. Y., took in the season of 1877 29,500,000 fish, yielding 82,350 gallons of oil and 3,275 tons of scrap, about one-half of which was dried fresh from the presses.

The two sloop-yachts of William Y. Fithian & Co., Napeague, N. Y.,

*Public Ledger, Philadelphia, July 17, 1872.

seined in 1877 10,500,000 fish, which yielded 24,000 gallons of oil and 1,300 tons of scrap.

The Sterling Company of Greenport, N. Y., took in 1877, with three seine-yachts and six lighters, 14,449,000 fish.

The steamers often make wonderful captures. The "Cambria," Capt. Lorenzo Tallman, is, I am informed, one of the most successful, fishing chiefly outside of Montauk. In 1876 this steamer was brought to the factory, loaded to the water's edge, thirty-six days in succession. In 1876 the "William Spicer" captured 729,300 fish in five days.

Review of the fisheries of New England since 1875, *by Mr. D. T. Church.*

110. Mr. D. T. Church, who is recognized to be one of the leading spirits in the menhaden fisheries, gives the following estimate of the success of the fisheries for three years past:

"1875 was a successful year; so was 1876. The year 1877 from New York to Cape Cod was the best since 1870. North of Cape Cod it was the worst since 1865. There was plenty of fish but no oil. J. Church & Co. caught, in 1876, 200,000 barrels and made over 620,000 gallons of oil. During the year 1877 they caught 183,000 barrels, and only made little over 300,000 gallons of oil. A fish called baracouta drove the menhaden from their usual feeding-grounds, and were absent until they (the baracouta) disappeared; they then put in an appearance, but too late for the factories to do much. The first taken during the summer of 1877 in Maine were from the waters of bays and rivers, and they were less than one-half as fat as they were the year before, when we took them 10 to 15 miles at sea.

"The fishermen usually steam square out to sea, and for the last ten years have found immense beds of them, and apparently inexhaustible amounts, 3 to 4 miles off shore, and generally after about the middle of July they get fat. This year the fat sea-fish could not be found at sea.

"About September 10, the baracoutas left and then they suddenly made their appearance off Portland and vicinity, and at one time the bay between Cape Elizabeth and Wood Island was packed full of the largest and fattest fish that was ever seen on this coast. Our fleet were in the midst of the schools part of two days. A storm came on, and after it was over, they were gone and were not seen afterward. It was about the 1st of October."

The baracouta referred to by Mr. Church is doubtless the tunny or horse-mackerel.

Review of the fisheries of Long Island Sound since 1870, *by Mr. G. W. Miles.*

111. Mr. George W. Miles, of Milford, Conn., for fifteen years engaged in the menhaden fisheries, writes:

"We cannot perceive any diminution in numbers or quantity, but we

do find a great difference at times (and some whole seasons) in size and quality.

"Our usual average catch here in Long Island Sound has been about 8,000,000 per season, beginning June 1, ending October 1. The past season, 1877, our catch was 15,000,000; nearly double the catch of previous years.

"In 1870 there was a large quantity of large fat-fish in the sound; these fish could be seen occasionally several feet under the surface by persons at the mast-head, but could not be seen by the fishermen from the deck of the vessel except occasionally. For some cause, we think they were at the bottom feeding; they did not appear on the surface sufficiently long for the fishermen to catch them until very late in the season.

"On the 10th day of August we had made only 14 barrels of oil. Some of our neighbors, having got discouraged, closed their factories, thinking there would be no catch for the season. At this time the fish suddenly made their appearance on the surface, and were caught in great abundance. They being unusually fat, yielding from 12 to 14 gallons of oil per 1,000, we made in the next six weeks 3,000 barrels prime oil.

"In 1871–'72 there was about the usual quantity of fish, yielding from 4 to 6 gallons of oil per 1,000; an average of several years previous to 1870.

"In 1873 there were immense numbers of small fish from one to two inches long appeared on the surface in the month of September; thousands of shoals could be seen at a time and great numbers in each shoal; these appeared to take possession of all the waters for the remainder of that season.

"In 1874 these small fish appeared again late in the season and were about double the size they were in 1873.

"In 1875 they appeared again much earlier; and in 1876 they came in about the 1st of June, having increased in size and numbers; apparently they occupied the whole waters of the sound, so much so, the larger fish that frequented these waters were actually crowded out of the sound, or left for other waters, and remained off Block Island, at sea, the remainder of the season, and gave up the field to be occupied by the smaller fish.

"The result of this abundance of small fish was a complete failure of the business for the two years 1875 and 1876 in Long Island Sound, the factories and fishing gears having run at great loss.

"In 1877 we provided ourselves with smaller mesh-nets and proceeded to catch the smaller fish, which had now attained a size about two thirds the average here and averaging about one-half pound each. We could catch these by using nets of 2⅜ inches mesh. They were hardly worth catching, but the men could not stand another season of light catch, and there was no alternative for them; they must catch these or noth-

ing. There was not much oil in them, averaging only from 1½ to 3 gallons per 1,000. Consequently, those manufacturers who carried on a large business barely paid their expenses."

On the coast of New Jersey.

112. At Atlantic City, New Jersey, according to Mr. A. G. Wolf, the mossbunker is the most numerous fish. About 215 barrels were taken in 1873 by Adams & Co., and about the same the previous year. The fishing does not tend to diminish their numbers

At Somers Point, Great Egg Harbor, the mossbunkers are "a thousand fold more numerous" than any other species. In 1873, 7,200 barrels were taken; in 1874, 12,000. Mr. Morris thinks that there is no decrease from fisheries or any other cause.

At Cape May, Mr. D. E. Foster writes they are more numerous than any other fish, but are not so plenty as on the eastern coast of New Jersey. As none are caught in this vicinity, the fisheries are not likely to affect their abundance, nor are they at any point south of Delaware Bay.

On the coast of Delaware.

113. About Bombay Hook, Delaware, according to Mr. J. B. Benson, the oldwife is the most numerous fish in July and August. At Mispillion River, writes Mr. James H. Bell, "they rank equal to, if they are not more abundant than, the sea-trout,* and far exceed any other fish in number: a thousand bushels of trout are sometimes taken at a haul, but the main fishing season does not last over a month, while menhaden are caught more or less during six months of the year. No diminution is noticeable, and the number seems to be about the same one year with another. These fish are not sought in this vicinity for any purpose whatever: they are caught in seines laid for other fish and are left on the beach to rot or taken home to feed hogs, or are composted for fertilizing the soil, for which they are only valuable. The quantity taken from the water never seems to affect the supply."

On the coasts of Maryland and Virginia.

114. In Tangier and Pocomoke Sounds, Maryland, the alewife is the most abundant fish. Mr. Lawson thinks that their number is decreasing from the influence of the fisheries.

At Apateague Island, Accomac County, Virginia, the alewives are more abundant than any other fishes, and are increasing, according to Mr. J. L. Anderton; and this is also the case at Cape Henry, in the opinion of Mr. Richardson.

Mr. H. L. Dudley informs me that a party of New London manufacturers, visiting the Chesapeake in 1866, found menhaden in almost incredible quantities. As he expressed it, "they were so thick that for

* *Cynoscion carolinensis.*

25 miles along the shore there was a solid flip-flap of the northward-swimming fish." One enthusiastic member of the party jumped into the water and with a dip-net threw bushels of fish upon the beach.

On the coast of North Carolina.

115. Mr. Manning writes that at Edenton, North Carolina, these fish are very few.

According to Messrs. Jennett and Simpson the fat-back is by far the most numerous species on the coast of North Carolina. Mr. Simpson writes: "Heretofore the fat-back has been only about one-third more abundant than any other species, but I have seen twice as many during the fishery season of 1873 as I ever saw of any other species on our coast. They are on the increase, and not even their wholesale destruction by the bluefish seems to affect their abundance. About fifty barrels were netted in 1873 at Cape Hatteras. In 1877, in Cape Dare County, about 300 barrels."

"At Beaufort," writes Mr. A. C. Davis, "the menhaden are more abundant than any other species and are increasing; and so it is at Body's Island, North Carolina, where 50,000 barrels were taken in 1868, the fishery having since been discontinued. About 500 barrels were taken in 1877. They are used only for fertilizing purposes."

Mr. Simpson describes their abundance at Cape Hatteras in 1874 in these words: "During the past season the fishermen provided themselves with seines and boats in time to meet the first run of the bluefish. The seines were made of cotton marlin and were about 100 yards long, 2½-inch mesh, and from 40 to 50 meshes deep. The bluefish made their first appearance on the coast from the north. The menhaden passed about three days in advance of the bluefish. I do not think I ever saw so many of this species at any one other time, or at any one other season. From the balcony of the light-house at least 25 schools might have been seen lying along the coast, both north and south of the cape. Each school seemed to cover many hundred yards of surface and to be moving south at the rate of from four to five miles an hour. This continued, and school after school followed, for ten days, before the appearance of the bluefish; and when the bluefish did appear there seemed to be more of the menhaden with them than had passed the station during the three previous days. Hundreds of barrels, I think, were washed ashore and were driven so close by the bluefish that they had not the power to resist the surf, which was quite rough or heavy, and they were consequently thrown ashore upon the beach. Only a very small quantity of these fish were saved, as the fishermen give their attention more particularly to bluefish, but some of them were saved and salted down, when they were sold to a good advantage. Some sold as high (in trade) as to bring ten bushels of corn, equal to $7 in currency, for one common fish-barrel of the menhaden.

"It has been generally thought by old experienced fishermen here,

that the bluefish drive the fatback south in winter, but I have learned differently during the past season from personal observation, which the following fact strongly attests. The menhaden came three days in advance of the bluefish, and entered the sound at all the principal inlets, and made their way directly for the fresh-water rivers. They could be seen as numerous in the sound heading north as they were in the sea heading south. Furthermore, by a letter from a gentleman of Plymouth, N. C., I learn that they passed that place, eight miles above the mouth of the Roanoke, in five days after passing this station; and, by another letter from Windsor, 38 to 40 miles above the entrance, I hear that they arrived there as early as the 18th of December. Thus it may be readily seen that the bluefish are not the cause of the fatback coming south. I would sooner think that the fatback caused the bluefish to come south in winter, as they generally follow in the sea, and among the last of the run of fatback.

"Last year there were not so many of the menhaden, but there were millions of young spot about two years old; but, however, this winter there was not a spot to be seen."

Dr. H. C. Yarrow found enormous schools of very small menhaden about Fort Macon, N. C., December 31, 1871.

Dr. Elliott Coues, U. S. A., states that they appear in great numbers about the harbor at Fort Macon, N. C., in spring and summer.*

On the coast of Florida.

116. In the Saint John's River, Florida, the menhaden are more abundant than any other fish, and apparently on the increase. They clog the shad-nets in the spring.

Summation of evidence.

117. The statements above quoted seem to indicate that the menhaden is by far the most abundant fish on the eastern coast of the United States. There is, moreover, no evidence whatever of any decrease in their numbers. They are apparently quite as abundant as any species on the eastern coast of the United States, not even excepting the cod, herring, and mackerel. There are, however, no data for definite comparison, nor is there any means of determining the ratio of increase or decrease within a given period of years. The same must be said regarding the effects of the wholesale capture going on every year on certain parts of the coast, for the present perfection of fishing apparatus and the skill of the fishermen is likely to prevent any apparent diminution in the yearly returns of the fisheries, even though the species be gradually approaching extinction. It is quite evident that with the improved methods now in use a much larger proportion of the fish frequenting any given body of water may be taken than was formerly possible.

* Notes on the natural history of Fort Macon, N. C. <Proc. Phil. Academy of Natural Sciences.

18.—Abundance in the future.

The probability of future decrease.

118. There is no evidence of a decrease in the abundance of menhaden during a period of fifteen or more years of fisheries conducted on an immense scale. It seems, therefore, that no one can reasonably predict a decrease in the future. The movements of marine fishes are capricious in the extreme. The only cases in which the fisheries have been clearly shown to exercise a pernicious effect is where the spawning fish are taken in great quantities. It has been clearly determined that the menhaden are never captured upon their spawning-beds.

F.—FOOD.

19.—Food of the menhaden.

The opinions of fishermen.

119. Fishermen generally say that the menhaden feed on "brit" and "seed," "red-seed," "cayenne," or "bony-fish feed." These are sailors' names for small floating animals of any kind, such as the minute crustacea, mostly entomostracans (*ostracoda* and *copepoda*), which swarm the surface of the North Atlantic and are the favorite food of mackerel, herring, and many smaller species. They describe this food as "something of a red or green color and about the size of hay-seed," and very naturally suppose the menhaden to be feeding upon it when they are swimming with their heads at the surface. Others think that they "live by suction," meaning that they feed by drawing through the mouth water containing particles of organic matter. The sturgeons, pipe-fish, and cyprinidæ, all with toothless mouths, are supposed to have this habit. Others say that they feed upon the jelly-fishes (*acalephæ*),* upon the "mossy substance" which clings to the eel-grass (*Zostera marina*), and upon the "scum" or "mucus" which floats on the surface. Perhaps all are right, for most fishes relish changes of diet. At Greenport, N. Y., according to Mr. W. S. Havens, the slimy coating of the eel-grass (which is composed of small algæ, *Spyridia filamentosa*, with various species of *Polysiphonia* and *Ceramium*, &c., often clogged with a soft, slimy deposit) is known as "bunker-feed."

Peculiar movements of the menhaden.

120. Captain Loring has seen the menhaden in Provincetown Harbor in groups of from 20 to 500 gathered among the eel-grass in shoal water, swimming around and around in circles. He supposed them to be spawning, but it seems quite probable that they were feeding. Mr. Hance Lawson states that in Chesapeake Bay the schools break up into small

* Acalephæ do not have the appearance of being nutritious food, but the fattest hogs I have seen in Florida are those at Mayport, which greedily devour a large species of discophore which is cast on the beach in great quantities.

bodies at night, coming in-shore to feed and dispersing into deep water in the morning. Mr. Simpson states that in spring and summer they subsist principally upon mud and scum from the surface of the water, which they obtain by feeding in muddy slues and channels on the ebb, and grassy rivers and shoals on flood-tide.

The examination of stomach-contents.

121. The examination of the stomachs of a hundred or more menhaden, just from the water, taken off Portland, Me., in Block Island Sound, at the mouth of the Potomac, and in the Saint John's River, Fla., has failed to reveal any traces whatever of animal food. Mackerel examined at the same time, in Maine, contained numerous specimens of "seed," which were mostly a large entomostracan (*Irenæus Pattersonii*), and small shrimp (*Thysanopoda*, sp.). Every menhaden stomach which I have opened has been found full of a dark greenish or brownish mud or silt such as is found near the mouths of rivers and on the bottom of still bays and estuaries. When this mud is allowed to stand for a time in clear water, the latter is slightly tinged with green, indicating the presence of chlorophyl, perhaps derived from the green algæ so common on muddy bottoms. A microscopic examination by Dr. Emil Bessels brought to light, in addition to the particles of fine mud, a few common forms of diatoms.*

Inferences from these examinations.

122. Perhaps no decided opinion should be formed without additional data, but the plain inference seems to be that the food of the menhaden, in part at least, is the sediment which gathers upon the bottom of still, protected bays, which is largely composed of organic matter, and upon the vegetation which grows in such water. Upon what they feed during their long sojourn at sea there are no sufficient grounds for conjecture, though it is quite possibly the soft gray ooze and mud which recent explorations of the depths of the Atlantic have shown to exist at every depth, and on the numerous protozoans and *Bathybius*-like substances there flourishing. The peculiar digestive organs of the menhaden were described in paragraph 53.

Professor Verrill on bottom-mud.

123. In remarks upon the characteristics of different deposits of mud, Professor Verrill writes as follows:

"In some cases, especially in well sheltered localities, where the water is tolerably pure, the mud may contain large quantities of living and

* "A large number of specimens [of menhaden] freshly caught in seines were examined, and all were found to have their stomachs filled with *large quantities of dark mud*. They undoubtedly swallow this mud for the sake of the microscopic animal and vegetable organisms that it contains. Their complicated and capacious digestive apparatus seems well adapted for this crude and bulky food." (Prof. A. E. Verrill, in American Naturalist, 1871.)

dead microscopic organisms, both animal and vegetable, and these may even constitute more than one-half of the bulk of the mud, which, in such cases, is peculiarly soft and flocculent; such mud is extremely favorable to many kinds of animals that feed on the microscopic organisms, especially the bivalve shells, holothurians, and many annelids, and the 'menhaden' among fishes. The last variety of bottom, when it has a substratum of sand or gravel a few inches below the surface, is the most favorable kind for oysters, which grow very rapidly and become very fat in such places." *

The evolutions of the schools.

124. Why do the menhaden, when in deep water, swim from morning to night with their mouths at the surface? Perhaps, with their widely expanded jaws and the complicated straining apparatus formed by their gill-rakers they are able to gather nutritious food which is floating on the water. To be convinced that this is possible, one needs only to observe the immense "slicks" of oily matter, often miles in extent, remnants of the bloody feasts which bluefish and bonito have made on other fish, generally the menhaden. An insight into the habit may be gained by watching the menhaden at the head of New Bedford Harbor, near the mouths of the large city sewers. Here a school of these fish is said to be invariably found circling around near the surface with open mouths, apparently in the act of feeding.

Whatever may be the character of their food, their rapid increase in size and oiliness indicates that there is an abundant supply in our waters.

Mr. J. Carson Brevoort states that he has seen menhaden plunging among the floating beds of jelly-fishes. He infers that they feed upon these creatures, though he has not seen the entire act.

The value of menhaden for bait affected by their food.

125. Fish taken in Salem Harbor are not considered good bait. Something in the food which is there obtained renders them very liable to decay, and however carefully they may be packed in ice the viscera soon rot away. A similar phenomenon is well known to the herring fishermen of the coast of Norway, where a certain kind of food, presumably larval forms of small mollusks, often eaten by the herring, causes the fish to decay, in spite of the utmost precaution in salting. It is the custom of these fishermen to keep these fish alive in the nets for several days, to allow them to "work off" this undesirable food. Perhaps a similar precaution might be useful to the Salem Harbor fishing gangs.

G.—REPRODUCTION.

20.—STUDIES OF THE PARENT FISH.

Dissections of Connecticut fish.

126. Of the breeding habits of the menhaden, like those of the bluefish, nothing definite is known. Hundreds of specimens have been ex-

* American Naturalist, 1871.

amined in the north by the naturalists of the Fish Commission, between the months of June and November, and in the south in March and April, without in a single instance discovering matured spawn, so it may be regarded as a demonstrated fact that the species does not breed upon the coast of New England and New York. A large number dissected by me at Noank, Conn., in July and August, 1874, had the ovaries and spermaries partially developed, but still far from maturity, and it seemed probable that three or four months would pass before spawning time.

Others examined at Pine Island, Groton, Conn., October 30, 1877, had the ova more mature, but at least six weeks or two months from perfection, as nearly as I could estimate. The fish then examined were taken in the last runs of the fall, and were supposed to be the Maine schools on their southward migration.

Dissections of Maine fish.

127. Boardman and others state that in the last week in September fish taken in Boothbay had spawn and milt so slightly developed that only persons accustomed to the examination of such subjects could distinguish the sexes.*

The number of eggs in immature ovaries.

128. Hon. S. L. Goodale took the ovaries from a large number of menhaden at Boothbay, September 14, 1876, three to five days before their autumnal departure from the coast. Twelve hundred fishes were examined, and only three were found to contain ovaries which approached

*The following letter by Mr. Atkins was received while this report was being printed:

"BUCKSPORT, MAINE, *June* 4, 1878.

"DEAR SIR: I have discovered something about menhaden which is new to me.

"A short time ago a fisherman sent me a menhaden caught in Verona, an adjoining town to Bucksport, which turned out to be a male adult, with well developed spermaries, weighing $\frac{1}{10}$ ounce, the whole fish weighing 11½ ounces; 10 inches long. To-day I have another specimen, also taken in Verona, which turns out to be a female, 11 inches long, with fully developed ovaries, which I have not yet weighed, but which contain eggs a little more than half a millimeter in diameter. I should think they would count out 200,000 or more.

"Another Verona fisherman, Mr. Dudley Abbott, says that last year he slivered a lot of menhaden, and should judge that one-third or one-half of them contained spawn; previous to last year he had seen menhaden with spawn occasionally, but not often he thought; continued to find some such till August last year.

"Mr. Harrison Heath, who sent me the female before me, told me yesterday that he had observed these 'pogies' with spawn for three years past, but did not recollect seeing them before; thought they were plentiest last year.

"You will recollect that I stated to you some months ago that the smelt fishermen reported that last fall they caught considerable numbers of young menhaden of various sizes—small at first and a good deal larger the first of winter—and that it was quite uncommon for so many of them to be taken.

"If these facts are sufficiently interesting, I will endeavor to follow the matter up.

"Very truly, yours,

"C. G. ATKINS."

maturity. These ovaries are deposited in the United States National Museum (Cat. No. 16946). I examined the ripest of them in order to estimate the number of ova. The ovaries with their membranes weighed 17,570 milligrams, or 271.140 grains (0.62 ounce). A portion weighing 420 milligrams was detached. This was found to contain approximately 250 ova, giving to each an average weight of one milligram and eight-tenths. The estimated total number of ova is 9,760, or in round numbers 10,000, which is close enough for all probable necessities. There is no indication of the size of fish from which the ovaries were taken. I am informed by Mr. Milner and Dr. Bean that in the shad and whitefish the number of eggs varies with the weight of the parent. In the latter species a mother fish of one pound weight will yield 20,000 eggs, and one of twice that weight double the number of eggs. This enumeration of the menhaden eggs merely serves to show that, comparatively, the species is not exceedingly prolific.

I am not aware that the number of ova in the ovary of the menhaden has ever before been accurately determined. Mr. Joseph D. Parsons, of Springs, Suffolk County, New York, writes that 70,000 have been counted. Mr. Walter Wells, of Portland, Me., states that he has somewhere heard of two millions having been counted. Several writers have lately expatiated on the immense fecundity of the menhaden. This has not yet been established.

No mature ova have been observed.

129. From Maine to Florida there can be found very little satisfactory evidence that spawn fully ripe has been seen, or that spawn or milt ever has been observed to run from the fish when handled after capture.

An instructive circumstance is mentioned by Mr. Bell, of Mispillion River, Delaware Bay, who states that after the last of these fish had disappeared from those waters, about the 7th of November, 1874, the bay from Cape May to Cape Henlopen and eighteen miles above its mouth was crowded with the largest menhaden ever seen on the coast, many of them equaling a medium-sized shad, and nearly three-fourths of them pregnant with large and nearly matured roe. They had been driven in by the bluefish which destroyed and pursued them ashore in vast numbers. Sixty hours after the arrival of the menhaden not one was to be found on the coast.

According to Captain Atwood, of Provincetown, some menhaden taken at that place in December had mature spawn.* He suggests that these fish, which were very few in number, may have been detained in the creeks by accident.

A statement by Mr. Atkins.

130. Boardman and Atkins, apparently quoting from Mr. George B. Kenniston, state that off the coast of Virginia, about Christmas, the

*Proceedings of the Boston Society of Natural History, vol. x, p. 67.

females can be readily distinguished by the distension of the abdomen; both sexes are so ripe that eggs and milt can be easily pressed from them. In Chesapeake Bay, in early spring, just after the advent of the adult fish, great schools of the young are seen, thought to be one and a half or two inches long. These little ones huddle together in dense schools, preyed upon by shovel-nosed sharks and other enemies. They are bound, so far as can be seen, in no particular direction, and are not supposed to come further north, but to pass the summer there and leave in the fall greatly increased in size. The color of these young fish, when seen in mass, is black, instead of red, which is the color of a school of adults when seen beneath the surface. These statements are not authenticated by the name of the observer, and must be received with caution.

21.—STUDIES OF THE YOUNG FISH.

The young fish in Southern New England.

131. Young fish from four to six inches long make their appearance in vast numbers a few weeks after the arrival of the adult fish. So extensive are the schools that experienced fishermen are sometimes deceived, mistaking them for schools of large fish, and make every preparation for setting their nets. These little fish play up into the shallow coves and the brackish water at the mouths of rivers and become an easy prey to small bluefish, eels, flatfish, and other small fishes.

Young menhaden seldom round Cape Cod, though they are not uncommon in Provincetown Harbor in September, where the fishermen catch them in dip-nets for bait. They have never been seen on the coast of Maine. Mr. Dodge states that they are occasionally seen in coves near Marblehead, Mass., and Mr. Babson has seen schools of half-grown fish at rare intervals about Cape Ann. In the museum of the Peabody Academy of Sciences, at Salem, is a bottle containing specimens about three inches long taken in Salem Harbor. South of Cape Cod, as far as Cape Hatteras, they swarm in the waters in late summer and autumn, and in the Saint John's River, Florida, the creeks and coves are alive with them in summer and early autumn. In the harbor of Beaufort, S. C., they are said to occur in December.

These schools of small fish, some of them little over an inch in length, suddenly make their appearance in the bays of the Vineyard and Fisher's Island Sounds about the middle of August. It may be regarded as certain that they are not hatched from the eggs in these localities, because for several seasons the ground has been thoroughly explored daily for two months before the appearance of these fish without finding a trace of fish of smaller size.

Locomotive powers of the young menhaden.

132. It has been suggested that young menhaden, less than two inches in length, cannot be thought to have traveled from the Virginia coast, a

distance of three hundred miles, nor even fifty miles, and from this it is argued that some of the species must spawn not far from the Vineyard Sound. It is not impossible that this conclusion may be true, still the premises are hardly sufficient. The young menhaden at the time of their first appearance on the southern coast of Massachusetts are strong and active, and apparently fully developed in bone and muscle. There is no apparent reason why they might not make long journeys.

22.—Inferences as to time and place of spawning.

The testimony of young and parent fish.

133. Certain inferences may perhaps be drawn from the facts mentioned above. The menhaden taken in summer and early autumn on the coast of New England show ovaries and spermaries in an undeveloped state, but evidently slowly approaching maturity, while others accidently delayed in Cape Cod Bay and Delaware Bay show in November spawn nearly ripe and in December ova quite mature. In October the southward migration begins, and by the 1st of December they have deserted the coasts of the Northern and Middle States. These schools winter, in part, on the coast of North Carolina, where they arrive in large numbers from the last of November to the middle of December, and are also found throughout the winter on the coast of Florida. The young fish, from one to three inches in length and upward, are common throughout the summer on the southern coasts, and those of a larger growth, from five to eight inches, occur in late summer and autumn on the coast of Southern New England south of Cape Cod. There is no satisfactory evidence that spawning takes place in the rivers of the Southern States. Will not these considerations warrant the hypothesis that the breeding-grounds of the menhaden are on shoals along the coast, from North Carolina, and perhaps Florida, northward as far perhaps as Virginia or New Jersey? This idea was first advanced by Captain Atwood and has received the sanction of Messrs. Goodale and Atkins.

The opinions of fishermen.

134. The majority of intelligent fishermen in the North seem to believe that the menhaden is a winter spawner, breeding in Southern waters, though some, arguing from the presence of small fish in autumn, advance the idea that they spawn in Long Island Sound and Narragansett Bay, while others still think it probable that there are two spawning seasons, one at the north in the summer and another in the winter at the south. I have been assured by several fishermen that when seining menhaden they have found a mass of their spawn, two or three feet in diameter, carried in the center of the school, and the idea was advanced that the fish transported and in this way cared for their eggs until they should be hatched.

I have had the opportunity of examining one of these supposed

masses of menhaden spawn, which proved to be a cluster of squid (*Loligo Pealii*) eggs, and it is probable that these singular objects have given rise to all similar stories.

A claim that menhaden spawn in Southern rivers.

135. The young menhaden which frequent the coasts north of the Carolinas are usually four or five inches in length, and there is no record of their having been seen of a less size than three inches, and these are probably the fish hatched from the eggs during the winter, which, in obedience to the migratory instinct, move northward along the coast. The movements of the schools of young resemble in every respect those of the grown fish, and they approach the shore from deep water by the same routes. At Cape Hatteras, according to Mr. Simpson, the young fish from one inch upward are seen throughout the summer, which points clearly to a proximity to the spawning-ground at that point. In the Saint John's River they are found two inches in length. It is the opinion of Mr. Kemps that many of the menhaden spawn in the river, and he is positive that he has seen spawn running from the fish taken in the early part of the year. The presence of the young fish in the waters, however, does not necessarily point to that conclusion, as he very naturally supposes it to do.

Mr. Simpson believes them to spawn in the Neuse River, but this is not proven to be a true supposition.

Criticism of a statement by Professor Hind.

136. In this connection I must call attention to a misapprehension on the part of my friend Professor Hind, who, basing his conclusions upon some uncollated returns in Professor Baird's first report, states that the spawning period of the menhaden is in the spring, at which time it appears to come from its winter home in the deeper waters off the coast to the shores, at dates corresponding to those of others whose movements are governed by temperatures.* And again he states, without citing any authority, that "following the law which govern fish life, its mode of spawning resembles that of the typical herring." This may or may not be true. No one knows.

23.—THE FEASIBILITY OF ARTIFICIAL CULTURE.

A claim that menhaden may be acclimated in Northern waters.

137. In a report to the minister of marine and fisheries, Mr. J. G. Whiteaves remarks: "It would perhaps be desirable to try and acclimatize menhaden in British waters. All that would be necessary would be to send a vessel or two, each provided with well-room, to the United States, and liberate the menhaden thence procured at the mouth of any of the New Brunswick or Nova Scotia rivers, such as Saint Andrew's

* The effect of the fishery clauses of the Treaty of Washington, &c., 1877, p. 73.

Bay, L'Etang, Lepreaux, or Musquash, in New Brunswick, or Saint Mary's Bay and its tributaries, or Tusket River, in Nova Scotia."*

In his report for 1873, Mr. Peter Mitchell, minister of marine and fisheries, announces that he intends to suggest the artificial production of bait for the deep-sea fisheries on some part of the coast of Nova Scotia, and to devote attention especially to the growth of the menhaden and other bait-fishes of that class.†

In the "Case of Her Majesty's Government," before the Halifax Commission (see below in paragraph 219), the claim is made that "the menhaden bait itself can be bred and restored to places in the Bay of Fundy on the coast of Nova Scotia, where it existed up to the time of its extermination."

With regard to these claims it can only be said that they are untrue and unsound. No one having the slightest acquaintance with the principles of fish culture would entertain the idea of the feasibility of such schemes.

II.—ENEMIES AND FATALITIES.

24.—Diseases.

Mortality in the Merrimac River.

138. Capt. Moses Pettingell tells me that great mortality often prevails among the menhaden at the mouth of the Merrimac River. In 1876 the dead fish were heaped upon the shore to a depth of two feet, and the municipal authorities of Newburyport expended a large sum of money in carting them away. The fish seem to die in great pain; they come first to the surface, then, after a severe flurry, die. They sink immediately to the bottom, but float at the surface after a day or two.

It is stated that the same mortality prevailed forty years ago as now among the mendaden in the Merrimac. They covered the shores, tainted the air, and were taken away by the farmers as dressing for land. It was noticed that the fish would come to the surface, spin around and around, and then turn over on the back and die.‡ These strange deaths are very probably caused by the presence of some internal parasite.

25.—Parasites of the menhaden.

The crustacean, Cymothoa prægustator.

139. Some of the parasites which infest the menhaden are particularly curious and interesting.

The name "bug-fish," commonly applied to the menhaden in the Southern States, has reference to a large parasitic crustacean frequently

* Sixth Annual Report of the Department of Marine and Fisheries, 1874, appendices of the fisheries branch, p. 196.

† Fifth Annual Report, &c., p. 66.

‡ Springfield Republican, August 21, 1871.

found in the mouth of this fish. This parasite appears to have been first described by Latrobe, who proposed for it the name *Oniscus prægustator.** Say subsequently referred it to the genus, *Cymothoa.*† It is known to the fishermen as the "bug," "fish-louse," or "crab-louse," and belongs to the order of Isopoda or equal-footed crustaceans, familiar examples of which are the whale-lice (*Cyamus ceti*, &c.) and the boring shrimps (*Limnoria lignorum*) which riddle so completely the planks of ships and other submerged timbers, or, better still, the "wood-lice," "saw-bugs," or "pill-bugs" to be found in any old cellar or wall and under stones and logs which have lain for a time on damp ground. Verrill and Smith‡ give twenty-three marine species for the coast of Southern New England. Most of these inhabit the rocky shores, clinging to the roots and branches of rock-weed or crawling among the rocks near high-water mark. Three are parasitic, one upon the bluefish, one upon the orange filefish; a third was found by Professor Leidy in the gill cavity of a hermit-crab (*Gelasimus pugilator*). *Cymothoa prægustator*§ resembles in its shape a large "pill-bug," the females reaching the length of two inches, the males somewhat smaller; they are provided with seven pairs of legs, with claws sharply pointed and adapted for clinging to their protector; their color is dirty white. The females carry their eggs in a large pouch on the under side of the body, formed by a series of large scaly plates, where they are retained until the young are hatched and large enough to care for themselves. The *Cymothoa* is not in any true sense of the word a parasite, drawing nourishment from the fish to which it attaches itself; it is commensal, stealing shelter and transportation, but not subsistence, and Latrobe was very happy in his selection of a specific name, for a Roman *prægustator* was a foretaster, a cup-bearer, one who tasted the meats and drinks before they were served on the table of a prince. Clinging with its hook-like claws to the roof of the menhaden's mouth, its back downward, its mouth in close proximity to the front of the fish's upper jaw, it is in a very favorable location to take toll from every mouthful of food which passes into the brevoortian throat. It may change its quarters at will, and when the fish is dead frequently relaxes its grasp and crawls out of the mouth. Latrobe writes: "I have sometimes succeeded in taking out the insect in a brisk and lively state, but as soon as he was set free he immediately scrambled back into the mouth of the fish and resumed his position." The presence of so bulky a guest must greatly inconvenience the menhaden. I have taken from the mouth of a fish nine inches long two of these crustaceans, a male three-fourths of an inch long, and a female measuring an inch and three-

* A drawing and description of the Clupea Tyrannus and Oniscus Prægustator. By Benjamin Henry Latrobe, F. A. P. S. Transactions of the American Philosophical Society held at Philadelphia, for promoting useful knowledge. Vol. V., 1802, p. 77, pl. 1.

† Journal of the Academy of Natural Sciences of Philadelphia, Vol. 1., part II, 1818, p. 395.

‡ Report of the Commissioner of Fish and Fisheries for 1871–'72, p. 567.

§ See plate X.

quarters, the vertical diameter of whose body, with distended egg-pouch, was a half-inch; this pair of lodgers completely filled the mouth of the fish, and must have *incommoded him in the act of feeding*. Aside from inconveniences of this nature, the presence of the parasite does not appear to affect the well-being of the fish, those whose mouths are tenanted seeming as plump and healthy as those having apartments to let.

About seventy per cent. of the menhaden from the Potomac examined by me in November, 1874, had the *Cymothoa* in their mouths, and even a larger proportion of those in the Saint John's, in April, 1875. Say states that a large number of those in the Delaware were thus infested, and Mr. F. C. Goode writes that this is the case in the Saint John's River, Florida. The thirty-first question of the "Menhaden Circular" issued by the Commissioner of Fisheries was intended to draw out information on this point, and, from the statements of correspondents, in reply to this query, we may quite definitely conclude that this parasite of the menhaden is unknown in northern waters. Mr. A. G. Wolf, keeper of Absecum light, New Jersey, writes that a "bug" is sometimes found in the roof of the mossbunker's mouth, and almost every correspondent from localities south of that point notices its occurrence. On the other hand, it has never been observed in the waters of New England and New York. I have examined many specimens from Long Island and Block Island Sounds without finding it, and Prof. S. I. Smith tells me that his search for it in the vicinity of Great Egg Harbor, New Jersey, was equally unsuccessful. In Chesapeake Bay and the Potomac, in the Delaware River and Bay, in the inlets of North Carolina, and the Saint John's River, Florida, it is well known as the companion of the alewife or fat-back.

Capt. Robert H. Hulbert, in the latter part of May or early in June, while seining mackerel from the Ellen M. Adams, of Gloucester, near Block Island, took, with the mackerel, about a barrel of large menhaden, most of which had the parasite in their mouths. At this time most of the menhaden had gone farther north. The later a school comes in, the faster it runs to the northward, says Captain Hulbert.

Inferences to be drawn from the presence of this parasite.

140. It is not known whether *Cymothoa prægustator* is a constant companion of the menhaden, accompanying it in its migrations and dependent upon it for existence, or whether it simply seeks shelter in the mouth of the fish at a particular season of the year. Is it not possible that it may be free during a part of its life, seeking shelter perhaps during the breeding season? Latrobe found it parasitic in March; my observations were made in November. It is very important that the chasm between these dates should be bridged, for whatever the truth may be, it will throw much light upon the migrations of the menhaden. If it be a constant parasite, the presumption will be that the schools of fish which frequent the shores of the Southern States, during the summer, do not in their

winter migration come in contact with the schools from the north, otherwise the parasites would naturally be communicated. If it inhabits the mouths of the fish only while they remain inshore, and has therefore a fixed faunal relation to certain parts of the coast, it may be concluded that the menhaden of particular schools are like, the anadromous fishes, restricted to particular portions of the coast, and that those schools which enter the southern inlets in spring do not proceed farther north in their migration, but remain in those localities throughout the season. Still other conclusions may be forced upon the investigator: it may be that the adult *Cymothoa* never quits its position in the mouth of the fish, and that the young only swim about in search of unoccupied quarters, and in this case it need not necessarily follow that the parasite would be communicated by southern to northern fish if they were to find their winter homes in the same waters. The study of this curious parasite and its habits will at any rate prove interesting and instructive.*

Other parasites.

141. The menhaden seems remarkably free from other parasites, and especially from intestinal worms, not one of which has been met with in numerous dissections. Leeches are occasionally found upon the gills, and there are one or more species of lernæans. Mr. Hance Lawson, of Crisfield, Md., refers to one of these, saying that "there is a five-pronged insect sometimes found on the tail which makes a sore and which we call grappling"—a name doubtless referring to its shape, which might call to mind a grappling-iron; several other correspondents refer to a parasite which is unmistakably a lernæan.

I know of only one described species of crustacean parasitic upon the species, and this is found also upon the alewife. It is the *Lernæonema radiata* (Lesueur) Stp. and Ltk., first described in 1828. It is found figured in the first report of the United States Commissioner of Fisheries, plate VII, Fig. 30, and below, plate X.

26.—PREDACEOUS FOES.

Whales and dolphins.

142. Man, with his instruments for wholesale destruction, takes six or seven hundred millions of these fish annually, but he is only one of its many enemies. Whales follow the schools and consume them in great numbers. Mr. E. B. Phillips states that fin-back and hump-back whales always appear in Massachusetts Bay when the menhaden come. According to Capt. John Grant, keeper of the light-house on Matinicus Rock, Maine, "The whale rises beneath them as they play upon the surface and, with extended jaws, forces himself up through the school with such speed as to project his body half out of water, closing his jaws over large quantities of fish as he falls heavily back."

* This paragraph was written two years before paragraphs 84–91.

Mitchill remarks: "The whalemen say he is the favorite food of the great bone-whale or *Balæna mysticetus*. This creature, opening his mouth amid a school of menhaden, receives into its cavity the amount of some hogsheads of menhaden at a gulp. These pass one by one head foremost down his narrow gullet; and eye-witnesses have assured me that on cutting up whales after death great quantities of menhaden had been discovered thus regularly disposed in the stomach and intestines."*

I have seen fin-back whales apparently feeding in this way at the eastern end of Long Island Sound. Schools of dolphins and porpoises follow the menhaden, consuming them in immense numbers, and seals are said to be among their persecutors.

Mr. Dudley informs me that in 1877 the fish left the sound on the 12th of October; on the 19th enormous quantities were driven back by a school of 30 or 40 whales which the fishermen saw playing off shore.

Sharks.

143. Sharks prey largely upon the menhaden. Capt. B. H. Sisson has seen 100 taken from the stomach of one shark. Mr. D. T. Church gives an account of the destruction of a school off Seaconnet, R. I. "They were lying," he writes, "apparently undisturbed, when a school of sharks appeared among them. The havoc was fearful. One gang of fishermen had their seine in the water at the time, and they completely destroyed it; they were so ugly that they would seize the end of an oar as if it were a fish."

Mr. E. E. Taylor, of Newport, R. I., gives an amusing account of the habits of the thresher shark (*Alopias vulpes*): "The heaviest shark we have around here is the thresher shark; they feed on menhaden. I saw a thresher shark kill with his tail, which was nearly eight feet long, half a bushel of menhaden at one blow, and then he picked them up off the water. They come up tail first, and give about two slams, and it is 'good-by, John,' to about half a bushel of menhaden."† This story should be taken *cum grano salis*, but still may contain a few grains of truth.

The horned dog-fish (*Squalus americanus*) and the smooth dog-fish (*Mustelus lævis*), the smallest representatives in our waters of the shark family, doubtless do more injury than their larger brethren by reason of their great abundance. The former are so voracious that when they make their appearance all other fishes are driven away. When the dog-fish "strike on," an experienced fisherman always pulls in his lines or his nets and abandons his work.

Other fishes.

144. All the large carnivorous fishes prey on the menhaden. The horse-mackerel or tunny (*Orcynus thynnus*) is one of the most destruc-

* Trans. N. Y. Lit. and Phil. Soc., 1, 1815, 453.

† Report of Commissioner of Fish and Fisheries, 1871-'72, p. 28.

tive in certain localities. "I have often," writes Mr. George R. Allen, of Brooklin, Me., "observed these pests, with the most imaginable indignation, in their destruction of these fish, and watched their antics from the masthead of my vessel, rushing and thrashing like demons among a school of fish, darting with almost lightning swiftness through them, scattering them in every direction, and throwing hundreds into the air with their tails." This is doubtless the barracoutar spoken of by Maine fishermen.

Boardman and Atkins accuse the pollock (*Pollachius carbonarius*) and the whiting or silver hake (*Merlucius bilinearis*) of much damage done. In reference to the latter they write: "It is known to pursue both herring and menhaden. The former it devours in great numbers, and at Grand Manan a great many of the smaller ones are sometimes caught in the herring-nets. In Bluehill Bay, in Kennebec River, and doubtless in other places, it is caught in the weirs, and the Brooklin fishermen often take it in their seines with menhaden. Its teeth are rather long and remarkably sharp, and they are charged with wounding a good many menhaden which are afterward caught with their sides and backs lacerated as if in that way."*

The striped bass (*Roccus lineatus*) is destructive, and so is the squeteague or weakfish (*Cynoscion regalis*) and its southern representative, the spotted squeteague or so-called "sea trout" (*Cynoscion carolinensis*.†) I have found a menhaden a foot in length in the stomach of a squeteague.

In the southern rivers the gar-fish (*Lepidosteus osseus*), the "trout" (*Micropterus nigricans*), and the cat-fishes (*Siluridæ*) with the tarpum, (*Megalops thrissoides*), are said to be its worst enemies. I have found menhaden to be the only thing in the stomachs of specimens of the latter species, taken on the northern coast in summer, and it is probable that these were attracted from their usual haunts in pursuit of their favorite food. The sword-fish (*Xiphias gladius*) destroys many, rushing through the masses of fish, striking right and left with its powerful weapons. From examination of their stomachs it would appear that the bayonet-fish (*Tetrapturus albidus*) also feeds extensively upon them. The codfish is said to eat many of them, and this seems quite probable, for these fish bite freely at a menhaden bait.

The bluefish and the bonito.

145. The bluefish (*Pomatomus saltatrix*) with the bonito (*Pelamys sarda*) are, however, their most destructive enemies, not even excepting man. Mr. Simpson, examining a great many of the bluefish caught on the North Carolina coast in the summer of 1874, found from one to three "fatbacks" in the stomach of each. These corsairs of the sea, not content with what they eat, which is of itself an enormous quantity, rush

* Op. cit., p. 14.

† A southern correspondent speaks of finding eight menhaden in the stomach of one sea trout.

ravenously through the closely crowded schools, cutting and tearing the living fish as they go, and leaving in their wake the mangled fragments. Traces of the carnage remain for weeks in the great "slicks" of oil so commonly seen on smooth water during the summer season.

Menhaden driven ashore.

146. The terrified fish fly in every direction, and are often driven ashore in great numbers. Mr. Church states that the bluefish sometimes come into Massachusetts and Narragansett Bays in such force as to completely exterminate the menhaden, driving them ashore in great numbers.

Mr. James H. Bell, keeper of Mispillion River Light, Delaware Bay, writes that about November 7, 1874, the shores of the bay from Lewes up to Mispillion River were lined with dead fish, bitten to death by the bluefish, or snapping mackerel as it is there called. Many of the dead fish were without tails, and all were more or less mutilated. Many other cases may be mentioned where the fish were thus floated ashore, but whether their death is to be traced to the persecutions of the bluefish or to some epidemic prevailing at the time can never be certainly known.

Mr. David F. Loring, keeper of Highland Light, Truro, Mass., has seen hundreds of barrels of them cumbering the shore in the western part of Provincetown Harbor, driven up by bluefish, and has also seen them thrown ashore in numbers at the mouth of the Merrimac River.

About 1856 they were thrown up on the coast of Maine in such quantities that the people in the vicinity were obliged to bury them as a sanitary measure.

Capt. Joseph Hardy second, light-house keeper at Chatham, Mass., states that in 1832 they drifted ashore on the southeastern point of Cape Cod in such numbers that the inhabitants were summoned to bury them in pits, for fear of a pestilence, and that the same thing occurred a few years later.

Mr. B. Lillingston, of Stratford, states that large numbers are sometimes washed up along the coast of Connecticut in September and October. Mr. F. Lillingston, of the same place, has seen thousands dead upon the shore, some with "a reddish blotched appearance, others eaten as if by cancer." According to Mr. Albert Morris, they floated ashore by tons at Somers Point, New Jersey, in October, 1873.

Mr. Isaac D. Robbins, keeper of Hog Island light station, Maryland, states that in August, 1852, he saw a great many dead ones, about two inches in length, in Swangut Creek, on the Eastern Shore, near the line between Maryland and Virginia. He attributes their death to the effects of the warm weather.

According to Mr. Wallace R. Jennett, they have sometimes drifted ashore on Cape Hatteras in such abundance that the stench of the decomposing mass was almost unendurable.

Capt. David Kemps, of Yellow Bluffs, Fla., writes that about the year 1870 the menhaden in the Saint John's River died in large numbers and were washed ashore upon the banks.

The Newport (R. I.) Daily News of June 13, 1870, states: "Millions of fish, principally menhaden, scup, and young shad, have been driven on to the New Jersey and Long Island shores the past week. Coves, rivers, flats, inlets, and ditches have been so full that farmers have gathered them up by the common pitchforks and shovels, carrying off thousands of cart-loads to manure the land. It is supposed that these schools of small fry were driven inshore by the bluefish."

Mr. Phillips has known them driven by the bluefish up the great rivers of Maine until they died and were washed ashore by thousands.

Captain Spindel on the ravages of the bluefish.

147. Capt. Isaiah Spindel, manager of a fish-pound at the eastern extremity of Buzzard's Bay, states: "I do not think pound-fishing is a quarter as bad as bluefish for destroying fish. A bluefish will destroy a thousand fish in a day. When they get into a school of menhaden you can see a stream of blood as far as you can see. They go into them and they will destroy the whole school before they let them go. I think menhaden are more scarce than they used to be. They put up the guano factory here (at Wood's Holl) on account of menhaden being so plenty then. Twenty-five or thirty years ago there were no bluefish, and menhaden were plenty. Only once in a while were there any bluefish there. Finally the bluefish got so plenty they drove all the menhaden out of the bay. There are plenty of menhaden up in the heads of the harbors; some bluefish will go up and drive them up as far as they can, but bluefish don't like to go up into fresh water. Squeteague will swallow menhaden whole. I have seen bluefish and squeteague throw the food out of their stomachs when caught. I think the bluefish fill their stomachs and then empty them just for the fun of the thing, so as to catch more fish. I have seen them go into a school of menhaden and catch some and throw them up again, and then go in again. I could not swear they throw the stuff up, but I am positive that it is so. I have seen the fish all chewed up thrown out in the water. They often bite and swallow a part and leave the rest."*

Professor Baird on the destructiveness of the bluefish.

148. Professor Baird, in his well-known and often-quoted estimates of the amount of food annually consumed by the bluefish,† states that probably ten thousand millions of fish, or twenty-five hundred millions of

* Testimony in regard to the present condition of the fisheries, taken in 1871. <Report of the United States Commissioner of Fish and Fisheries, 1871–'72, pp. 68–70.

†Natural History of Important Food-Fishes of the south shore of New England. II.—The Bluefish (*Pomatomus saltatrix*, (Linn.) Gill. Report of United States Commissioner of Fish and Fisheries, 1871–'2, p. 241–'2.

pounds, daily, or twelve hundred million millions of fish and three hundred thousand millions of pounds annually, are much below the real figures. This *estimate is for the period of four months* in the middle of the summer and fall, and for the coast of New England only. The calculation allows ten fish, or two and one-half pounds, daily, to each bluefish, and estimates the number of these corsairs of the sea in New England waters at one thousand million. This calculation includes only those fish which exceed three pounds in weight, taking no account of those of a smaller size, which are at least a hundred-fold more numerous, and fully as voracious, and which prey upon the young fish.

Such *estimates profess to be nothing more than vague approximations*, but are legitimate in their way, enabling us to appreciate more clearly the luxuriance of marine life. The application of similar methods of calculation to the menhaden would be much more difficult. At least one-fourth of the fish devoured by bluefish on the shores of New England are probably menhaden, and as many more are no doubt destroyed by squeteague, bonito, sharks, horse-mackerel, cod, and other predaceous species. The waters of New England wash only one-fourth of the extent of coast upon which the menhaden is abundant, and *the estimate* of Professor Baird covers only one-fourth of the entire year. Bluefish are abundant for at least half the year as far south as the Carolinas, and commit terrible havoc among the menhaden in the winter months. Farther south they are the favorite food of other species, chief among which are *the sea-trout (Cynoscion carolinensis)*. Then there are the schools of porpoises and the whales, which pursue the herded menhaden with wholesale destruction.

An estimate of the annual destruction of menhaden.

149. Is it too much, then, to multiply the three hundred *millions* of millions of menhaden probably consumed by the full-grown bluefish alone on the coast of New England in the summer months by ten? This would allow three thousand millions of millions of menhaden, old and young, annually destroyed in the waters of the United States, in comparison *with which the number annually taken by man* is perfectly insignificant. This estimate will seem extravagant at first sight, but I believe that it will be found a very moderate one by any who may take the pains to investigate the question for themselves.

The place of the menhaden in nature.

150. It is not hard to surmise the menhaden's place in nature; swarming our waters in countless myriads, swimming in closely-packed, unwieldy masses, helpless as flocks of sheep, close to the surface and at the mercy of any enemy, destitute of means of defense or offense, their mission is *unmistakably to be eaten*. In *the economy of nature* certain orders of terrestrial animals, feeding entirely upon vegetable sub-

stances, seem intended for one purpose—to elaborate simpler materials into the nitrogenous substances necessary for the food of other animals which are wholly or in part carnivorous in their diet. So the menhaden, deriving its own subsistence from otherwise unutilized organic matter, is pre-eminently a meat-producing machine. Man takes from the water annually six or seven hundred millions of these fish, weighing from two hundred and fifty to three hundred thousand tons, but his indebtedness to the menhaden does not end here. When he brings upon his table bluefish, bonitos, weakfish, swordfish, bass, codfish, what is he eating? Usually nothing but menhaden!

27.—MAN AND THE FISHERIES.

Former allusions to the influence of the fisheries.

151. I have remarked above (paragraph 117) that the menhaden appears to be the most abundant species on the eastern coast of the United States, and that there is no evidence of any permanent decrease in its numbers, although from year to year there are fluctuations in their numerical representation.

I have also discussed (paragraph 102) the question of the alleged change in their habits from the tendency of seine-fishing to drive them farther from this coast. Upon this question there can be no decided judgment at present. In paragraph 118, I have spoken of the slight probability of decrease in future.

Future increase or decrease.

152. Whether there is any likelihood that the myriads which now swarm our waters will ever be perceptibly diminished by the loss of six or seven hundred millions of their number annually I will not presume to say. I simply call attention to the fact that spawning fish are apparently never taken in the nets. It is the opinion of many authorities that if fish are not interfered with at the time when they are reproducing their kind there is no great probability of decreasing their number.

Alleged destruction of the fisheries.

153. The Commissioners of Fisheries of the State of New York, Messrs. Horatio Seymour, Edward M. Smith, and Robert B. Roosevelt, in their report for the year 1874* (p. 31), speaking of the depletion of the waters of Great South Bay, remark:

"Last season was favorable for the pound-fishermen, in the circumstance that the sharks did not destroy their nets. The result was, that there was absolutely no fishing inside the bay the entire summer. Usually, by the month of August, they have to move from the inlet to

* Report | of the | Commissioners of Fisheries | of the | State of New York. | —— | Transmitted to the legislature, February 1, 1875. | —— | Albany: | Weed, Parsons and Company, Printers. | 1875. | 8vo. pp. 61.

safer quarters, and the weakfish get in sufficiently to furnish fair fishing, and to promise a continuance of the supply. But that year the pounds remained undisturbed, and not even the weakfish could find an entrance. Formerly moss-bunkers, or bonyfish which are manufactured into oil and manure, frequented the bay and brought bluefish after them. They are the favorite food of the latter. They have been the foundation for quite a business in that part of our State, a number of factories having been established along the shore. Now they are never taken inside the bay, and the bluefish, whether for the reason that their food is wanted, or on account of their natural shyness, are also rarely seen inside. The latter are still caught in seines at some of the inlets, but seem to be stopped by the pound-nets, or else return of their own accord to the ocean. They do not enter the pound-nets, being seldom taken in them. This would go to show that they are frightened away; that when they meet the wings of the net they do not attempt to pass around it, but simply retrace their steps to safer quarters. The loss thus inflicted on the residents along the bay, without benefit to any one, is incalculable."

Comments upon these allegations.

154. It is the commonly received opinion that purse-net fishing is destined eventually to destroy all the menhaden in our waters. Many decided views to this effect have been advanced by correspondents. All that can be said at present is that the commonly received opinion has not yet been proved to be true. The same may be said regarding pound-net fishing. It is doubtless true that the fisheries in a given locality may deplete the waters of the immediate region in which they are prosecuted. The cod and halibut may be fished for upon a single bank until the local supply is exhausted. This depletion does not, however, necessarily affect the aggregate numbers upon the entire coast.

The barrier of pounds will doubtless prevent the menhaden from entering a body of water like the Great South Bay, but this does not necessarily have any effect upon the aggregate representation of the species in the coast waters. The small number of fish consumed by man proportionately to the number consumed by other fishes has been alluded to.

A writer in Chambers's Journal estimates the herring-eating power of the Solan goose as follows: "Say that the island of St. Kilda has a population of 200,000 of these birds, and they feed there for seven months; let us also suppose that each bird, or its young ones, eat only five herrings per diem; that gives a sum total of one million of these fish, and counting the days in the seven months from March to September as 214, that figure may be taken to represent in millions the quantity of herrings annually devoured by these birds. It has been calculated that the cod and ling in the seas and friths around Scotland would devour more herrings than could be caught by 50,000 fishermen. We have examined the internal economy of a codfish, which contained in its stomach no less than eleven full grown herrings."

Professor Hind's unwarranted statements.

155. A voice of warning comes to us from the provinces. Professor Hind writes: "It is not the fishermen alone who diminish the value of the waters of the United States as food producers, it is the agriculturist, the manufacturer, and the lumberer. If the supplies directly or indirectly afforded by British-American coastal fisheries were suddenly annihilated, the effect of the inquiries instituted under the direction of the United States Commissioner of Fish and Fisheries would be at once diverted against the fish-oil and fish-guano manufacturers as well as the lumbering and other interests, which have so diminished the anadromous species and destroyed the cod-fisheries on the New England coast. What with the ravages of the bluefish and the demands of the industrial interests named, the drain upon the United States waters is far beyond the natural resources of the limited area in which the cod, the hake, the halibut, and other deep-sea fish are sought. Hence recourse must be had to British-American waters or the open sea remote from the coast of the United States, and bait must be obtained to secure remunerative fares. Without this bait the fishery would be commercially impossible; with it, it becomes not only renumerative, but permits those special fisheries which have fish-oil and fish-guano as their object to go on without that legislative interference which would otherwise be invoked by a powerful interest contemplating impending ruin and discerning its cause."*

Comment is unnecessary. The facts above stated alone are a sufficient commentary.

Protective legislation in Maine.

156. As this memoir goes to press, the question of legislative restrictions of the menhaden fisheries is being agitated in Maine. One of the valuable results of this discussion has been the publication of Mr. Maddock's report upon "The Menhaden Fishery of Maine," which is intended to counteract the statements of the advocates of more stringent laws. The proposed law is intended to prohibit fishing with seines in waters within three miles of the shore. Mr. Maddock's remarks, quoted below, seem very sensible and temperate, and I am prepared to indorse them:

"In fact, where all the data point to the conclusion that the menhaden while on our coast are being destroyed by predaceous enemies in greater numbers every day than by man with all his appliances in a whole season, it would seem sheer unreason to establish a petty restriction of the catch lest the stock should be ultimately exhausted.

"No other State will be guilty of such folly, even if we should allow our own to be. The effect of restricting the fishery, as referred to, would be to drive the oil and guano manufacture and those engaged in it out of the State, with all their capital and equipment, and to extinguish the industrial activities set in operation by their business. The time for

*HIND, *op. cit.*, p. 142.

restriction will be when restriction has been shown to be needed. Other States have made a trial of the interference policy in this same matter and have abandoned it as uncalled for and unwise.

"The complaint that the seines 'scare' the edible fish from the interior waters may be dismissed as too trivial for notice. If the limited operations of seining inshore scare the fish out, much more should the far more extended operations outside scare them in. The same weight is to be attached to the charge that the seines injure the shad fishery by capturing the fish. The total number of shad caught by all the members of the Oil and Guano Association combined does not amount to over two hundred barrels per year. Salmon are never caught in their seines."

I.—THE MENHADEN FISHERIES.

28.—The fishing grounds.

The location of the fishing grounds.

157. As has been already indicated in the description of the migrations and movements of the menhaden, there are certain portions of the coast which they frequent more certainly and constantly. These are marked upon the map accompanying this memoir and may be designated as (1) the Booth Bay Region, (2) the Cape Ann Region, (3) the Cape Cod Region, (4) the Narragansett Bay Region, (5) the Long Island Sound Region, (7) the Sandy Hook Region, (8) the Chesapeake Region, and (9) the Hatteras Region.*

Bearing in mind the fact that the menhaden is fond of shallow, brackish waters while the mackerel is not, it is quite curious to remark that their favorite haunts are much the same. Both species are caught most successfully in the great, partially-protected indentations of the coast. Whether it is on account of the calm waters, the abundance of food, or the detention of the schools in these great "pockets," as they may be called, is not apparent. Perhaps all have their influence, probably the latter has the greatest.

In these localities, at different seasons of the year, the fisheries can be most successfully carried on, and here only can they be made profitable.

29.—Methods of capture.

Past and present methods contrasted.

158. Twenty years, ago when the menhaden fisheries were of very small importance, the business of manufacturing oil and guano being still in its infancy the only use for the fish was as a fertilizer in its raw state. This demand was easily supplied by the use of seines and gillnets along the shore, for at that time the habits of the fish were probably very different. They swarmed our bays and inlets, and there is quite good authority for the story that 1,300,000 were once taken with

* Plate XI.

one haul of the seine in New Haven Harbor.* Constant fishing on the northern coast has driven the menhaden out to sea, though in the south their habits are much the same as of old. In NewEngland the menhaden fishery has become to a considerable extent sea-fishing, and is prosecuted on the grandest scale.

Estimates of numbers of vessels and fishermen by collectors of customs.

159. Under the statistics of manufacture will be found the statements of the manufacturers in reference to the number of vessels and men employed by them. It may not be out of place here to give a corresponding estimate on the part of the collectors of customs and others in connection with a general statement of the location and methods of the fisheries. The manufacturers' enumeration excludes the vessels engaged in catching the menhaden for bait, but is, as far as it goes, probably more nearly correct than any other, the laws of registration being so lax that many fishing-vessels do not appear upon the custom-house books.

Fisheries of Maine.

160. Mr. William H. Sargent estimates for the district of Castine, Me., about 20 decked vessels and 150 open boats. The vessels range from 15 to 80 tons. The number of men employed (probably including the factory hands) is about 425.

For the district of Belfast, Mr. Marshall Davis estimated in 1873 about 25 vessels with 125 men. In 1877, according to the same authority, there were about 100 boats owned by line fishermen, each of which uses from three to six gill-nets.

Mr. Benjamin F. Brightman, collector of customs at Waldoborough, Me., gives 54 gangs of 10 to 12 men each. This district includes the region between the Penobscot and Kennebec Rivers, where all the large factories are located. The vessels in this region are steamers, schooners, and sloops of from 20 to 100 tons. This estimate is for 1873 and reference to the report of the Maine Menhaden Oil and Guano Association for the same year shows that these gangs include 55 vessels, 17 of which were steamers and 533 men. The number of men for 1874 is 551. More than half of these gangs are fitted out in Rhode Island.

For the town of Booth Bay, in this district, Mr. G. B. Kenniston estimates 21 gangs and 210 men.

Mr. J. Washburn, jr., collector of the Portland, Me., district, gives an aggregate of 110 vessels with 500 men, but this estimate evidently includes parts of other districts.

*Mr. Arthur T. Neale, of the Connecticut Agricultural Experiment Station, tells me that he has talked with one of the fishermen concerned in this famous haul. There was no accurate account of the numbers and the catch was variously estimated at from 1,000,000 to 1,300,000. Numerous carts were employed for three days in carrying the fish from the shore and finally a large part of the fish were allowed to escape.

Fisheries of Massachusetts.

161. Mr. F. T. Babson, of Gloucester, Mass., states that in his district are 40 vessels employing 400 men and a capital of $200,000. In this enumeration are included at least four steamers belonging to Judson Tarr & Co., of Rockport, which are used for their factory in Bristol, Me., and perhaps others. The remaining vessels are schooners of from 20 to 70 tons, which are wholly engaged in taking fish for bait. Fisheries of some importance are carried on at the mouth of the Merrimack River. They are described under the section relating to boats.

Mr. Simeon Dodge, of Marblehead, Mass., reports "no large vessels employed" in his district, though small boats fish for menhaden to be used for bait, and Mr. E. B. Phillips makes the same report for the vicinity of Swampscott.

Mr. Thomas Loring, Plymouth, Mass., says that in his district no vessels are wholly employed in this business; a few menhaden are caught for bait in gill-nets.

Capt. Hermann S. Dill, of Billingsgate Island, writes that for about three weeks, in the fall when menhaden are fat, 12 or 15 men and one or two small vessels are employed in catching them in Wellfleet Bay. A few are caught from dories.

About the extremity of Cape Cod very slight attention is paid to the menhaden. Capt. David F. Loring, keeper of Highland Light, North Lynn, Mass., writes under date February 23, 1875: "I believe the fishermen in this vicinity have an idea of going into the business quite extensively the coming season." He probably refers to the business of catching the fish for bait, which would naturally prove very profitable in the neighborhood of a great fishing center like Provincetown.

At Chatham, on the heel of Cape Cod, according to Capt. Josiah Hardy, 2d, in Chatham Bay, there are 13 weirs, but no vessels are employed in taking the menhaden.

From Nantucket, Mass., Mr. Reuben C. Kenney, collector of customs, reports that sail-boats of 5 tons burden are employed in setting the gill-nets, of the proceeds of which about half is used for bait, the other half sent to factories upon the mainland.

In the vicinity of Hyannis, Mr. Alonzo F. Lothrop, keeper of the light, states there are no menhaden fisheries.

Edgartown, Mass., and the Island of Martha's Vineyard employ no vessels in this fishery. Mr. C. B. Marchant, collector, writes that large numbers are taken in the pounds, and are sold for bait.

Fisheries of Rhode Island.

162. In Narragansett Bay, according to Mr. Church, about 10 gangs and 100 men are employed. Nearly 30 gangs fit out for the fisheries in Maine, and these usually seine Narragansett Bay for a short time, spring and fall.

No vessels are engaged in the menhaden fisheries at New Shoreham, R. I. (Block Island), nor in the vicinity of Point Judith.

Fisheries of Connecticut.

163. In the vicinity of Fisher's Island Sound, according to Capt. William H. Potter, of Mystic, Conn., there are employed 14 large boats and 36 small, and about 240 fishermen. There are 14 gangs working between the Thames River and Stonington, Conn.

Between the Thames and the Connecticut, Capt. S. G. Beebe states that there are 8 sloops of about 20 tons, each carrying about 10 men. Luce Bros., of East Lynne, have 1 steamer, 9 sloops, 48 fishermen, and 40 factory hands.

Mr. R. E. Ingham, of Saybrook, Conn., thinks that between Saybrook and New Haven there are employed about 14 vessels and 80 men, but this estimate is undoubtedly too great.

In Western Connecticut, according to Mr. G. W. Miles, there are employed 7 gangs, with 21 sloops and 230 men. Mr. F. Lillingston, of Stratford, puts the figures at 30 sloops and 300 men.

Fisheries of New York.

164. For the Eastern District of Long Island, Mr. W. S. Havens estimates 60 vessels and 540 men. Captain Sisson, for 1873, put it at 105 vessels and 400 men; in this estimate he probably includes the lighter boats.

Hawkins Brothers, of Jamesport, N. Y., employ 110 men, 50 of whom are factory workmen.

The Sterling Company, of Greenport, N. Y., employ 3 gangs, consisting each of 8 men, 2 boys, and a cook, working from 3 yachts and 6 lighters.

Mr. Joseph D. Parsons, writing from Springs, Suffolk County, New York, December 10, 1877, states that in that vicinity 43 vessels and 175 men are employed in the menhaden fishery.

At the entrance to New York Bay and off Sandy Hook the fish are taken for the sardine factories, small sail-boats of about 10 tons being used.

Fisheries of New Jersey, Delaware, and Maryland.

165. In the vicinity of Little and Great Egg Harbor, New Jersey, Mr. A. G. Wolf, keeper of Absecum light-house, states that there are 10 vessels and 40 men employed; this includes the gill-net boats of 4 and 5 tons, sloops, schooners, and one steamer of about 15 tons. This perhaps includes the Somers Point Oil Works, where, according to Mr. Albert Morris, there is a gang of 9 men with 3 vessels.

In Delaware Bay there are no menhaden fisheries, though many of these fish are taken in seining for other kinds.

In Chesapeake Bay no effort is made to take them in quantity except

in Tangier and Pocomoke Sounds, where, according to Mr. Hance Lawson, of Crisfield, Md., there are employed 5 vessels averaging about 15 tons each and 5 oared barges. Small numbers are taken in gill and trap nets at other points.

Fisheries of Virginia and North Carolina.

166. In the inlets of North Carolina no menhaden are taken in quantity.

The Quinnipiac Fertilizer Company, of New Haven, inaugurated menhaden fishing in North Carolina and Virginia in 1866. Their prospecting party passed the winter in Roanoke Sound and established weirs for the capture of menhaden, which were there very abundant. They were, however, driven away by the natives, whose jealousy of strange fishermen led them to tear up their weirs. They then located themselves near Cape Charles. Four companies established factories here—one from Maine, one from Long Island, and two from New London. They found the fishery very good, although the fish produced little oil, and were only adapted for the manufacture of fertilizers. The laws of Virginia do not encourage the inauguration of such enterprises by strangers, and the following year it was thought unadvisable to continue the business.

Since 1872 several stock companies have been organized, under Virginia laws, for the purpose of carrying on the menhaden fisheries in the Chesapeake, and their success is well assured. Although the oil is not produced in great quantities, there is sufficient to pay the cost of manufacture, thus leaving a clear profit in the scraps.

Fisheries in the South.

167. At Cape Hatteras and in the five adjacent townships there are, according to Mr. Simpson, 200 boats and about 500 men. None of these, however, make a special effort to capture the menhaden.

In the rivers near Beaufort, N. C., they are taken in small quantities in gill-nets worked from open boats and canoes.

South of Beaufort, N. C., the menhaden has no statistical importance. They are sometimes caught incidentally in the shad and mullet nets of the Saint John's River, Florida, but, as in the Potomac, they are considered by the fishermen to be useless annoyances.

30.—APPARATUS OF CAPTURE.

The purse-seine.

168. The purse-seine is doubtless more effective than any other fishing apparatus ever devised. By its use a school of almost any size may be secured without the loss of a single fish. The enormous demands of the oil factories can be met only by fisheries conducted on the grandest scale, and the purse-seine is used by the factory fleets to the exclusion

of all other nets. In the vicinity of Gloucester, where menhaden are caught for bait, the purse-seine is also used. It need only be said that it is an immense net, which when in use is a flexible wall of twine, suspended by its upper edge, extending from 90 to 180 feet below the surface, and from 800 to 1,500 feet long. This wall is made to encircle the fish and then its lower edge is gathered up by a rope passing through rings prepared for the purpose. The seine when pursed becomes essentially a huge dip-net, from which the fish may be taken at the pleasure of their captors.

The purse-seine is said to have been invented about the year 1837 by a native of Maine, who had been for some years employed as a hand on a Gloucester fishing-smack. He conceived the idea of capturing mackerel in large numbers, and invented a seine which is substantially the same as that now in use. Finding the Gloucester fishermen unwilling to experiment with his new apparatus, he carried it to Rhode Island, where it was first put into use in the vicinity of Seaconnet for seining menhaden.

The first seine used north of Cape Cod was introduced in the year 1850 by Capt. Nathaniel Adams, of Gloucester, in the schooner "Splendid." Capt. Nathaniel Watson, of the "Raphael," began using one the same year.*

The early seines were about 200 yards in length, 22 fathoms in depth, and of 2.5 inch mesh, there being about 350 meshes in the bunt of the seine. The twine used was much heavier than that used in the present seines, and the whole net weighed six or seven hundred pounds. The present seine, however, did not come into general use, as I am informed by Mr. Marchant, of Gloucester, until about 1860.

During the last eight years there has been greater change in their size than during the ten years previous. In 1869 the nets were 160 fathoms in length, 700 meshes deep, the meshes being 2¼ inches, and would weigh about 400 pounds, being made of No. 9 twine (Hadley 29).

Fishing in deeper water began in the years from 1869 to 1872; and since that time a gradual increase has taken place in the size of the nets corresponding to that which has already been described in the case of the seine-boats. The popular size for seines in 1877 is 200 fathoms in length, 1,000 meshes deep, the mesh being 2 and 2½ inches, those in the bunt being sometimes finer, the twine heavier. They are made of No. 6 twine (Hadley 16), and weigh about 700 pounds. The largest one known to Captain Marchant is 247 fathoms long, and weighs about 1,000 pounds.

In order to understand the method of working a purse-seine, it is necessary that the manner of "hanging it" should be described. At the top of the net is the cork-line, upon which corks are placed at distances apart of from 12 to 15 inches; two corks are usually put together (which are designated in trade as numbers 2 or 3), and are 4 inches in

* Mr. Maddocks states that the first purse-seine was used on Chelsea Beach.

diameter. There is no lead-line, properly speaking, though light weights are placed upon the bottom line of the seine, near the ends, about 2 ounces in weight, about 60 pounds in all, four inches apart at the sides, and farther apart near the middle. Sometimes twelve rings are strung close together so that they touch. The rings through which the pursing rope passes are almost heavy enough to render other weights unnecessary. The lower edge of the seine is hung on six-thread manilla rope; to this is attached a series of so-called bridles, these bridles being 3 fathoms in length and placed 3 fathoms apart. Upon each of these bridles slides an iron ring weighing $1\frac{1}{2}$ to $2\frac{1}{4}$ pounds and $3\frac{1}{4}$ inches in diameter; through these rings runs the purse-line. The average weight thus placed upon the bottom of the mackerel-seine is about 220 pounds; this, however, includes special leads put on at the ends of the seine, 55 to 80 pounds of lead being thus distributed in leads of one-eighth to one-quarter to one-sixth of a pound in weight. Upon the menhaden-seine about 35 pounds of lead is considered sufficient. In operating this seine a large heavy weight, called by the fishermen of Gloucester a purse-weight, by those of Southern New England "Long Tom," is used, which is placed upon the vertical ropes at the end of the seine by the use of snatch-blocks, and is allowed to run down to the bottom of these ropes, thus fastening securely together the ends of the so-called lead-line before the operation of pursing begins. The mackerel-seine is usually arranged so that when it is pursed there are large triangular flaps of netting hanging at the end and closing the opening. This is accomplished by allowing the purse-lines to pass obliquely from the last purse-rings, which are placed at the distance of about six feet from the ends of the lead-line. In mackerel-seining these are not, by all fishermen, considered necessary, as the mackerel do not, like the menhaden, strike for the bottom of the net when they find themselves inclosed. This weight weighs from 60 to 120 pounds, and varies somewhat in shape; the usual form is figured in plate XIV. Some seiners now use two smaller weights, one upon each line. The best fishermen prefer to use the weight, and by this method the largest fares of fish are taken.

The seines used by the menhaden vessels are smaller than mackerel seines, although the latter are frequently used in this fishery, especially near Gloucester.

From the letters of our correspondents it appears that the length of menhaden seines varies from 100 to 300 fathoms, and their depth from 10 to 25 fathoms. Some seines, 50 fathoms long and 5 fathoms deep, are mentioned, but these must have been exceptionally small.

In early days, it is said, a mesh of $4\frac{1}{4}$ inches was used. In 1873 Maine fishermen preferred a mesh of $3\frac{1}{4}$ inches. From 1875 to 1877 a still smaller mesh was employed. The seines now in use in Connecticut have a mesh of $2\frac{1}{2}$ inches (that is, $1\frac{1}{4}$ inches square, or $1\frac{1}{4}$ "bar"); they are 130 fathoms long when "hung," or 200 fathoms "straight twine" or stretched as they leave the factory, and 15 fathoms deep. They are made

of small cotton twine (No. 20 to No. 12 thread), except in the middle, or "bunt," which is knit of stronger twine (No. 14 to No. 9 thread), to hold the fish when they are gathered into a small compass. They weigh 600 or 700 pounds, and cost not far from $1,000 when ready for use. On the coast of Maine they are larger, being commonly from 225 to 275 fathoms long and 20 fathoms deep in the middle, tapering to 14 fathoms at each end.*

The American Net and Twine Company supplies the Maine fishermen with seines usually 250 fathoms long and 20 or 25 fathoms deep, those of Southern New England and New York with shorter ones, usually 150 fathoms long and 15 to 20 fathoms deep.

The steamers of the Pemaquid Oil Company carry each two seines; a long one and a short one. The long seines are about 9,500 meshes long and 650 meshes deep (size of mesh 3⅛ inches), and when rigged are from 280 to 300 fathoms long, and 15 to 17 fathoms deep. The shallow-water seines are from 7,000 to 7,500 meshes long and 500 to 550 meshes deep (size of mesh 2½ inches), and when rigged are from 170 to 180 fathoms long, and 8 to 10 fathoms deep. Each steamer employs from 12 to 15 men, including captain, mate, engineer, fireman, cook, and sharesmen, and is supplied with two large working boats from 22 to 82 feet long, as well as two small boats,—"drive boats,"—which are rowed by the men who drive the fish into the seine.

The three sloops of Gurdon S. Allyn & Co. carry seines 200 fathoms long and 580 meshes (2½-inch mesh) deep.

Gallup & Holmes use seines of 3-inch mesh, 9,200 meshes in length and 600 meshes deep, with shallower seines for shoal water.

The three steamers of E. T. De Blois carry seines 300 fathoms long and 17 fathoms deep.

The two sloop-yachts of William T. Fithian & Co., Napeague, N. Y., carry seines about 160 fathoms long and 15 fathoms deep.

The three sloop-yachts and two steamers of Hawkins Brothers, Jamesport, N. Y., carry seines from 100 to 130 fathoms in length and of 2½-inch mesh.

Luce Brothers, of East Lyme, Conn., use seines 150 fathoms long and 18 fathoms deep.

The seines used by the Sterling Company of Greenport, N. Y., are 125 to 150 fathoms long and 80 to 100 feet deep.

The seine-boats.

169. The boats used by the Gloucester fleet in the purse-seine fishery are built after a peculiar model and solely for this purpose. The present form of the seine-boat was devised, about the year 1857, by Messrs. Higgins & Gifford, boat-builders, Gloucester, Mass. The seines had previously been set from square-sterned lap-streak boats, about 28 feet in length, and resembling in shape an ordinary ship's yawl.

* Boardman and Atkins, *op. cit.*, p. 23.

The seine-boat as now in use resembles the well-known whale-boat, differing from it, however, in some important particulars.

The seine-boat, according to Mr. Gifford, must have three qualities: (1.) It should tow well; consequently it is made sharpest forward; a whale-boat, on the other hand, is sharpest aft, to facilitate backing after the whale has been struck. (2.) It should row well, and this quality also is obtained by the sharp bow; the whale-boat also should row well, but in this case it has been found desirable to sacrifice speed in part to the additional safety attained by having the stern sharper than the bow. (3.) It should be stiff or steady in the water, since the operation of shooting the seine necessitates much moving about in the boat.

The Gloucester seine-boat of the present day is a modification of the old-fashioned whale-boat, combining the qualities mentioned above. The average length of such a boat is about 34 feet, its width 7 feet 5 inches, its depth amidship 33 inches. At the stern is a platform, measuring about 4 feet, fore and aft, on which the captain stands to steer: this is 6 to 8 inches below the gunwale. Another platform extends the whole length of the boat's bottom, from the after part of which the seine is set. In the bow is still another platform, on which stands the man who hauls the cork-line. There are four thwarts or seats, a large space being left clear behind the middle of the boat for the stowage of the seines. Upon the starboard side of the boat, near the middle, is arranged an upright iron support, about 18 inches in height, to which are attached two iron snatch-blocks used in the working of the purse ropes. Upon the opposite side of the boat, generally near the bow and stern, but with position varied according to the fancies of the fisherman, are fixed in the gunwale two staples, to which are attached other snatch-blocks used to secure additional purchase upon the purse-ropes. In the center of the platform at the stern of the boat is placed a large wooden pump, used to draw out the water which accumulates in large quantities during the hauling of the seine. The steering rowlocks, with the peculiar attachment for the tow rope and the metallic fixtures described above, are manufactured especially for seine-boats by Messrs. Wilcox & Crittenden, Middletown, Conn.*

Until 1872 the seine-boats were always built in the lap-streak style; since that time an improved form of smooth-bottomed boats, built with battened seam set-work, sheathed inside with pine, and with oak frame and pine platform, has been growing in popularity. The advantages claimed for this boat by the builders are: (1.) Increased speed; (2.) greater durability, on account of the more solid character of the wood-work and tighter seams; and, (3.) less liability to catch the twine of the nets by reason of the smooth sides. It is not so stiff as a lap-streaked boat of same width, but in other respects superior.

Since the general adoption of the purse-seine, in the menhaden and mackerel fisheries, an account of which is given elsewhere, there has

* The Cape Ann seine-boat, with all its attachments, is illustrated in Plate XV.

been a gradual increase from year to year in the size of the seine-boats, keeping pace with a corresponding increase in the size of the seines.

In 1857 all boats were 28 feet in length. In 1872 the length had increased to 30 feet, and in the summer and fall of the same year an additional foot was added to the length. In 1873 almost all boats which were built had a length of 31 feet; a few of 32 and 33. In 1874 almost all were 33 feet, as they were during 1875 and 1876, although some were made 35 and 36 feet. In 1877, 34 feet is the most popular length, though one or two 38-foot boats have been built. Seven, eight, or nine oars, usually 13 or 14 feet in length, are used in these boats, besides a steering-oar of 16 or 17 feet.

These boats last, with ordinary usage, six or seven years. At the close of the fishing season they are always taken ashore and laid up for the winter, in a shed or under trees, and are completely refitted at the beginning of another season.

The seine-boats, carried by the "menhaden catchers" south of Cape Cod and by all the steamers, are shaped like ships' yawls, square-sterned, smooth-bottomed, and batten-seamed, 22 to 26 feet long and 6½ feet beam; they are built at New Bedford, New London, Greenport, and at Mystic River, and cost about $125 each, the finest $185. The New Bedford boats are preferred by many fishermen.

When boats of this model are used every gang has two, each carrying three men and half of the seine; this arrangement leaves one of the crew upon the sloop and two in the lighter. On the coast of Maine, a man is usually sent out in a dory to drive the fish.

The Cape Ann fishermen stow their seines in one boat, and in shooting the seine one end of it is carried in a dory.

The Cape Ann dory is 15 feet long on the bottom, 19 on top, 5 feet 2 inches beam amidships, 21.5 inches deep, 36 inches high at the stem, 34 inches at the stern, 2 feet 10 inches wide at bottom of stern. These dories are built with considerable difference in their "sheer," those used on the shore having a straighter bottom than those used in the Bank fisheries. The boats used on the seine fisheries are generally of an intermediate form.

Messrs. Higgins & Gifford manufacture an improved pattern of dory (patented January 2, 1877), for which they claim the same advantages already mentioned under the description of the seine-boat. They are built of pine, with oak-timber gunwales, stem and stern. There are four boards upon each side fastened in battened set-work. The gunwales are whole instead of being bent and capped. They have no projecting stem-head, in this respect also differing from the old form.*

The sailing-vessels and steamers.

170. Small schooners and sloops were used in the early stage of the business, these succeeded by larger, and these to a great extent by

* The Cape Ann dory is illustrated in Plate XVI, fig. 1.

steamers, of which there are now about sixty, each from 60 to 150 feet in length, and costing from $7,000 to $40,000. The advantages of steam are too obvious to need special notice, such as dispatch, economy of time and labor, etc. With the advent of steam-vessels, larger factories with more ample equipment become a necessity in order to utilize the augmented supply. The first factory had the capacity to work up 500 barrels per day. The larger factories can now take 3,000 to 4,000 barrels daily. At the outset 4,000 barrels per steamer was a large catch to each fishing "gang." Now the average catch per steamer is 10,000 barrels, and 20,000 barrels are not unprecedented.* The Pemaquid Oil Company employs several vessels in shipping oil, and in carrying the dried scrap to England.†

Description of steamers.

171. The average burden of the menhaden-steamers is about 60 tons. They are built of hard pine, with white-oak frames, with a water-tight tank in the middle in which the fish are stowed. This tank is said to make the vessels exceedingly safe, enabling them to float when their planking is badly injured. The steamer "Jemima Boomer," owned by Joseph Church & Co., while at sea in rough weather had 50 feet of her keel knocked out, together with eleven of the bottom planks. She was taken upon a marine dock without sinking. Each steamer carries from twelve to fifteen men, who live in the forecastle.‡

Mr. George Devoll, of Fall River, Mass., describes his steamer, the "Chance Shot." It is 39 tons in burden, 68 feet long, and 18 feet wide, and 5 feet in depth of hold. Its carrying capacity is about 700 barrels of fish. The consumption of coal is about one ton daily. The cost of running is about $8 per day, including coal, oil, and the wages of the engineer. The crew are employed on shares, each man paying his own board and running his chance. The boat and seine draw one-half of the profits, and the gang half—the gang paying provision-bills and cook's wages. There are seven men in the gang besides the cook and the engineer.

A model of the fishing steamer "Leonard Brightman," owned by Joseph Church & Co., of Round Pond, Me., was exhibited in the United States Government building in Philadelphia and is now deposited in the National Museum. The steamer "Seven Brothers," also owned by Joseph Church & Co., was the first steamer built for and used in this fishery.

31.—CERTAIN REQUIREMENTS OF PURSE-SEINE FISHING.

Methods of handling the net.

172. Much care and expedition are necessary in handling a purse-seine full of fish. In the event of a very large draught, if the fish are

* Maddock's Menhaden Fishery of Maine, p. 15.
† Appendix I, contains a partial list of vessels employed in the menhaden fishery.
‡ Plates XVII and XVIII show the menhaden-steamer and its plan of arrangement.

left in the net too long they are killed by the confinement and close pressure, and sink. In such a case the only alternative offered the fishermen is to cut open their seine. Sometimes the dead fish carry the net with them to the bottom. When there are more than enough fish in the seine to fill the vessel to which it belongs, and there is danger that they may be lost, other vessels which are near often take the surplus fish. In such a case, writes Mr. Babson, one-half the value of the fish is paid to the captors.

In calm or moderate weather, fishing is carried on from dawn till dark, though morning and evening seem most favorable. In rough weather the nets are not easily set, while the fish usually swim farther from the surface and cannot be seen. Cold northerly and easterly winds seem to affect the fish, causing them to sink toward the bottom. Southerly winds seem the most propitious.

Mr. Dudley states that in the fall, during the southward migration, the fish play at the surface with a northwest wind.

The best time for seining.

173. The early morning is apt to be the stillest part of the day, and a large part of the fish are taken at that time.

So far as I can learn, the motions of the fish are not particularly affected by the tides, except that, like other *Clupeidæ*, they prefer to swim *against* strong tides and winds. An impression seems to hold among the fishermen that rather better success attends fishing on the flood-tide. This is no doubt the case where gill-nets are in use, for in localities where the fish have not been frightened off shore by constant fishing they like to play up into coves and bays with the rising tide, and are then easily taken by the gill-nets and the pounds or weirs.

Where the purse-seines are worked in deep water off the shore, as on the coast of Maine, little attention need be paid to the tides; but where they are used in bays or channels where the tide has much head, there is a practical difficulty in using them except at or near the time of slack water. In a swift current the seine is liable to accidents from being caught on rocks or other obstructions, or may be capsized or pulled out of position. In Narragansett Bay, the difficulties of this kind appear to be particularly great. According to Mr. Church it is not uncommon for a gang to work all day without success, their net being capsized every time it is set.

32.—Descriptions of fishing scenes.

Menhaden fishing in Southern New England.

174. The first time the writer ever saw menhaden-fishing was in August, 1874, when cruising off Watch Hill, Rhode Island, in the Fish Commission yacht "Cygnet." Several trim-built sloops are beating off and on, within a mile of the rocks. That they are "bony-fish catchers"

is evident from the two long boats which are towed astern, carrying the purse-seine, which looks like a bale of brown hay stowed in the middle of each boat. A man stands at every mast-head watching for the well-known ripple. A school passes under the bows of our yacht and rises to the surface at a short distance, the bright sides of the fishes glistening in the sun and their tails flipping the surface noisily. The sharp eyes of the "lookout" of the nearest vessel soon detects their presence. The sloop comes about and sails to the leeward of the school. As soon as they are near, three men jump into each boat. Two man the oars, a third stands in the stern and pays out the net, while the boats, rapidly diverging, are rowed around the fish, each describing a semicircular course. Now their courses converge and the men row faster. They come together and pass, thus closing the circle of net-work. The men all jump into one boat, the purse-weight, or "long Tom," as they call it, is hooked to the two lead lines, and a splash of water announces that it has been thrown overboard to slide down the ropes and draw the lower ends of the net together. Now they begin hauling at the bottom lines, and in ten minutes they have drawn the bottom of the net into a purse and the fish are secured. The "lighter," or transporting boat, now sails up. The men on board heave a line to the seine-boats and they are brought alongside. A large dip-net, three feet in diameter, is now suspended by a block and tackle in the rigging of the lighter, and the fish are rapidly transferred from the seine to its hold. The silvery masses of fish are hoisted into the air and dropped into the vessel, settling in the bins with a flapping noise like the sound of distant thunder or the hand-clapping of a large audience.

In August, 1876, when on the steamer from Saybrook to Greenport, I saw a fleet of sixty vessels busily plying their nets in the sound near the mouth of the Connecticut. In the evening a gale sprang up from the southwest, and as the steamer entered Peconic Bay the little sloops were seen scudding to harbor under low-reefed sails. Every wave swept the decks, but they floated like sea-birds. Some of them were loaded to the rail with fares of fish.

Menhaden fishing about Cape Ann.

175. We are indebted to Captain Babson for facts about the fisheries at Cape Ann, which are carried on for the purpose of securing bait for the codfish and mackerel fleets. Vessels for this business are fitted out from the port of Gloucester on the same basis as those for other fisheries. The owners furnish the vessel-outfits, seine and boats, the crew going "on the halves"; that is, taking for their share half of the entire "catch" while the other half is claimed by the owners. A good vessel with boats costs about $5,000. A seine costs about $1,000, and with fair usage lasts through two seasons; it is made of cotton twine and preserved by the use of salt and tar. The seine is carried on a small deck at the stern of the seine-boat, which is about 30 feet long and 8 feet

wide and is built on the plan of a whale-boat of the old style. Only one seine-boat is used here, and on this the whole seine is carried, one end of the seine being taken by a "dory" with two oarsmen.

The Cape Ann Advertiser reported in 1872 that the menhaden fishery was prosecuted by about 40 vessels from that port.

Mr. Frederic G. Wonson, of Gloucester, states that the crew of a "pogie-catcher" consists of about 10 men, and that the cost of a three weeks' trip is about $400.

Menhaden fishing in Maine.

176. Mr. Church has furnished a very full account of the organization of crews on the seining-vessels. The largest steamers are 70 tons in burden, the smallest 25, the sailing-vessels about 30; these vessels are used for the men to live on, and tenders are employed to carry the fish to the factories. These tenders have an average capacity of 250 barrels, though recently they are built of a larger size, some carrying 600 barrels. Besides these there are the "purse" and "mate" boats from which the seine is worked. These are 28 feet long, 6 feet wide, and 2 deep. The sailing-vessel has a cook who manages the vessel while the crew are working the seine. Each boat carries a "seine-setter" and two men to row. The captain of the gang is in charge of the "purse-boat," the first mate of the other, and in addition to these most gangs have a "fish-driver," who keeps close to the school in a small-boat and guides the gang in setting the seine. Some gangs have still another man, called the "striker," who is generally an apprentice learning the business and working at low wages. Four men to row, two to set the seines, and one (the cook) to manage the vessel, seven in all, are all that are really necessary for steamer or sail-vessel, the other functionaries being added as may be convenient. "The seines are 280 fathoms long and 100 feet deep. One-half of the seine is put in each boat. The steamer cruises with men at mast-head looking for fish. When they raise a school they put what are called striker-boats on them. Each steamer has two, with one man in each; they are men with sharp eyes, quick and active. They row close to the school of fish, observe its course, and then by signs they direct the purse-crew how to set their seine to catch them. If fish get scared, they drive them with white sea-pebbles which they carry in their boats. If the fish turn to run out of the seine, they throw the pebbles before them, and as they pass through the water before them the fish turn and swim in an opposite direction. After the fish are surrounded the purse-crew and strikers all work together to get the seine around them. It is different from sail-gangs in this, that sail-gangs hoist the fish by hand, and have boats to take the fish from the fishing-grounds to market, while the purse-crew stay on the ground with a separate vessel. Steamers go on the ground, catch their fish, hoist them on board by steam, and when the day is done take them to market, and the same men that catch them discharge them." A steamer has no tenders, and thereby saves much

expense. A sail-vessel with a purse-gang of seven men requires three tenders, with a man to sail each of them, making ten men in all as sharesmen. The steamer dispenses with the three extra men, and in consideration of the expense of coal and machinery takes their three shares. This leaves the shares of the remaining men proportionally the same as on a sailing-vessel.

Sail-gangs and steamers have gear just alike to catch the fish. It is not a sure thing to catch even when they see plenty of fish. A gang last year set nineteen times and did not catch a fish.

A writer in the Boston Daily Advertiser newspaper of August 5, 1875, states that persons chartering a steamer and sharing equally the profits with its owner easily make from $1,000 to $3,000 in a season.

Boardman and Atkins thus describe the methods in use about Boothbay, Me., in 1874:

"Attached to each seine is a gang of fishermen and boats. The gangs are described as 'sailing gangs' or 'steamer gangs,' according to the means of locomotion. A sailing gang comprises two working boats and a light row boat for the 'driver'; two carry-away boats, with a capacity of about 250 barrels each; one vessel and ten men in all. The working boats work the seine, the carry-away boats carry to the factory, and on the vessel the crew are fed and lodged. In a steamer gang, the vessel and the carry-away boats are replaced by a screw-steamer of 35 to 60 tons (new measurement), and the number of men is reduced to nine. These steamers cost from $10,000 to $16,000 each, and will carry 800 barrels of fish. They were introduced on the coast of Maine three years ago. The advantage of the steamer over the sailing gang is obvious. It is not dependent on the wind, and can proceed without loss of time to the place where the fish are playing. Of course they catch a great many more fish, but they are so much more expensive that they do not appear to be much more profitable. The seine gangs are always attached to the oil-factories, and the latter employ no other mode of fishing. Each factory runs several gangs.

"Let us now follow the process of catching the fish as practiced by a steamer gang. We will begin at the sailing of the gang from the harbor, some clear morning in August. The engineer bestirs himself and has on steam early enough to reach the fishing-ground about as early as the fish can be seen. The fishing-ground is just where experience, and particularly the experience of the last few days, dictates. Commonly it is out to sea. As soon as it is light a sharp watch is kept on every side. Wherever menhaden are seen, thither the steamer's head is pointed. Sometimes it is close by home, and sometimes twenty or thirty miles are passed over before there is a single school to be seen. On approaching a playing school they always try to get on the outside of it, because the first movement of a school of pogies on finding themselves entrapped is invariably a rush seaward. The driver, in his swift row-boat, armed with a pile of stones, gets on the other side. Having

divided the seine between them, one end and half the seine being on each, the two working boats approach the school within a short distance and endeavor to get in a favorable position. Sometimes a whole day will be spent in vain endeavors to get near swiftly moving or capricious schools. When the favorable moment comes the boats separate and row around the schools of fish, paying out the seine from each as they go. Meanwhile the driver, on the opposite side, throws stones at the timid fish and starts them in the direction of the boats. At last the boats have encircled the fish, and meet on the side opposite to their starting point; instantly the purse-lines are seized, and no man stops to breathe until the bottom is pursed up. The crews exert themselves to complete the operation before the fish take the alarm, and many a time it happens that they pass out between the boats just before they meet, or under the bottom of the seine before the pursing is complete. The affrighted fish first, it is said, rush seaward. Finding themselves shut in on that side, they turn and rush landward; headed off there, they furiously follow the net around at the top of the water, some going this way and some that. Finding the circuit complete, they gradually subside, and finally settle to the bottom of the bag. The seine is now drawn aboard the working boats until only a small portion of it is left in the water, and the fish brought in a compact body to the surface. The steamer is now brought alongside, and with a great tub holding two or three barrels, and worked by steam, the fish are rapidly taken on board. When everything works well it takes about two hours to catch and take on board a school of 500 barrels; commonly it is longer than that."*

Gill-net fishing in Eastern Maine.

177. East of the Penobscot River, in Maine, most of the fishing is carried on with "float" or gill nets. These are knit usually of twine (size No. 12 to 14, 4-threaded), and of 3½ to 4 inch mesh, and are from 30 to 180 feet in length and from 6 to 16 and 24 feet in depth; usually from 12 to 18. Two men in an open sail-boat will, according to Mr. W. H. Sargent, of Castine, take care of a dozen nets. These nets are usually set in the night by being anchored in favorite haunts of the menhaden. When a school strikes the net large numbers of the fish are "meshed" by running their heads through the openings until they are caught by the gill-covers. According to Mr. Brightman, of Waldoborough, the gill-netting in that vicinity is mostly done early in the season; he states that this method of fishing is not nearly so productive as in former years. Netters sometimes build a furnace for trying out oil on the deck of a small vessel, thus saving the trouble of transportation.

Gill-nets are also used about Boothbay in the early part of the season, but not so much as formerly. The nets are made, according to Mr. Brightman, of fine cotton twine, about 4 inches mesh, 12 feet deep, and 20 fathoms long.

* Op. cit., pp. 24, 25.

Until the introduction of the purse-seine and its general adoption, about the year 1860, gill-nets were exclusively used. In the intermediate time the stationary gill-nets were supplanted by sweep-nets, arranged by fastening together several small gill-nets.

Weir fishing for menhaden.

178. Weirs and pounds are never set for the express purpose of capturing the menhaden, but large numbers of these fish are taken in these traps. In Chatham Bay, Massachusetts, there are thirteen weirs of various lengths set in water from 2 to 5 fathoms in depth for the purpose of catching mackerel, sea-bass, and shad. The average catch of menhaden for the past five years has been about 5,000 barrels, about half of which is sold for bait, the remainder thrown away. Goodale and Atkins state that on the coast of Maine there are a very few weirs built especially for the capture of menhaden; two or three near Stockton, on Penobscot Bay, being all of which they have knowledge. Some are also taken in the weirs built for salmon and alewives. The herring-weirs, on the other hand, are not adapted to their capture, their entrances being so wide that the menhaden generally "play out" after once entering.

On the eastern end of Martha's Vineyard are numerous pounds, extending 1,200 feet and more from the shore, set for sea-bass, squeteague, scuppaug, and bonitos. Many menhaden are taken here, which are sold for bait.

In the vicinity of Greenport, N. Y., "'longshore seines" are sometimes used, though not so generally as in former years, when this was the usual mode of capture.

Colonel Lyman on weir fishing at Waquoit.

179. Col. Theodore Lyman has given a very graphic account of the capture of bait menhaden in the Vineyard Sound:

"The weir is hauled once a day, and always at slack water, because with a strong tide running east or west it is impossible to handle the bottom-lines. The men pull out in two parties, of which one in a large scow passes round the outside of the bowl, casting off the bottom-lines, while the other in a yawl-boat pushes inside the bowl, pulls up the sliding poles, and closes the entrances. The slackening of the bottom-lines allows the bowl-net to hang free, and the crew inside begin to haul up the bottom of this net in such a way as to work the fish toward one corner, letting the net as it comes to the surface pass under their boat, which is thus slowly drawn across the bowl toward the corner where the capture is to take place, and where the scow is already waiting outside.

"The scene now becomes an exciting one. The menhaden in thousands begin to show the sharp upper lobes of their tails above the water;

here and there darts a feverish mackerel like a blue and silver flash; great leathery skates, looking like pigs rolled out flat, raise their snouts in slow astonishment; here a shark suddenly works his way through the crowding mob; hundreds of goggle-eyed squid, smothered in the press, feebly ply their force-pumps; and there the murderous bluefish, undismayed by imminent death, glares fiercely and snaps his savage jaw to the last. All these, with flat-fish, sea-robins, butter-fish, and many more, are taken and rolled in a fluttering mass iridescent with changing colors, and shower their silver scales high in air. It moves even the wear-men, in their oil-skin clothes, with a slight excitement as they cull out from the menhaden the choice and the offal fishes. There is Uncle Abishai smiting sharks with a spear, like so many Sauls, and he smiteth them not twice, and Captain Ed'ard endeavoring with a swift scoop-net to capture a dodging shad, because Mrs. Asa has boarders and needs a fish for dinner; and Captain Charles, with the air of one who gets a toy for a good child, diligently striving after some of them 'ere striped robins that the professor wanted. All this is strange and entertaining even to a commissioner, who, by the motion of a long swell and the evil piscatory odor, is somewhat afflicted with what the local satire terms 'white-cars.' And now the menhaden, bushels on bushels, are scooped all quivering into the great scow, for a little outside lies a mackereler who has just let go her anchor with a rattle, and a boat is pulling in with the skipper to buy bait. 'What you got,' cries he, in an indifferent tone. 'Menhaden,' retorts Captain Warren, as if speaking of a new and scarce fish. (A pause.) 'I don't know but I might take a few barrels if they was low,' says the skipper. (No reply.) 'What do you want for 'em?' 'Eighty-five cents,' shouts Captain Warren, and then (*sotto voce*), 'I don't believe he's got a scale.' At this answer, the man of mackerel pushes over the tiller and steers off indignantly; but presently pauses, 'Give you sixty-five, for seventy barrels.' 'Seventy-five cents is the lowest,' replies Captain Warren. 'Call it seventy cents for seventy-five barrels.' 'Waal! Waal!' And by this time the scow is full, and the weir-men pull for the vessel, whose numerous crew is ready to hoist the bait on board and salt it down. They stand with knives, barrels, and chopping-blocks, and rapidly cut off the heads and tails of the fish, and the thin parts of the sides, then give a gash in the shoulder, and throw them into the barrel for salting. A mackereler will take as many as 120 barrels of such bait, which is minced fine in a hand-mill and thrown over to toll the fish.

"Many years ago, when mackerel were cheap, the younger ones, called 'No. 3s,' were laboriously chopped up with a hatchet and thrown over as 'chum.' When mackerel became dear, especially during the war, the No. 3s were too valuable to be thrown away, and cheaper material, such as menhaden, was resorted to."*

*Ann. Rep. Commissioners on Inland Fisheries, for the year ending January 1, 1872, pp. 24, 25.

Fatback fishing in North Carolina.

180. At Cape Hatteras, according to Mr. A. W. Simpson, two kinds of nets are used in the capture of the "fatback." The "drag-net" is from 75 to 100 yards long, and 25 to 37 meshes deep, with a mesh of from 1½ to 2 inches. The lead line is provided with heavy lead sinkers, the cork line with floats made of gum-tree roots. The "set net" (which like the preceding is made of gill-twine No. 25 or 30, and five or six strand cotton cord made of No. 10 cotton) is from 35 to 45 yards in length, 18 to 20 meshes deep, the mesh being the same as in the "drag-net." Instead of a lead line is used a heavy cotton cord which has been dipped in pine tar and rolled in a bed of pebbly sand until a sufficient quantity is fastened to it to weight the bottom of the net. Such a net is called a "fly-tale," and is set at night on the playing ground of the fish, with both ends made fast. To work these nets canoes are used, ranging from 16 to 30 feet in length and 3½ to 7 in beam; two men are required for a small canoe, three for a large one. The fish are taken mostly on the flood-tide. When fishing with the drag-net, moderate weather is preferred; with the gill-net, a light wind, as the fish run most in windy weather. The fishermen do not make a special business of catching the menhaden, but are on the lookout for all kinds of fish. Purse-nets have been used about Cape Hatteras, but without very great results.

In the rivers near Beaufort, N. C., according to Mr. Davis, the fatbacks are taken in gill-nets about 50 fathoms in length, and 50 or 60 meshes deep, the meshes being 1¼ to 1⅝ inch in dimension. Nets which are partially worn out are generally used, the fishermen having an idea that the slime of the fatback ruins a net so that it cannot be used after the first season. The nets are worked from open boats and canoes carrying from 10 to 25 barrels of fish. Two men and a boat are necessary for each net. In making what is called a "drop," from four to six boats join their nets and surround the school. The fish, getting confused, mesh themselves and are easily pulled in with the net, and are then disentangled. From two to four hours are necessary for each haul, and one haul will generally fill the canoes. Two loads can be taken in a day.

33.—The relation of the menhaden fishery to the fishermen and the maritime villages.

181. On the coast of Maine, according to Mr. Maddocks, "the catching of menhaden is a favorite occupation with fishermen. The steamers return every night if they have any fare, and are hardly ever absent more than two or three days. Operations are suspended in bad weather. The oil is manufactured at once, and meets a ready market. The men can thus be promptly paid; whereas in the mackerel and cod fisheries the hands are obliged to wait until the end of the season for settlement, the service is dangerous, and comparatively full of hardships, the Men-

haden Association has never lost a man in its service, and not one of the steamers has ever burst a boiler. This is the more important since the cod and mackerel fisheries have been and are grievously oppressed, and greatly reduced by the tariff regulation that admits English fish free to our markets. The Englishman can build his craft at less cost than the American, can fit and equip her cheaper, and can therefore afford to sell his fish at a lower figure than the home fisherman; and at the same time he pays none of our taxes while enjoying the benefit of our market. The menhaden fishery has afforded no little relief in this condition of things to the unemployed fishing population on our coast and elsewhere."

182. Mr. Maddocks gives a very interesting picture of the influence of the menhaden fishery upon the population of the neighboring shores.

In the villages of Boothbay, Bristol, Bremen, and East Boothbay, the centers of the menhaden fishery on the Maine coast, the number of dwellings has doubled in the past few years, and all the outward signs of thrift, of enlarged comfort and abundance manifest themselves. The companies engaged in the menhaden business pay in the aggregate a handsome per cent. of the annual taxes of the towns in which they are located. The oil companies of Bremen pay over one-fourth of the total tax of the municipality. The oil-factories of Boothbay have, since they were built, paid an amount of tax equal to two-thirds of the war debt of the town. The Bristol factories pay one-eighth of the town tax. The indirect contributions of the business to the public treasury, by promoting the building of houses, vessels, &c., have been very considerable. All the money made has been spent on the spot, where it is open to taxation.

"About $60,000 worth of cotton twine is used yearly in the menhaden fishery of Maine for the manufacture and repair of seines. Quite a number of hands, men, boys, and girls, are employed in this work. The seines are of course made by machinery. Ten thousand tons of coal are consumed for various purposes, and 40,000 bushels of salt."

A correspondent of the "American Agriculturist" states in that paper* that the proceeds of the menhaden fishery and industry between New London and Stonington in 1872 amounted to $113,000, which was distributed along the coast of 12 miles on the north side of Fisher's Island sound. The business gave employment to over 200 men at the factories, and indirectly to as many more, besides the business of freighting the products.

34.—PROTECTIVE LEGISLATION.

Laws of Maine.

183. The legislative acts relating to the menhaden fishery in Maine are summed up as follows:

SEC. I, chap. 313, Public Laws, 1865, provides as follows:

"No person shall set or use any seine within three miles of the shore

*American Agriculturist, 1873, vol. XXXII, p. 139.

in any waters of this State, for the purpose of taking menhaden or pogies; but a net of no more than one hundred and thirty meshes deep shall not be deemed a seine." * * * * * * *

The penalty for violation of this act was fixed at "not less than four hundred nor more than one thousand dollars, and the forfeiture of all the vessels and apparatus employed."

By the act of February 21, 1866, chap. 30, Public Laws, the penalty for violation of the law was reduced to "not less than one hundred nor more than five hundred dollars," and the number of meshes deep increased to one hundred and forty to constitute a seine.

The act of February 27, 1869, chap. 36, Public Laws, repeals the foregoing, and re-enacts it in substance with various modifications.

The legislature of 1870 re-enacted the above with fuller details as to the collection of penalties, &c. Chap. 120, Public Laws, 1870.

In the revision of the statutes in 1871 the above act was consolidated into one section, sec. 54, chap. 40, Revised Statutes, 1871, which still retained the three-mile restriction, and the penalty of one hundred to five hundred dollars for each violation, and a forfeiture of all equipment employed.

Chap. 211, Public Laws, 1871, approved February 27, 1871, repeals the above sec. 54, chap. 40, of the Revised Statutes.

Laws of Massachusetts.

184. The following acts have been passed by the legislature of Massachusetts:

"AN ACT to protect the menhaden fishery in the towns of Duxbury, Plymouth, and Kingston.

"(Ch. 85.) SECTION 1. *Be it enacted*, Every person who shall, between the first day of May and the first day of November, inclusive, in each year, deposit the offal or waste dressing of the menhaden fish upon the shores or flats, or throw the same into the waters of the bays, harbors, rivers, or creeks of the towns of Duxbury, Plymouth, or Kingston, shall, for each and every offense, forfeit and pay a sum not exceeding fifty dollars, one-half to the complainant, and the remainder to the town within whose jurisdiction the offense was committed, to be sued for and recovered in any court competent to try the same, on complaint of any one of the selectmen, or any legal voter of either of the towns of Duxbury, Kingston, or Plymouth.

"SEC. 2. Any boat, craft, vessel, or fishing apparatus used by persons violating the provisions of this act, may be seized and detained not exceeding forty-eight hours by the selectmen of either of the towns aforesaid, in order that the same, if need be, may be attached or arrested by due process of law, to satisfy said fine with costs.

"SEC. 3. This act shall take effect from and after its passage."—[April 24, 1857.

"AN ACT regulating the seining of menhaden in the rivers of the commonwealth.

"(Ch. 52.) SECTION 1. *Be it enacted*, The mayor and aldermen of any city or the selectmen of any town situated upon or adjacent to any river in which the seining of the fish is now or may hereafter by law be prohibited, may, upon the petition of twelve or more legal voters, and after due notice and hearing thereon, grant permission to such persons, upon such condition and with such restrictions as they may see fit, to seine menhaden therein, if, in their judgment, the same is consistent with the public good: *Provided, however*, That in all cases where two or more cities or towns are situated upon such waters and interested in said fishery, no action shall be had except upon petition to each of them, and by their concurrent vote.

"SEC. 2. If any person so licensed shall exceed in any manner the terms of said permission, or violate any of the conditions thereof, he shall be subject to the same penalties as would attach to seining without such license.

"SEC. 3. Such license may be altered or revoked at any time, by the concurrent action of the municipal authorities granting the same."—[March 15, 1858.

"AN ACT relating to the taking of menhaden in the waters of Buzzard's Bay and Vineyard Sound.

[1856, ch. 176. Additional act, 1870, ch. 249.]

"(Ch. 212.) SECTION 1. *Be it enacted*, From and after the passage of this act it shall be lawful for any person to take menhaden by the use of the purse-seine, so called, in the waters of Buzzard's Bay or of Vineyard Sound, or the waters of any bays, inlets, or rivers bordering on or flowing into the same: *Provided*, That no authority shall be hereby given to use any such seine at the mouth of any river where there now is or where there may hereafter be a herring fishery established by law, until after the fifteenth day of June, in each year: *And provided further*, That no authority shall be hereby given to use any seine in the waters around Nantucket or the islands belonging thereto."—[May 9, 1865.

In the report of the commissioners of inland fisheries for 1877, p. 65, it is stated:

"Fishing with seines in the Merrimac, at the season when the menhaden stand in, is forbidden by law. The *mouth* of the river has, however, never been defined by the governor, as permitted by statute; and it was represented to the commissioners that valuable menhaden fisheries existed in this neutral ground of brackish water. Therefore, under the personal promise of the fishermen to capture no shad or salmon, and with the guarantee of responsible persons in Newburyport, the commissioners agreed to defer the definition of the river-mouth, and to assume that these menhaden were not positively included in the river proper."

K.—ECONOMICAL VALUE AND APPLICATION.

35.—THE MENHADEN AS A TABLE-FISH.

Its use in a fresh state.

185. In many parts of the United States menhaden are in favor as table-fishes. When perfectly fresh they are superior in flavor to most of the common shore-fishes, but if kept they soon acquire a rancid and oily flavor. The Maine fisherman finds his breakfast of fried pogies both substantial and palatable. I can testify from personal experience that a bony-fish chowder is not to be despised.

They are often eaten in the vicinity of Newburyport, under the name of "hard-head shad." They are considered more palatable than the early runs of the river shad.

I am indebted to Mr. Barnet Phillips, of the New York "Times," for the information that in 1813, during a season of scarcity, large numbers of moss-bunkers, both fresh and smoked, were consumed in New York City. It does not appear probable that they were ever extensively used for food except in seasons of scarcity.

Professor Gill, writing in 1856 of the fishes of New York, remarks that moss-bunkers appear in the markets in the fall months, but in small quantities.

Storer remarks* that the fishermen who supply Boston market with codfish set their nets about the outer islands in the harbor each night as they come up to the city, and examine them in the morning as they go out for the day's fishing. Large numbers of menhaden are thus taken, frequently one hundred barrels at a haul, and such as are not used for bait are sold to the poorer classes for food, at about 6¼ cents per dozen.

The Rev. A. W. Church, editor of the Middletown (Conn.) "Constitution," informs me that the moss-bunker is a staple article of food among the people living on the sea-coast of New Jersey in the vicinity of Bricksburg, Somers Point, etc., and ten or fifteen miles inland. Every family makes a practice of salting down a barrel or two for winter use. They are preferred to any other fish which can be taken in that vicinity.

In the fall and winter the alewife is in good demand on the shores of Chesapeake Bay. In November and early part of December, 1874, I frequently saw twenty or thirty strings on the tables in the Washington fish market and they seemed to meet with a ready sale at 40 cents a string, a price nearly as high as that of striped bass, the favorite fish in Washington.

At Cape Hatteras the winter fish are in demand and are salted in quantity for summer use. In 1873 they sold for $7 a barrel. The summer fish are used only as fertilizers.

* Hist. Fish. Mass., p. 159.

The abundance of bones and the oily flavor have given rise to a prejudice against the menhaden as a food-fish, which the oil factories on the coast have done much to confirm. Still the fish is not unpalatable, and is capable of much valuable service in the capacity of a table-fish.

Its use salted.

186. For many years salted menhaden have been shipped from Gloucester to the WestIndies and Guiana, to serve as food for the negroes upon the plantations. These fish are not carefully prepared, but are chiefly the surplusage of the bait supply remaining in the hands of outfitters of fishing vessels at the close of the season. They sell for about $2 per barrel. Mr. F. W. Homans ships from 1,500 to 2,000 barrels annually to Surinam. These would weigh from 300,000 to 400,000 pounds, and be worth in the aggregate some three or four thousand dollars. Other individuals doubtless dispose of their refuse stock in the same manner.

Capt. Moses Pettingell, of Newburyport, informs me that about the year 1840, and before, large quantities were annually salted down in Newburyport, to supply a regular market in the West Indies. Salted menhaden were found to meet with a readier sale than salted mackerel, since, while little inferior in quality, when well prepared, they could be sold at a much lower price.

In the "Topography and History of Wareham," 1815, it is stated that the inhabitants of Wareham and Plymouth were accustomed to vote to allow a certain number of barrels of alewives to be taken annually from the brooks within town limits, and that "menhaden were also taken in quantity at Wareham and barreled for exportation in former years."*

It is stated by the editor of Forest and Stream† that some Brooklyn people have a patented process for extracting the bones and superfluous oil from the menhaden or moss-bunkers, hitherto useless as food, and then salting the fish, which they claim are fully equal to No. 3 mackerel. Thus all parts are utilized.

Salt mackerel at times replaced by menhaden.

187. The inspection returns of Massachusetts show a curious relation between the annual returns of salted menhaden, alewives, shad, and mackerel. An examination of the table given in Appendix G shows that an effort was made during the season of scarcity in the mackerel fisheries to supply the demand by the use of menhaden.

The question of drawback on salt.

188. Capt. Fitz J. Babson, collector of customs for the port of Gloucester, states that the question yearly comes up as to whether the menhaden fishermen are entitled to privileges under the law granting

* Collections | of the | Massachusetts | Historical Society | —— | vol. iv. | of the second series. | Boston: | printed MDCCCXVI | : p. 284.

† Vol. II, 1874, p. 215.

drawback on salt used in pickling, nets, and fish. This discussion brings on the question whether menhaden are or are not "food-fishes." The decision has usually been made that they are food-fishes.

36.—Food preparations derived from menhaden.

The manufacture of sardines.

189. On the coast of New Jersey, near Port Monmouth, are several factories, which carry on an extensive business in canning menhaden in oil and spices. One of the largest of these is that of the American Sardine Company, a representation of which is given in Plate XXIV. Mr. F. F. Beals, of New York, gives the following description of the methods in use in this establishment:

"We aim to have our catch of moss-bunkers in by 6 or 7 o'clock a. m., as the fish seem to be strongly impregnated with phosphorus and soon spoil in warm weather. As soon as the fish are landed, we put our entire force of men to cleaning, cutting, and scaling, for which we have machines adapted. When the fish are cleaned, they are at once put in hogsheads, and salted just sufficiently to keep and to remove their extreme freshness. They are then packed in cooking cans, which are a little larger than the packing cans, and put into the tanks, where they are steamed for the space of about two hours. After the fish are taken out, they are placed in the regular market cans, which are then laid upon zinc-covered tables, where they are filled with salad oil. They then go to the tinners, who solder on the lids, after which the can is again steamed and vented, and passed up into the cleaning and labeling room. Each day's work is piled up separately, each can being thoroughly tested to see that it is perfectly air-tight. For this we have an experienced hand. Not a can is packed until it has stood for at least a month. At the expiration of this time, after being again tested, the cans are packed in wooden cases containing two dozen each, and are then ready for the market. As we make all our tin cases, we are able to secure good results, and it is a rare occurrence to have a swollen can. If there is one, it is at once thrown aside.

"Our company was incorporated April 21, 1871, under the laws of the State of New York. Seeing the magnitude of the sardine business on the other side of the Atlantic, we were impressed with the idea that there was a large field for operations in this country alone. We at once set about to find a fish which would supply the place of the European sardine. After many experiments, we at last found one to suit the purpose, viz, the moss-bunker, and commenced a series of experiments to find a means of extracting or softening the bones without the use of acids of any kind. After over a year of experiment, we at last found the desired process, which we secured under United States letters patent, dated May 21, 1872. This process consists of various modes of steaming until the bones become so soft that they can be eaten, like the flesh of the fish, without the slightest inconvenience. The two first years most of our time was con-

sumed in experimenting, so that it was not until a year ago that we really commenced to manufacture, though prior to that we put up some goods. Last year, 1873, we packed and sold about 30,000 dozen whole cans or boxes. We have now capacity to turn out double that amount and we expect to be obliged to do so, as our trade is rapidly increasing. Our goods have received various awards, including a medal of merit at Vienna in 1873, and a silver medal at Bremen in 1874."

During the season of 1877, the works of the American Sardine Company were not in operation. Mr. Beals, the secretary, informs me that the manufacture will be pressed strongly in 1878.

The qualities of American sardines.

190. Many persons are incredulous with regard to the possibility of manufacturing sardines of good quality from the menhaden. It need only be said that they have been carefully tested by many unprejudiced judges in the city of Washington, and that the verdict has always been that they were almost equal to French sardines of the best brands. There can be no reasonable doubt that if olive oil of good quality were to be substituted for the cotton-seed oil now used in the preparation of American sardines, they would be fully equal to similar articles imported from abroad.

The American sardines should be carefully distinguished from the sardines prepared at Eastport, Me., from young herrings; they are sealed up in tin cases imported ready-made from France, and are put upon the market in the guise of foreign goods—a misrepresentation which is not at all necessary, since they are quite as good as the articles with which they profess to be identical.

Menhaden preserved in spices.

191. There are other establishments near Port Monmouth which prepare menhaden in spices and vinegar under the trade names of "Shadine," "Ocean Trout," and "American Club-fish." I have been unable to obtain statistics of this branch of manufacture. Hoope & Coit, of New York, contributed samples of these preparations to the Centennial collection of the United States Fish Commission, and I suppose this firm to be engaged in the manufacture.

"Russian sardines" are prepared at Eastport, Me., from the herring, and are branded with spurious names and labels imported from Germany.

Mr. Barnet Phillips describes, in the New York Times, a visit to the "ocean-trout" manufactory at Port Monmouth. He writes: "If the name of the *salmonidæ* be taken a little in vain, the trout manufactured out of moss-bunkers are by no means to be despised. "Ocean trout" may not be the *garum* cooked with Tragasœan salt, but is a fair fish-food and as an alimentary substance is in good demand. The process of manufacture is simple. The fresh fish are scaled by machinery, by means of a revolving wheel, are then cooked in steam, packed into

boxes, which boxes have a cover put on them perforated with a couple of holes. The box containing only the fish is then plunged into a bath of pickle, where it remains until it fills itself, then the box, now full of fish and pickle, goes through a second cooking. When all hot, filled with steam, the two minute holes are closed with solder, a label is put on, and the moss-bunker, now metamorphosed into "ocean trout," instead of being turned into oil or being employed as a top-dressing for sterile soil, makes quite a delectable food, and doubtless to-day the advance of civilization in the United States is shown in remote portions of the country by cairns made up entirely of empty tin boxes once filled with edible moss-bunker.

Goodale's "Extract of fish."

192. The Hon. S. L. Goodale, of Saco, Me. (secretary of the Maine Board of Agriculture from 1856–1873), has invented a process by which the juices of the flesh of fish are extracted to form an article of food which promises to be of much commercial value. He writes: "Some time since the idea was conceived by me and reduced to practice of concentrating the juices of the flesh of fish into a food extract. The attempts were successful and the product satisfactory, bearing close resemblance to Liebig's *extractum carnis*, and possessing a like percentage of saline constituents and extractive matter, soluble in alcohol. My results thus far indicate that the more abundantly occurring *Clupeidæ* appear to be much better adapted to this use than any other fish yet tested, especially the menhaden and the herring, the latter having a more distinctively fish flavor, the former more nearly a simply rich-cooked meat flavor. The alewife I have not yet proved, but anticipate excellent results from its employment.

"During the two seasons past I have worked a few barrels of menhaden at a time, at intervals of a fortnight or more, to see if the juices varied in flavor or richness. My apparatus is imperfect, and although the extract *must be*, judging from my former experience with beef extract, inferior in flavor to what it would be if prepared with a vacuum pan and all suitable conveniences, it is good enough to elicit many commendations. No one needs less than yourself to be told how great are the possibilities for this new project. From each barrel of menhaden, as taken, I get three pounds of extract when flesh alone is used and four pounds if the spine is retained in dressing. And my rejections yield just as much oil and scrap as any manufacturers get who treat them for this alone. The skins may be used to make glue. I remove them by scalding quickly, in either mode of dressing. The details of manufacture are fully worked out.

Considering the large amount of fish annually taken and hitherto treated for oil and scrap alone, the juices of which have been allowed to run back into the ocean as a worthless by-product, I cannot avoid the

conclusion that a new source of food is within reach, which at no distant day may contribute materially to human welfare."

Mr. Goodale exhibited specimens of the extract of fish at the International Exhibition in Philadelphia.

The writer has had an opportunity of testing the qualities of the preparation and can testify to its agreeable flavor and manifestly nutritive properties. Two tablespoonfuls of the jelly dissolved in hot water yield a large dish of savory soup, most closely resembling the *potage consommé* of the French cooks.

Professor S. W. Johnson, of Yale College, wrote to Mr. Goodale: "I cannot doubt that the fish extract is entirely new, and as food or stimulant is equal to beef extract in all respects (except *possibly* in the matter of iron*), and if put into the market in the proper shape would shortly share the patronage now so largely bestowed on beef extract, &c." And again: "I find your extract of fish both by actual use and by chemical analysis in all respects equal to the best Liebig's extract of beef.

Mr. Frederick Law Olmstead, of New York, wrote: "I have made a trial of your extract and find it more palatable than any beef extract I have used. It is not at all fishy, but I think it has a slight distinctive agreeable flavor which is also found in rich fish gravy. I am strongly disposed to regard it as a very important invention."

The extract of fish has also been tested in hospitals in Portland, Me., and in New York City. Concerning the latter, Professor Johnson may again be quoted: "The fish extract was tried in this hospital. The physicians consider it in no way inferior to Liebig's. It was not suspected by nurses or patients to be anything else."

Possible yield of "extract of fish."

193. Mr. Goodale estimates that the fish used by the factories in the towns of Bristol and Boothbay, Me., in 1873, 1874, and 1875, allowing the product to equal one-fifth of the weight of the live fish, would have yielded in either year upwards of a million of pounds, or five hundred tons of extract of fish. Carrying out the same calculation for the entire catch of the Atlantic States the potential yield of the menhaden fisheries would exceed ten millions of pounds.

37.—MENHADEN AS FOOD FOR ANIMALS.

Menhaden scrap as food for cattle and poultry.

194. At a meeting of the "Maine Board of Agriculture and Farmer's Convention" at Wiscasset, Mr. Wasson gave an interesting account

* With regard to Professor Johnson's suggestion of possible difference in contents of iron, I cannot speak confidently, but my impression is that this element occurs mainly if not wholly in the blood corpuscles; that these are entangled in the albuminous constituent, as it coagulates in boiling and are removed in the serum which rises and is taken off, consequently that iron would not be found in appreciable quantity in extract made from either beef or fish.—S. L. GOODALE.

Professor Johnson's later analyses seem to confirm the impression of Mr. Goodale.

of the use of "porgy chum" as a food for sheep and poultry, stating that he had used it for five years. To prepare it for food it is prepared by drying it in the sun for two days on elevated racks, thus expelling a large portion of the water. When thus dried it will keep for an indefinitely long period. Mr. Wasson had kept a quantity in an open barrel in his barn for at least five years. One barrel, costing $2, was sufficient to feed three sheep during the entire winter. Sheep thus fed showed an average increase each of one pound and a quarter of wool, while they were constantly fat and brought heavy lambs. Hens also ate the scrap with avidity. Mr. Thomas Boyd of Boothbay, stated that hens, ducks, and turkeys prefer it to corn, and become large and heavy when fed upon it. It is customary to discontinue the scrap and feed them on corn three or four weeks previous to killing them. Professor Charles A. White inquired in regard to its effects upon the quality and flavor of the meat of animals fed with chum, stating that hogs fed in the acorn or mast region of the west do not make such firm sweet pork as those fed on corn. None of the members present were able to answer this question.

Mr. Luther Maddocks, of Boothbay, a leading manufacturer, stated that if a demand should occur for scrap to be used as animal food, it could be so pressed as to retain only 25 per cent. of water, and in that form it would be more suitable for transportation. Ordinarly it contains about 50 per cent. of water.

Apparently this subject deserves careful investigation. In the Norwegian Department in Agricultural Hall at the International Exhibition of 1876 were exhibited some biscuits made from "fish-flour," a preparation invented by the late Anton Rosing, a prominent agricultural chemist of Norway. These biscuits were in good condition after having been kept for ten years in an unsealed jar. They were intended to be applicable to the uses of soldiers, miners, and farmers, to whom a supply of fish, other than salted, is beyond reach. The editor of the American Agriculturalist suggests that a similar process might be employed in utilizing the refuse of the oil manufactories as food for stock.* The proper preparation of this material for feed, either alone or mingled with bran, corn-meal, or other products of grain, would doubtless be a great economy, both for feeding and enriching the manure.†

L.—THE MENHADEN AS A BAIT FISH.

38.—The use of menhaden for bait.

Menhaden as cod bait.

195. Menhaden bait is extensively used in the cod and mackerel fisheries in New England and the British Provinces. Its popularity is no doubt chiefly due to the ease with which it may be obtained in large

* American Agriculturist, Vol. XXXV, 1876, p. 314.

† The value of menhaden as a food for animals is discussed more in detail by Professor Atwater in the succeeding part of this report.

quantity, though its oily nature and strong odor render it particularly well adapted for use as a toll bait for mackerel. "Slivered pogies" are carried by the "bankers" or vessels fishing for cod on the Newfoundland and George's Banks from the ports of Gloucester and Provincetown.* According to Captain Atwood, salted menhaden are good bait for haddock but inferior for cod. On the Labrador coast the bait principally used is a small fish of the salmon family known as the capelin (*Mallotus villosus*) large quantities of which are easily procured in those waters for a short period in the summer. The herring (*Clupea elongata*) is the most common bait in the Bay of Fundy cod-fisheries and it is also used by the English "bankers" to a considerable extent, as well as young mackerel. The English vessels also consume a large amount of "slivered pogies" which they buy from Massachusetts vessels. Fresh "slivers" are preferred to those which have been salted, and vessels bound to George's Banks usually carry their bait preserved on ice.

Menhaden as mackerel bait.

196. As a toll bait for the mackerel fishery, the menhaden is better than any other fish. The mackerel seem to prefer it, and the presence of a great quantity of oil renders it especially convenient for the use of fishermen, since a small quantity of ground menhaden bait will spread over a large area of water.

The introduction of the use of menhaden bait.

197. In early days it was the custom to grind up small mackerel for bait, much to the detriment of the fisheries in succeeding years. Captain Atwood remarked in his testimony before the Fishery Commission at Halifax: "We now use menhaden for bait; but when I first went fishing we did not do so. Our practice then was to grind up small mackerel for the purpose. Any quantity of these mackerel were at that time to be found along the coast and plenty of them are there to be met with now. These fish were of no account then, and so we ground them up for bait; and when we could not obtain them, we ground up for bait what you call gurry, the inwards of fish with the gills attached. American fishermen, when they fish with hooks, use menhaden bait almost exclusively. The superiority of this bait over all others is such that when this fish can get menhaden they won't take any other. At first mackerel fishermen were afraid of this bait. It is a very bony fish, and they then thought that if it was cut up for bait, the mackerel would soon get sick of it, owing to the number of bones. There is a species of fish belonging to this family found on our coast which is exceedingly fat. We call them blue-backed herrings;† and some preferred this fish for bait, as it was not so bony as the menhaden; but when the poorer

* Vessels also carry for bait "sea-clams" (*Mactra solidissima*) salted, and the common long clam (*Mya arenaria*). The former are preferred by vessels fishing off Block Island and Nantucket to supply the New York market with fresh cod and haddock. They are sold at Nantucket at the rate of 30 cents a bushel

† The alewife, *Pomolobus pseudoharengus*.

mackerel got to be worth having, about everybody adopted menhaden for bait. It is the cheapest bait."*

The comparative value of herring and menhaden for toll bait

198. Mr. Sylvanus Smith stated before the Halifax Commission: "All the bait used in mackerel fishing consists of menhaden or porgy, which is only found off the coast of the United States, and which the Canadians bought from the American fishermen to a great extent"†

Also to the same effect Mr. James G. Tarr: "The only bait used for mackerel is the porgy or menhaden, which is found entirely in the United States, and which all the Canadians have to buy from the Americans in a salted state. This fish (the porgy) is not found in Canadian waters, and is almost the only bait used in the mackerel fishery; if the Canadians were unable to procure this bait, they would be compelled to use herring bait, which is much inferior for the purpose. * * * I have known vessels to sail from this port (Gloucester) with as many as 300 barrels of porgy bait on board, which was sold in Halifax and the Straits of Canso to Canadian fishermen. * * * The bait which we buy from them for the cod-fishery consists of herring and some small mackerel."‡

John E. Saunders remarked: "Fresh herring is used by Canadians somewhat, but it is an inferior sort of bait, and they much prefer menhaden when they can get it. * * * Canadians import menhaden bait from the United States to some extent; the menhaden is not found north of Cape Sable."§

Richard Hannan, of Gloucester, also stated: "I have sold menhaden bait to the Canadians, a few barrels each year; they import a great deal of this bait from the United States; now by the treaty they can come here and catch this bait themselves. To my own knowledge there have been two or three vessels here from Yarmouth and Argyle which came to catch porgies for use in the bay.‖

James G. McKeen, of Port Hastings, Nova Scotia, on the Strait of Canso, stated: "The bait chiefly used by American mackerel-fishing vessels is menhaden or porgies. These fish are taken, I believe, entirely on the coast of the United States, and mostly in seines within three miles of the land, so I have been informed. British mackerel fishermen use the same kind of bait principally, and depend on the United States for the supply. Clams are also used as bait for catching mackerel by both American and Colonial mackerel vessels, and they are obtained chiefly in the United States."¶

George Critchet, of Middle Milford, Guysboro County, Nova Scotia,

* N. E. Atwood. Proceedings of Halifax Commission, Appendix L, p. 42, September 19, 1877.
† Affidavit 34. Proceedings of the Halifax Commission, 1877, Appendix M, p. 81.
‡ Affidavit 36, *op. cit.*, p. 83.
§ Affidavit 41, *op. cit.*, p. 86.
‖ Affidavit 42, *op cit.*, p. 86.
¶ Affidavit 176, *op. cit.*, p. 195.

stated: "The only bait used by mackerel fishers in the Gulf of St. Lawrence is clams and porgies, and that comes all from the United States."*

Christopher Carrigan, of Lower Milford, Nova Scotia, also stated that, he has been on two trips in the north bay in provincial mackerel vessels and that they used only clams and porgies for bait.†

A similar statement was made by Martin Ryan, of Middle Milford, who had fished five seasons in provincial vessels,‡ and Philip Ryan of the same place, who stated that porgies and clams are universally used in the bay (Gulf of St. Lawrence), although a few provincial vessels may occasionally use herring.§

Andrew Laurie, of Lower Milford, also stated that herring is only used as bait when the vessels of the provincial fishermen are out of porgies and clams, which are better,‖ and this was confirmed by Thomas England,¶ Rufus Carrigan,** and Charles Lowrie,†† of Milford, George Laidlaw‡‡ and R. McDonald, of Low Point, Inverness County, Nova Scotia, who remarked: "The only bait American mackerel vessels use is porgies and clams, and that is the bait nearly always used by provincial vessels, but sometimes the latter use herring, which is not a good bait and would not do at all to use as bait in fishing alongside of vessels throwing out porgies and clams."§§

Daniel McDonald, also of Low Point, stated that "ten or twelve years ago or longer there were about 400 or 500 American mackerel vessels in the bay of Saint Lawrence, and during the same time there were about 100 provincial vessels in the bay. The only bait used for mackerel, or almost the only, consists in porgies and clams, and these all come from the United States, whether used by provincials or Americans; a few English vessels use also a little fat herring, but this is used in quantities hardly worth mentioning."‖‖

James R. Maclean, a merchant of Souris, Prince Edward Island, called on behalf of the Government of Her Britannic Majesty, sworn and examined, testified:

"Question. With regard to the bait in use for cod-fishing and mackerel, where is it obtained?—Answer. They very often use herring and sometimes porgies.

"Q. Where do they get the herring?—A. They catch them around the coast and at Labrador.

"Q. Are herring caught there?—A. Yes; there is a lot of herring taken.

* * * * * * *

"Q. The different fishermen—the large fishermen and the small fishermen—don't they all catch their own bait?—A. Yes, with nets; and for

* Affidavit 188, *op. cit.*, p. 202.
† Affidavit 189, *op. cit.*, p. 202.
‡ Affidavit 191, *op. cit.*, p. 204.
§ Affidavit 192, *op. cit.*, p. 204.
‖ Affidavit 193, *op. cit.*, p. 205.
¶ Affidavit 194, *op. cit.*, p. 205.
** Affidavit 195, *op. cit.*, p. 206.
†† Affidavit 197, *op. cit.*, p. 207.
‡‡ Affidavit 200, *op. cit.*, p. 209.
§§ Affidavit 201, *op. cit.*, p. 210.
‖‖ Affidavit 202, *op. cit.*, p. 210.

mackerel bait they take capling—a very fat little fish—and they make out that it is a better bait for mackerel than porgies.

"Q. But the large proportion of the bait is herring?—A. Yes; but they use porgies, which they often buy for bait.

"Q. To any extent?—A. The vessels which go fishing generally buy them. They prefer herring when they cannot get porgies good.

"Q. Where do they buy porgies?—A. They generally buy them on the island, where they are imported.

"Q. They buy them from the merchants?—A. Yes. It would not pay to send down to American waters to fish for porgies for the number of vessels engaged in mackerel-fishing.

"Q. They prefer to take herring, to do that?—A. Yes.*

"Cross-examined by Mr. Dana:

"Q. And your people are buying bait from the United States?—A. They sometimes do so.

"Q. You said that they very often bought pogies, which were used by your people?—A. Yes.

"Q. You mean menhaden—it is the same thing?—A. Yes.

"Q. Where do the merchants get their pogies?—A. From the States.

"Q. Do you really suppose that the American fishermen, instead of buying menhaden from first hands, would buy them of your merchants, paying their profit, and commissions, and freight, and all that?—A. Yes. I have seen these fishermen buy them when their own bait had turned sour or was bad. If the merchants have a quantity of good bait on hand, they can generally sell it.

"Q. Is that considered an article of trade?—A. No; not to a great extent.

"Q. Then the Americans get caught; their bait sometimes turns sour?—A. Yes. Consequently, of course, if out with other vessels fishing, a vessel having bad bait could not secure her share of the fish.

"Q. Can they not catch something else to be used in place of it; herring, for instance?—A. Not always. The mackerel-catchers could not wait for this. Their business is to catch mackerel.

"Q. But they can obtain it at the Magdalen Islands?—A. It would take too much time to cross at that point.

"Q. Your own fishermen could not get across any sooner?—A. No.

"Q. If you could fit out a great number of large vessels for mackerel-fishing, you would want to import a good deal of this bait, pogies or menhaden, would you not?—A. Yes; we would then, likely, import quite a lot of it. They could, however, use herring if no menhaden or poges were thrown into the fishing ground. Herring would do nearly as well.

"Q. But the fish want something better.—A. Yes."†

Mr. George Mackenzie, fisherman, of New London, Prince Edward

* Proceedings of Halifax Commission, 1877. Appendix F, p. 24.

† *Ibid.*, p. 29.

Island, witness called on behalf of the Government of Her Britannic Majesty, cross-examined by Judge Foster, testified:

"Question. There is no mistake but what the American bait is a good deal better than any other; there is no question about that?—Answer. No; it is always very well liked, but we have to pay pretty high for it.

"Q. Do you buy it?—A. Yes.

"Q. How much of it do you use?—A. I used 20 barrels last year, and I bought 20 more barrels this year, at $5 a barrel.

"Q. That makes $100 spent for manhaden bait?—A. Yes.

"Q. Do you mix this bait with herring?—A. Yes; and sometimes we mix it with clams. At the latter end of the season it is that bait which we want. When the fish are poor almost any bait will do, but when they are in good condition they require good bait.

"Q. When do you use herring bait?—A. In the spring of the year and July.

"Q. Do you mix manhaden with it?—A. Sometimes.

"Q. If it was not for its expensiveness, you would not use herrings at all?—A. No.

"Q. Do you use mills to grind the bait?—A. Yes.

"Q. And you mix the herrings and menhadens together?—A. Yes; and we also chop up clams with it."*

And, again, James McKay, deputy inspector of pickled fish at Port Mulgrave, examined by Mr. Hanson:

"Question. On your different trips mackerel-fishing, what bait do you use?—Answer. Pogies.

"Q. These are generally put up on the coast of Maine?—A. Yes.

"Q. Where would you buy them if British vessels take them?—A. Our merchants used to import them from Portland, Boston, and Gloucester.

"Q. To Port Mulgrave?—A. Yes.

"Q. And sell them as articles of merchandise?—A. Yes.

"Q. They bought and sold them?—A. The same as a barrel of flour."†

The testimony of Canadian officers.

199. H. W. Johnson, of the Department of Marine and Fisheries, wrote, in 1868, a "Special Report on the Distress among the Nova Scotia Fishermen." One of the reasons assigned by him for the failure of the fisheries is that "the pogies, the only real mackerel bait, is not caught east of Portland, and must all be imported for our fleet, the increased cost of which, added to the American duty, the fisherman has to pay on his share of fish, besides charges of transportation, place him in the position that if he catches during the season, to his own share, forty barrels of mackerel in one vessel, he has not made as good a season by about $100, gold, as if he had been in an American bottom."‡

* Proceedings Halifax Commission, 1877, Appendix F, p. 132.

† *Ibid.*, p. 190.

‡ *Ibid.*, p. 67.

Capt. P. A. Scott, R. N., commanding the marine police of the Dominion, reported, in 1870, to the Commissioner of Marine and Fisheries: "For mackerel-fishing the Americans use pogies and clams, chopped fine, as bait. The pogies are found only on the coast of the United States, and when imported into the Dominion cost about $6 per barrel."*

Capt. Charles G. F. Knowles, R. N., commanding H. M. S. "Lapwing," cruising on fishing-station No. 4, which includes the west coast of Cape Breton and the east coast of Prince Edward Island, reported to Vice-Admiral Fanshawe, November 7, 1870, in these words: "The bait with which the Americans are supplied is far superior to any which can be procured in this country, to which may be attributed in a great measure the success of the Americans previously to the recent restrictions, although, even now, the local fishermen complain that they have no chance while an American schooner is fishing near them."†

200. Professor Hind, in his treatise on the Effect of the Fishery clauses of the Treaty of Washington on the Fisheries and Fishermen of British North America (part 1, p. 75), remarks that its value as a bait for cod is, in a considerable degree, superseded by the herring; but as a bait for "tolling mackerel" it is still in repute, although other fish, similarly treated and finely ground, appear to be equally useful in this respect. The first part of this statement is undoubtedly true, at least as far as the fishermen of the British Colonies are concerned. In regard to the comparative value of herring and menhaden for toll-bait, there is still room for difference of opinion.

An average of, perhaps, 250,000 barrels of mackerel is annually caught by the United States vessels, using menhaden bait solely, against 110,000 caught by the provincial fleet, which appears to use menhaden bait when it can be obtained, buying it at the rate of $6 a barrel in preference to herring bait, which costs only the labor of catching and the salt for preserving.

Slivering menhaden.

201. The method of preparing menhaden for salting, to be used as bait, is very simple. The head of the fish is taken in the left hand of the workman, and with a knife held in the right hand he cuts a slice, longitudinally, from each side of the body, leaving the head and vertebræ to be thrown away, or, occasionally, to be pressed for oil. The slivers (pronounced *slyvers*) are salted and packed in barrels. The knife used is of a peculiar shape and is called a "slivering knife." The operation of slivering is shown in Plates XXII and XXIII.

The preparation of mackerel bait.

202. The use of menhaden bait for mackerel-fishing was inaugurated in 1835 or 1840; the bait is ground up into a mush and salted, to be used

* Third Report Commissioner Marine and Fisheries, 1871, p. 312.

† Third Report Department Marine and Fisheries, 1871, p. 342.

as a "toll-bait," and to be thrown over the side of the smack to attract the school to the surface and to keep it alongside; this is called "chumming up the fish," and the bait is called "chum" or "stosh." To prepare it for use the "slivers" are passed through a "bait-mill," which is a machine like a farmer's feed-cutter; the fish are thrown into the hopper, from which the fish pass between a roller armed with small knives in rows, and a series of similar knives arranged along a board which slopes toward the bottom. The bait is usually ground at night, by the watch on deck; when the vessel has no "bait-mill," the fish are cut up with a hatchet or scalded with boiling water in a tub. Bait-mills were first introduced about the year 1824. In fishing for mackerel, one man throws over the bait while the rest ply their lines. "Toll-bait" is also used by the smacks, which use purse-seines and drift-nets, to attract the fish to the surface.

The use of menhaden bait in the coast fisheries.

203. Menhaden bait is also used in the coast fisheries for sea-bass, on the "bull-tows" or "trot-lines," and in the eel and lobster pots. They are not much in favor for the latter use, however, for the oil of the fish is thought to permeate the flesh of the lobster, imparting to it an unpleasant flavor.

Extent of bait-fishery in New England.

204. Captain Babson, of Gloucester, whose account of the bait-fishery of Cape Ann is quoted elsewhere, and to whom I am indebted for much other valuable information, informs me that there were over 60,000 barrels of "round fish" taken in his district in 1873. Vessels belonging to the companies of the Maine Oil and Guano Association sold in 1873 for bait 2,977 barrels; in 1874, 10,400; in 1877, 10,795. From the bait fisheries about Marblehead, in the vicinity of Provincetown, 1,000 to 2,000 barrels were taken for bait in 1873, according to Mr. Loring. At Chatham, for the past five years, the average catch has been about 5,000 barrels, a large portion of which are sold to the George's Bank codfish vessels. Nothing has been heard from the bait fisheries about Nantucket, which are, however, quite unimportant.

A large part of the fish taken at Martha's Vineyard are used for bait; in 1873 there were 5,000 barrels according to Jason Luce & Co.

At Gloucester, according to Mr. Babson, the 60,000 round barrels of fish make 20,000 barrels of "slivers," worth $4 per barrel to the producer. At Marblehead, it averages $1 per barrel for fresh and $6 for salt; at Chatham, $1.50 fresh; at Nantucket, 50 cents to 75 cents, and at Martha's Vineyard 50 cents, as I am told. In Narragansett Bay, according to Mr. J. M. K. Southwick, bait sold in 1871 for $1 and $1.50.

Bait-fishery in Merrimac River and Salem Harbor.

205. Fisheries of some importance are carried on at the mouth of the Merrimac River. The menhaden thus obtained are used chiefly to sup-

ply the Cape Ann fishing fleet with bait, although they are salted for food to a considerable extent. Ten seines and about seventy men are engaged in this fishery during its continuance, which is usually about one month—from the middle of June to the middle of July. The seines are 100 to 200 yards long and 5 to 8 fathoms deep, requiring 6 to 8 men to manage them. The boats from which they are worked are light scows, about 25 feet in length, and 8 feet in breadth of beam. The seine is set from the stern of the scow, and is worked from the shore by means of long warps.

Capt. Moses Pettingell, of Newburyport, to whom I am indebted for the above facts, tells me that the seine-gangs have occasionally taken 2,000 barrels of fish in a single day.

Boston and Gloucester vessels come to anchor at the mouth of the river and wait for their supplies of bait. At one time in 1877 there were 25 fishing schooners waiting. Captain Pettingell estimates that 500 supplies of bait of from 10 to 60 barrels are sold annually by the Merrimac seine-gangs.

The regular price of fresh bait for the past ten years has been $1 per barrel. Probably 1,000 barrels of slivered fish were prepared in 1876; these sold for $5 per barrel. Captain Pettingell estimates the annual catch for 1876 at 2,000 barrels to a boat, making an aggregate catch of 20,000 barrels, or perhaps 6,600,000 fish. The returns are probably not far from $20,000 in a good season.

The following table is from the Report of the Commissioners of Inland Fisheries for 1877 (p. 65). It is possibly not complete:

TABLE.—*Seine fishery at mouth of the Merrimac.*

Name.	Menhaden.
E. Thurlow R. Pierce B. M. Perkins W. H. H. Perkins N. Lattime B. Stevens	2,013,675

A similar fishery, though of much less extent, is carried on by Gloucester vessels in Salem Harbor. There being no considerable body of fresh water, the schools are small and are easily dispersed. July 15, 1877, I observed six or seven gangs busily plying their seines opposite The Willows. After a day or two the menhaden were driven away, and the fishing ceased until the following week, when they returned and were soon followed by the same boats.

An estimate of the total consumption of menhaden bait.

206. It is not practicable to make, from the data to which I have access, any very accurate estimate of the total quantity of menhaden

bait used in one year. I have given below a number of estimates for individual ports or fisheries; 60,000 round barrels are thus accounted for. I do not hesitate to estimate the total consumption for 1877 at 80,000 barrels, or 26,000,000 of fish.

Consumption by the George's Banks fleet.

207. The George's Banks cod fleet is owned entirely in Gloucester There are about 130 vessels, making usually one trip every twenty days. When they can get slivered menhaden they carry no other bait. Early in the summer they go to the Vineyard Sound for their bait, where they buy it from the pounds; later they are able to buy it from Gloucester and Newburyport seines. Each vessel carries about 40 round barrels of menhaden, iced. Mr. Joseph O. Proctor estimates the annual number of trips made with this bait at 600. This gives a total amount of 24,000 round barrels, or about 8,000,000 of fish; 24,000 round barrels are equivalent to 8,000 barrels of slivered fish.

Ten years ago, according to the estimate of the same gentleman, the "Georgiamen" did not carry menhaden bait on so many trips, nor did they carry so much. He estimates 300 trips, at 30 barrels each, giving an aggregate of 9,000 round barrels, or about 3,000,000 fish.

Consumption by the Grand Banks fleet.

208. Mr. Proctor estimates that the Grand Bank cod vessels of Gloucester use in all about 600 barrels of slivered menhaden bait.

Major Low's statement of the outfit of the schooner "Madam Roland,"* copied from the trip-book, shows that she was supplied with 5 barrels of pogie slivers, at $8 per barrel, making $40; and 5 barrels of slack-salted clams, at $11, making $55.† His model table, to show the cost of a new schooner fitted at Gloucester, 1875, for a four months' trip to the Grand Banks for codfish and halibut, with 14 hands, estimates for 12,000 pogies or herring, at $100.‡

Consumption by the mackerel line-fishermen.

209. Each mackerel-vessel engaged in line-fishing consumes during the course of the season about 20 barrels of salted menhaden slivers. In 1867, when the entire fleet fished with hooks, the amount consumed by Gloucester alone amounted, by Mr. Proctor's estimate, to 6,500 barrels, and the total consumption in the United States of mackerel bait must have exceeded 25,000 barrels. In 1877 the purse-seiners are in a large majority. The whole amount consumed by a seining-vessel does not exceed 5 or 6 barrels in a season. Gloucester had in 1877 about 60 "mackerel-hookers," using about 2,400 barrels of slivers, while its seining-fleet used about 2,000 barrels more.

* Sailed for the Grand Banks August 26, 1873; arrived at Gloucester October 10, 1873; time absent, one month fourteen days; gross stock, $2,758.27.

† *Ibid.*, p. 362.

‡ *Ibid.*, p. 368.

Capt. Sylvanus Smith, of Gloucester, stated to the Halifax Commission that a vessel fitting out for a four months' trip to the Gulf of St. Lawrence would need to be supplied with 40 barrels of pogie bait, worth $6 a barrel, making $240, and 10 barrels of salt clams, worth $8 a barrel, making $80.*

Major Low's statement, copied from the trip-book of the schooner Oliver Eldridge,† shows that she fitted out with 55 barrels of slivered pogies, at $6.50 a barrel, making $357.50, and 7 barrels of clams, at $6, making $42.‡

The amount of these outfits is much greater than that upon which the above estimate was made.

The entire amount used in the mackerel fishery in 1877 probably did not exceed 8,000 or 9,000 barrels of slivers, or 24,000 to 27,000 barrels of "round fish."

Consumption by the Connecticut smacks.

210. There are seven Connecticut smacks fishing for the flounder (*Chaenopsetta ocellaris*) in Long Island and Block Island Sounds. Five of these hail from Noank, one from Mystic, and one from New London. Captain Ashby tells me that these smacks average one trip every four or five days for five months (May to September inclusive). They use only menhaden bait; about one barrel each trip, or perhaps 150 barrels in the season.

Sixteen Noank and four New London smacks fish for sea-bass. Each carries two or three barrels of menhaden bait each trip, making an aggregate annual amount of about 1,000 barrels.

Consumption by the New York halibut fleet.

211. The New York halibut fleet of 11 sails, owned at Noank, New London, and Greenport, uses only menhaden bait, which is iced fresh in the vessels' holds. Each vessel carries from 6,000 to 10,000 fish each trip. Each vessel makes five or six trips. The aggregate number of menhaden thus used is perhaps 480,000, or 1,400 barrels. The usual price is $4 a thousand.

Annual sale of bait by the Maine manufacturers.

212. The Menhaden Oil and Guano Manufacturing Association of Maine sold for bait:

	Barrels of fish.
In 1873	2,977
In 1874	10,400
In 1875	10,752
In 1876	8,432
In 1877	10,795

* Proceedings Halifax Commission, 1877, Appendix L, p. 334.

† Which sailed for the Bay of St. Lawrence August 5, 1875 (absent 2 months and 28 days), arrived at Gloucester November 2, 1875, stocking $1,771.83, or 224 barrels of mess mackerel.

‡ *Ibid.*, p. 364.

The Connecticut method of icing bait.

213. A peculiar method of preserving the unsalted menhaden is made use of on board of the Connecticut halibut-catchers. The fish, after being very carefully cleaned and eviscerated, are packed with pounded ice in bins holding about 125 cubic feet (about 5 feet in each dimension). A ground-layer of ice-blocks 12 inches thick is first laid, then a tier of fish consisting of two layers and about 4 inches thick, then a layer of 4 inches of pounded ice, and so on until the bin is filled, after which its sides are packed with pounded ice and covered with canvas. Seven to ten thousand fish are thus stowed in one bin. The stowing having been completed, the fish and ice freeze together in a solid mass, which is left untouched until the fishing-banks are reached.

Their supply of bait being thus secured, the vessels are never obliged to make harbor in search of a new supply. They often catch their fare upon La Have or Brown's Bank, and return home without having anchored. The bait is good for three weeks. Captain Ashby assures me that he has used it on the thirty-third day.

The Cape Ann method of icing bait.

214. On board the Gloucester vessels the menhaden are not eviscerated, nor are they packed with so much care; consequently they never last more than three weeks. Since twenty-four hours or more are usually occupied on both outward and home voyages, there is only a short time left for which the supply of bait can be counted upon. If by any means this time could be doubled, an important advantage would be acquired. Vessels would often be able to complete their fares on the eastern banks without going to Newfoundland for bait. Does the Connecticut method fulfill this requirement? Captain Hurlbert, one of the most experienced fishermen of Gloucester, says no. He claims that neither cod nor halibut will bite well at a fish which has had its blood removed. He says that a half-decayed fish, with the blood still in it, is better bait than a perfectly sweet one kept by cleaning it. He says, still further, that Gloucester fishermen formerly followed this method, but that it was abandoned many years ago, as early as 1866.

The comparative value of various methods of icing.

215. The comparative value of the different methods of preserving bait was discussed by Professor Baird in his testimony before the Halifax Commission, which is quoted:

"Question. Now will you state what observation you have made respecting the method of preserving fresh bait from the start all the voyage through?—Answer. As a general rule it is now preserved either by salting or freezing. Of course they keep it as long as it will remain without spoiling, and when you have to carry it beyond that time either ice it or salt it. Salting, of course, is a very simple process, but it alters

materially the texture and taste to such a degree that fish or other bait that under certain circumstances is highly prized by the fish is looked upon with a great deal of indifference when salted. Now, there are special methods of preserving the fish or bait by some chemical preparation, which preserves the fish without giving the saline taste. There are preparations by means of which oysters or clams or fish can be kept in solutions for six months without getting any appreciable taste, and without involving the slightest degree of deterioration or destruction. One process submitted to the group of judges, of whom I was chairman, was exhibited by an experimenter, who placed a jar of oysters in our room prepared in that way. I think about the 1st of August those were placed in our room, and they were kept there until the middle of September, for six weeks during the hottest portion of the Centennial summer, and that was hot enough. At the end of that time we mustered up courage to pass judgment upon this preparation, and we tasted these oysters and could not find them affected. We would have preferred absolutely fresh oysters, but there was nothing repugnant to the sensibilities, and I believe we consumed the entire jar. And we gave the exhibitor, without any question, an award for an admirable new method. That man is now using that process on a very large scale in New York for the preservation of fish of all kinds, and he claims he can keep them any length of time and allow them to be used as fresh fish quite easily. I don't suppose any fisherman ever thought of using any preservative except salt.

"Q. That is entirely experimental?—A. It is experimental, but it promises very well. Now, borax is one of the substances that will preserve animal matter a great deal better than salt, and without changing the texture. Acetic acid is another preparation, or citric acid will keep fish a long time without any change of the quality, and by soaking it in fresh water for a little while the slightly acidulated taste will be removed. I don't believe a cod will know the difference between a clam preserved in that way and a fresh clam.

"Q. Now, about ice. We know a good deal has been done in the way of preserving bait in ice. How far has that got?—A. It is a very crude and clumsy contrivance. They generally break up the ice into pieces about the size of pebble stones, or larger; then simply stratify the bait or fish with this ice, layer and layer about, until you fill up a certain depth or distance. The result is that if the bait can be kept two weeks in that method it is doing very well. They generally get a period of preservability of two weeks. The ice is continually melting and continually saturating the bait or fish with water, and a very slow process of decomposition or disorganization goes on until the fish becomes musty, flabby, and tasteless, unfit for the food of man or beast.

"Q. Well, there is a newer method of preservation, is there not?—A. There is a better method than using ice. The method described by the Noank witness, by using what is equivalent to snow, allows the water

to run off or to be sucked up as by a sponge. The mass being porous prevents the fish from becoming musty. But the coming methods of preserving bait are what is called the dry-air process and the hard-freezing process. In the dry-air process you have your ice in large solid cakes in the upper part of the refrigerator and your substance to be preserved in the bottom. By a particular mode of adjusting the connection between the upper chamber and the lower there is a constant circulation of air, by means of which all the moisture of the air is continually being condensed on the ice, leaving that which envelopes the bait or fish perfectly dry. Fish or any other animal substance will keep almost indefinitely in perfectly dry air about 40° or 45°, which can be attained very readily by means of this dry-air apparatus. I had an instance of that in the case of a refrigerator filled with peaches, grapes, salmon, a leg of mutton, and some beefsteaks, with a great variety of other substances. At the end of four months in midsummer, in the Agricultural Building, these were in a perfectly sound and prepossessing condition. No one would have hesitated one moment to eat the beefsteaks, and one might be very glad of the chance at times to have it cooked. This refrigerator has been used between San Francisco and New York, and between Chicago and New York, where the trip has occupied a week or ten days, and they are now used on a very large scale, tons upon tons of grapes and pears being sent from San Francisco by this means. I had a cargo of fish-eggs brought from California to Chicago in a perfect condition. Another method is the hard-frozen process. You use a freezing mixture of salt and ice powdered fine, this mixture producing a temperature of twenty degrees above zero, which can be kept up just as long as occasion requires by keeping up the supply of ice and salt.

"Q. How big is the refrigerator?—A. There is no limit to the size that may be used. They are made of enormous size for the purpose of preserving salmon, and in New York they keep all kinds of fish. I have been in and seen a cord of codfish, a cord of salmon, a cord of Spanish mackerel, and other fish piled up just like cord-wood, dry, hard, and firm, and retaining its qualities for an indefinite time.

"Q. Well, can fish or animals be kept for an unlimited period if frozen in that way?—A. You may keep fish or animals hard dried frozen for a thousand years or ten thousand years perfectly well, and be assured there will be no change.

"Q. Have geologists or paleontologists satisfied themselves of that by actual cases of the preservation of animal substances for a long period?—A. Yes; we have perfectly satisfactory evidence of that. About fifty years ago the carcass of a mammoth, frozen, was washed out from the gravel of the river Lena, I think, one of the rivers of Siberia, and was in such perfect preservation that the flesh was served as food for the dogs of the natives for over six months. Mr. Adams, a St. Petersburg merchant, came along on a trading expedition, and found it nearly con-

sumed, and bought what was left of it for the St. Petersburg Academy of Science—the skeleton and some portion of the flesh—which were preserved first in salt and afterwards in alcohol. Well, we know the period of time that must have elapsed since the mammoth lived in the arctic circle must be very long. We know we can talk with perfect safety of ten thousand years. The geological estimate of it is anywhere from fifty to a hundred thousand years; we cannot tell. There is no unit of measure; we know it must have been some hundreds of thousands, and probably it would have remained in the same condition as much longer.

"Q. Now, to come to a practical question, is this a mere matter of theory or of possible use? For instance, could this method be adapted to the preservation of bait for three or four months if necessary?—A. The only question of course is as to the extent. There is no question at all that bait of any kind can be kept indefinitely by that process. I do not think there would be the slightest difficulty in building a refrigerator on any ordinary fishing-vessel, cod or halibut, or other fishing-vessel, that should keep with perfect ease all the bait necessary for a long voyage. I have made some inquiries as to the amount of ice, and I am informed by Mr. Blackford, of New York, who is one of the largest operators of this mode, that to keep a room ten feet each way, or a thousand cubic feet, at a temperature of 20° above zero would require about 2,000 pounds of ice and two bushels of salt per week. With that he thinks it could be done without any difficulty. Well, an ordinary vessel would require about seventy-five barrels of bait, an ordinary trawling vessel. That would occupy a bulk something less than 600 feet, so that probably four and a half tons of ice a month would keep that fish. And it must be remembered that his estimate was for keeping fish in midsummer in New York. The fishing-vessels would require a smaller expenditure of ice, as these vessels would be surrounded by a colder temperature. A stock of ten to twenty tons would, in all probability, be amply sufficient both to replace the waste by melting and to preserve the bait."*

39.—Conflicts between bait fishermen and others.

Early feuds.

216. Some jealousy has naturally arisen at times between the bait-fishermen and the manufacturers, as is shown by the following extract from Professor Johnston's "History of the Towns of Bristol and Bremen, in the State of Maine."

A special branch of the fishing business has of late been undertaken quite largely here (in Bristol), as at other places on the New England coast, called the "porgey fishery." The fish are taken in seines, usually several miles from the coast, and are used for the oil they produce, and for manure.

* Proceedings Halifax Commission, Appendix L, p. 457.

These fish, the common menhaden of the coast, have been caught for use as bait in the cod-fishery from the earliest times; and at first the new branch of industry, in which such immense quantities are consumed, was viewed by the old fishermen with no little suspicion, as likely to interfere with the important and older branch of the fishing business by depriving them of bait. Some riots were at least threatened, and one oil factory was actually destroyed, as was believed, by the old fishermen, or at their instigation; but the opposition has ceased, and the general opinion seems to be that it is best to foster such an extensive branch of business, giving profitable employment for a part of the season, as this does, to so many men, even though it may be attended by some disadvantages, which in the end may prove more imaginary than real.*

The present aspects of the conflict in Maine.

217. In 1877 and 1878 a determined effort was made by the Maine line-fishermen to secure the passage of a legislative act forbidding the use of seines near the shores. Their claim was that the present methods employed in the fishery interfered with their legitimate privilege of catching menhaden for bait, and that their tendency was to drive away all other fishes as well, and to destroy the fisheries.

To this movement the manufacturers made strenuous opposition, claiming that the menhaden fishery is practically inexhaustible; that the habits of the species have not been changed by the fishery, and that so far from making it difficult to obtain bait the large fishery made it easier, capturing it in great masses and selling it to the fishermen in any desired quantity cheaper than they could obtain it for themselves. Mr. Maddock's report, which has frequently been mentioned, was prepared at the wish of the Maine manufacturers as an argument to be presented to the legislature on their behalf. All the questions involved have been elsewhere discussed. It seems very unlikely that any legislature will at present interfere with so extensive an interest as that of the menhaden oil manufacturers.†

40.—MENHADEN BAIT AS AN ARTICLE OF COMMERCE, AND THE CONSIDERATION OF ITS VALUE BY THE HALIFAX COMMISSION OF 1877.

The export of bait to the Dominion.

218. In the section relating to the value of the menhaden as a bait-fish (paragraphs 186–190), allusion was made to its extensive exportation for use in the fisheries of the Dominion of Canada.

The evidence of several witnesses was quoted to prove that menha-

* A History of the Towns of Bristol and Bremen in the State of Maine, including the Pemaquid Settlement. By John Johnston, LL. D., a native of Bristol, and Professor Emeritus of Natural Science in the Wesleyan University, Middletown, Conn., and Cor. Mem. of the Maine Historical Society. Albany, N. Y. Joel Munsell. 1873. 8vo. pp. 524. p. 460.

† See paragraph 156.

den bait was preferred to any other kind by the provincial fishermen. I am told that a considerable number of the vessels of the New England fleet fishing in the Gulf of St. Lawrence are accustomed to carry partial cargoes of salted menhaden to sell in the Straits of Canso. I have been unable to obtain any satisfactory statistics of this exporting trade. This is doubtless due to the fact that every mackerel vessel carries twenty barrels or more of salt slivered fish, and there being no law requiring their entry in the custom-house or for reporting sales after the return of the vessel, no one has the data upon which to found an estimate. More than 5,000 barrels of slivered menhaden, worth more than $30,000, were probably carried to Dominion waters during the past season. Many vessels doubtless expended all the bait which they carried; many others sold their surplusage to the provincial mackerelmen. I should hardly venture to estimate the amount of these sales at more than $8,000 or $10,000, and very possibly they are even less extensive.

The claim of the English Government.

219. The subject of the alleged trade in menhaden bait was referred to frequently in the course of the proceedings of the Halifax Commission of 1877. The subject was first introduced by the English counsel in the "Case of Her Majesty's Government," * as follows:

"The question of bait must now be considered, as some importance may, perhaps, be attached by the United States to the supposed advantages derived in this respect by British subjects. It might appear at first sight that the privilege of resorting to the inshores of the Eastern States to procure bait for mackerel-fishing was of practical use. Menhaden are said to be found only in the United States waters, and are used extensively in the mackerel-fishing, which is often successfully pursued with this description of bait, especially by its use for feeding and attracting the shoals. It is, however, by no means indispensable; other fish-baits, plentiful in British waters, are quite as successfully used in this particular kind of fishing business, and very generally in other branches, both of deep-sea and inshore fishing, as, for example, fresh herrings, alewives, capelin, sandlaunce, smelts, squids, clams, and other small fishes caught chiefly with seines close in shore. British fishermen can thus find sufficient bait at home, and can purchase from American dealers any quantities they require much cheaper than by making voyages to United States waters in order to catch it for themselves. It is a remarkable fact that for six years past American fishermen have bought from Canadians more herring bait alone than all the menhaden bait imported into Canada during the same period. The menhaden bait itself can also be bred and restored to places in the Bay of Fundy, on the western coast of Nova Scotia, where it existed up to the time of its local extermination."

* Proceedings of the Halifax Commission, Appendix A, p. 28.

And again: "It is notorious that the supply both of food and bait fishes has become alarmingly scarce along the United States coast. At Gloucester alone some thirty vessels are engaged during about six months in each year catching menhaden for bait. They sell about $100,000 worth annually, and, by catching them immoderately in nets and wears for supplying bait and to furnish the oil mills, they are rapidly exterminating them. The Massachusetts Fishery Commissioners, in their report for 1872, state that 'it takes many hands working in many ways to catch bait enough for our fishing fleet, which may easily be understood when it is remembered that each George's man takes fifteen or twenty barrels for a trip, and that each mackereler lays in from 75 to 120 barrels, or even more than that.' One of the principal modes for the capture of bait and other fishes on the New England coast is by fixed traps or pounds on the shore. By means of these, herrings, alewives, and menhaden are caught as bait for the sea-fishery, besides merchantable fish for the markets, and the coarser kinds for the supply of the oil factories. There are upward of sixty of these factories now in operation on the New England coast. The capital invested in them approaches $3,000,000. They employ 1,197 men, 383 sailing vessels, and 29 steamers, besides numerous other boats. The fish material which they consume yearly is enormous, computed at about 1,191,100 barrels, requiring whole fishes to the number of about 300,000,000. These modes of fishing for menhaden and other bait are, furthermore, such as to preclude strangers from participating in them without exceeding the terms of the treaty; and even without this difficulty it must be apparent that such extensive native enterprises would bar the competition and suffice to ensure the virtual exclusion of foreigners."

The reply of the agent of the United States.

220. In the "Answer on behalf of the United States of America to the case of Her Britannic Majesty's Government,"* Judge Foster, states: "Off the American coast are found exclusively the menhaden or porgies, by far the best bait for mackerel."

This is well stated by Sir John MacDonald (in a debate in the Dominion Parliament, May 3, 1872), who says:

"It is also true that, in American waters, the favorite bait to catch the mackerel is found, and it is so much the favorite bait that one fishing vessel having this bait on board would draw a whole school of mackerel in the very face of vessels having an inferior bait. Now, the value of the privilege of entering American waters for catching that bait is very great. If Canadian fishermen were excluded from American waters by any combination among American fishermen or by any act of Congress, they would be deprived of getting a single ounce of the bait. American fishermen might combine for that object, or a law might be passed by Congress forbidding the exportation of menhaden; but, by the provision

* Proceedings of the Halifax Commission, Appendix B, pp. 18, 19.

made in the treaty, Canadian fishermen are allowed to enter into American waters to procure the bait, and the consequence of that is, that no such combination can exist, and Canadians can purchase the bait, and be able to fish on equal terms with the Americans."

These statements were based upon the Canadian official reports previously published, which say:

"For mackerel, the Americans use 'pogies' and clams, chopped fine, as bait. The 'pogies' are found only on the coast of the United States, and, when imported into the Dominion, cost about $6 per barrel.

"The bait with which the Americans are supplied is far superior to any which can be secured in this country, to which may be attributed in a great measure the success of the Americans previously to the recent restrictions, although even now the local fishermen complain that they have no chance while an American schooner is fishing near them."*

"The menhaden fishery has within ten years grown into an immense business. Formerly they were taken only for bait, and were either ground in hand-mills, for mackerel, or used in what is called "slivers" for codfish bait. There is now a large fleet of steamers and sailing-vessels engaged in this fishery. Large factories have been erected on shore for extracting the oil. As these fish are not valuable until they are fat, which is in August and September, they are not much taken in their spawning time; and they will not therefore be exterminated. They are caught solely with seines, near the shore, their food being a kind of marine seed which floats upon the waters; consequently they will not take the hook. This fishery is one of the most profitable of all the fisheries, the oil being used for tanning and currying, extensively at home, and being exported in large quantities. The refuse of the fish, after being pressed, is used for manufacturing guano or fish phosphate, and is very valuable as a fertilizer. This fishery is purely an American fishery, no menhaden ever being found north of the coast of Maine. It is entirely an inshore fishery, the fish being taken within two miles from the shore."

The reply of Her Britannic Majesty's Government.

221. The "Reply on behalf of Her Britannic Majesty's Government to the Answer of the United States of America" responds:

"The Answer (pp. 18 and 19) lays much stress on the importance to Canadian fishermen of the menhaden bait-fishery on the coast of the New England States. The menhaden is here represented to be the best bait for mackerel, and is said to inhabit exclusively the American coast. An entirely fictitious value has been attached to this fishery. British fishermen do not frequent United States waters for the purpose of catching bait of any kind, or for any other purposes connected with fishing, consequently the privilege of entering those waters to catch menhaden is of no practical value. Any bait of that description which they may require may be purchased as an article of commerce.

* Annual report of the Department of Marine and Fisheries for the year ending June, 1870, pp. 312, 342.

"There are not now, nor have there ever been, treaty stipulations to prevent British fishermen from entering American waters to buy bait, if they prefer to do so. As a matter of fact, whatever menhaden bait British fishermen use is either purchased from American dealers or from Canadian traders, who import and keep it for sale like any other merchandise. Reference is made in the Answer to the possible contingency of legislation prohibiting the export or sale of menhaden-bait, the implied consequence being a serious disadvantage to Canadian fishermen in prosecuting the mackerel fishery. It would, in such contingency, be necessary to use other baits equally good, or resort to some other method of fishing, such as that described at page 10, enabling the fishermen to dispense with bait. Moreover, it is well known that menhaden are now caught in the open sea, many miles distant from the American coast. The Answer asserts, at page 19, that 'it is entirely an inshore fishery.' It can be proved that menhaden are chiefly caught off shore, frequently 'out of sight of land.'"

Mr. S. L. Boardman, of Augusta, Me., in an interesting report to the State Board of Agriculture, of which he is secretary, published in 1875, at page 60, says:

"Parties engaged in taking menhaden now go off ten or twenty miles from shore, whereas they formerly fished near the coast, and they now find the best and 'most profitable fishing at that distance.' This fish is included among the shore fishes described by Prof. S. F. Baird as having suffered 'an alarming decrease' along the inshores of the United States, owing partly to excessive fishing throughout their spawning time in order to supply the oil-factories."

Chapter 5 of the Answer deals with "the specific benefits which the treaty directs the Commission to regard in its comparison and adjustment of equivalents." The admission of Britsh subjects to United States fishing grounds has been dealt with at length in the third chapter of the Case. There is nothing in the Answer on this subject calling for any reply excepting the statement at page 20, that Dominion fishermen "have in the United States waters to-day over 30 vessels equipped for seining, which in company with the American fleet are sweeping the shores of New England." Leaving out of question the "American fleet," which has nothing whatever to do with the matter, the correctness of the statement is directly challenged in so far as it implies that these 30 vessels or any of them are British bottoms, owned by Dominion fishermen; and the United States is hereby called upon to produce evidence in its support.

References in the testimony and affidavits.

222. In the testimony and affidavits presented by the United States counsel,* referred to in the biography of the menhaden appended to this memoir and quoted to some extent in paragraphs 188–189, are many

*Proceedings of the Halifax Commission, Appendices L and M.

allusions to the value of menhaden bait. In the series of statistical tables filed* is given a statement, prepared by the writer, of the annual product of the menhaden fisheries. In the speeches of counsel during the session of the Commission very little attention was paid to the menhaden.

Mr. Dana's remarks in his argument.

223. Mr. Dana remarked in his closing argument:†

"We need not catch our mackerel bait any more than our cod bait, within the three-mile limit. On the contrary the best mackerel bait in the world is the menhaden, which we bring from New England. All admit that. The British witnesses say they would use it, were it not that it is too costly. They have to buy it from American vessels, and they betake themselves to an inferior kind of bait when they cannot afford to buy the best from us."

224. Few comments are needed upon these statements.

(1) While other fish than the menhaden *may* be used as bait, the latter is preferred by mackerel fishermen generally. (See quotations from affidavits of Nova Scotian fishermen quoted above, 186–190, and the depositions of numerous American fishermen before the Commission referred to in the Bibliography of the Species, Appendix C.)

(2) For the period of six years past, referred to in the comparison of the sales of menhaden bait and herring bait, the mackerel fisheries in Canadian waters have been far below their usual importance, and there has been no large demand for menhaden bait. The bank cod-fishery has been as successful as usual and the demand for herring bait undiminished. Moreover a large proportion of the frozen herring exported to the United States are consumed as food, not as bait.

(3) The claim that the menhaden are being rapidly exterminated is discussed above in paragraphs 151–156.

(4) The criticism by the British counsel of the statement that menhaden are not taken at a distance from the shore is well sustained.

(5) The very extraordinary statement that menhaden can be bred and restored to their former haunts in the waters of Nova Scotia may be met by the statement that there is no evidence that the species was ever other than an accidental visitor to those waters, that none have been seen there for the past twenty-five years, that the present eastern limit of the geographical range of the species is forty or fifty miles west of—

M.—THE MANUFACTURE OF OIL AND GUANO.

41.—A HISTORY OF THE OIL MANUFACTURE.

The claims of Maine to the discovery of menhaden oil.

225. The manufacture of menhaden oil has been prosecuted for a few years only. Several individuals claim the honor of having been first to

* *Ibid.*, Appendix O. † Appendix J, p. 78.

discover its value. About the year 1850 Mrs. John Bartlett, of Blue Hill, near Mount Desert, Me., while boiling some fish for her chickens noticed a thin scum of oil upon the surface of the water. Some of this she bottled, and when on a visit to Boston soon after carried samples to Mr. E. B. Phillips, one of the leading oil merchants of that city, who encouraged her to bring more. The following year the Bartlett family industriously plied their gill-nets and sent to market thirteen barrels of oil, for which they were paid at the rate of $11 per barrel, in all $143.*

Mr. Phillips gave them further encouragement, furnishing nets and large kettles, which they set up out of doors in brick frames, for trying out the fish. It was thought that much oil was thrown away with the refuse fish or scrap, and the idea of pressing this scrap was suggested. This was at first accomplished by pressing it in a common iron kettle with a heavy cover and a long beam for a lever; afterward by placing it under the weight of heavy rocks, in barrels and tubs perforated with auger holes. Mr. Phillips subsequently fitted out some fifty parties on the coast of Maine with presses of the model known as the "screw and lever press."

The claims of Connecticut and New York.

226. Others claim to have manufactured oil about the same time.† It is said that as early as 1850 or 1852 there was an establishment for the manufacture of white-fish oil near old Fort Hale, New Haven Harbor. I am informed that Elisha Morgan, of Poquannock Bridge, Conn., made oil from bony fish previous to the year 1850. He owned seines with which he caught fish to be spread upon land fresh. When he could not sell all his fish to the farmers he extracted their oil by boiling them.

Whether the value of the article and the methods of manufacture were first brought to notice in Maine or not, the people of that State were slow to improve their opportunities and the trade first assumed its importance on the shores of Long Island Sound. Whether the fisherman's wife of Blue Hill is the sole discoverer of the properties of menhaden oil is not evident; perhaps the facts were also known to others. At any rate the tradition of the Bartlett family is not current on Long Island. In the year 1850, according to Captain Sisson, D. D. Wells and

* As this account is somewhat different from those hitherto published, I give the story in the words of Mr. E. B. Phillips himself: "In about 1850 I was in the fish-oil business in Boston. An elderly lady by the name of Bartlett, from Blue Hill, Me., came into my store with a sample of oil, which she had skimmed from the kettle in boiling menhaden for her hens. She told me that the fish were abundant all summer near the shore, and I promised $11 per barrel for all she could produce. Her husband and sons made thirteen barrels the first year, and the following year one hundred barrels."

† The manufacture of oil and of artificial guano from fishes has long been practiced in France, where the fish called Merlan (*Gadus merlangus*) is employed for the purpose, yielding 1½ to 2 per cent. of oil. In France the fish cake remaining after the extraction of oil is dried at a steam heat and is then ground fine and packed in air-tight casks for sale as manure.

his son Henry E. Wells started the first factory in the vicinity of Greenport, using steam for making oil and scrap. "At that time there were some few pots (whalemen's try-pots)used by other parties in boiling the fish in water and making a very imperfect oil and scrap, but were not very successful. The first oil made by D. D. Wells & Son was very black, impure, full of fleshy matter, and had a very offensive smell. It did not come much into use, and for a long time the profits of the business were small; but by persistent effort in perfecting machinery the quality of the oil was so much improved as to come into general use for certain purposes, such as painting, tanning, manufacture of rope, and adulterating other oils. The scrap was also very much improved by grinding and drying, pulverizing, &c., so that during the war the business was quite remunerative. At that time quite a number of factories were established and for a time the business was somewhat overdone, which caused some to abandon it altogether, and others to consolidate; and at the present time there are ten factories in operation, doing a fair business, giving employment to a large number of people and bringing up a hardy race of boatmen and sailors."

Professor Baird, visiting this region in 1857, wrote: "Quite recently several establishments have been erected on Long Island for the manufacture of oil from the moss-bunker. The fish, as brought in, are chopped up and boiled, and the oil skimmed off; a heavy pressure on the residuum expresses the remaining oil, and what is left is still useful as a manure. The oil finds a ready market. It has been estimated that a single fish will furnish enough oil to saturate a surface of paper eighteen inches square."*

Notwithstanding the fact that the coast of Maine was adapted for much more profitable prosecution of the oil manufacture, nothing of importance was done there until 1865. The trade grew rapidly for about four years, but has not augmented considerably since 1870. Twenty factories were built in a short period, fourteen of which are still in operation, though several have failed from the too sudden expansion of their business. As has been seen, the only points at which the trade has any statistical importance are within a limited area on the coast of Maine, on Narragansett Bay, and on Long Island Sound. At other points, one or two factories absorb the whole business; they are but half worked, and many of them have been abandoned. I am informed that efforts are being made to establish factories on Cape Cod and on the coast of South Carolina.

Great improvement has been made in the processes of refining and clarifying the oil, and the clear, yellow, nearly odorless substance now produced is vastly different from the article manufactured in early days.

The process of extracting oil by steam was patented in 1852 or 1853 by Wm. D. Hall, of Wallingford, Conn., the originator of the Quinnipiac Fertilizer Company. Mr. Hall was engaged in bone-boiling and tallow-

* Fishes of the New Jersey Coast, 1855, p. 33.

rendering at Wallingford; he had a load of white-fish carted to his factory from Branford, 16 miles distant. At night, after his men had left the factory, he cleaned out his tallow tanks, steamed his fish, and extracted the oil; his experiment was satisfactory and the process was immediately patented. The priority of his discovery is challenged by Mr. D. D. Wells, of Greenport, who claims to have used the process for some years previous to this time. After securing his patents, Mr. Hall visited numerous "pot works," which had by this time been established, for the purpose of introducing his new methods. At this time he also secured a patent for the process of drying fish scraps upon platforms by solar heat.

The inception of the oil business in Maine.

227. The first factory in Maine was built by a company from Rhode Island, in 1864, at Blue Hill, and the next by another company from Rhode Island, at Bristol, on John's Bay, the same season. Operations being successful, home parties in Booth Bay, Bristol, Bremen, and Southport went into the business. In the spring of 1866 eleven factories were built, all using steam. This may be regarded as the beginning of the industry in Maine on a scale at all in ratio with its capabilities.

Erection of factories in Maine.

228. The following table, taken from Mr. Maddock's pamphlet, gives the dates at which the factories of the several firms named were built, and the cost of the same. The titles of some have since been changed by incorporation with others, change of ownership, &c. Of the eleven factories specified before as built in 1866, one has been burned, and two absorbed by now existing corporations.

Date of building of factories in Maine.

Names.	When built.	Where.	Cost of buildings and equipment.
Gallup & Holmes	1866	Booth Bay	$15,000
Gallup, Morgan & Co	1866	do	15,000
Suffolk Oil Works	1866	do	30,000
Kenniston, Cobb & Co	1867	do	15,000
White Wine Brook Company	1867	do	12,000
Maddocks' Factory	1866	Southport (now Booth Bay)	25,000
Bristol Oil Works	1866	Bremen	10,000
Albert Gray & Co	1870	do	12,000
Round Pond Company	1866	Bristol	15,000
L. Brightman & Sons	1866	do	15,000
Pemaquid Works	1869	do	15,000
Jos. Church & Co. Works	1871	do	40,000
Loud's Island Works	1873	do	6,000
Brown's Cove Works	1874	do	10,000
Tuthill, French & Co	1868	do	10,000
Wells & Co	1864	do	12,000
Fowler, Foote & Co	1874	do	2,000
South Saint George Factory	1876	South Saint George	1,500
Total			260,500

The original investment of $260,500 has been increased, as shown by the report for 1877, to $1,083,612.

42.—The locations of the oil factories.

Factories in Maine.

229. The oil and guano factories are located chiefly on the coasts of Maine, Rhode Island, Connecticut, and Long Island, at the localities already designated as being most frequented by large schools of menhaden.

In 1877 there were on the coast of Maine fourteen establishments of sufficient importance to be represented in the Maine Oil and Guano Association, all but two of them in good financial standing. I am indebted to Messrs. Church, Pryer and Maddocks for the detailed list given below, including those not now in operation. There are, besides, several small factories of no great statistical importance.

On Muscongus Sound, near Round Pond, are six factories owned by The Bristol Oil Works, with two presses; Albert Gray & Co., with two presses; Joseph Church & Co., with four presses; the Round Pond Oil Company, not now in operation; Leonard Brightman & Co., now bankrupt; the Brown's Cove Company (not operated in 1877), and the Loud's Island Oil Company.

On John's Bay, Liniken's Bay, and in that vicinity are ten, owned by the Pemaquid Oil Company, with three presses; Wells & Co., with two presses; Tuthill, French & Co., with two presses; Fowler, Foote & Co.; the Suffolk Oil Company, with two presses; Gallup & Holmes, with two presses; Gallup, Morgan & Co., with two presses; Kenniston, Cobb & Co., with two presses (not now in operation); Luther Maddocks; the White Wine Brook Company.

There is also a factory at Brooklin owned by Robert A. Friend, and the South Saint George Oil Works, at South Saint George.

The George W. Miles Company, of Milford, Conn., have for several years operated their ship, the Alabama, with two presses, in John's Bay.

There have also been within a few years factories at Blue Hill, owned by Conary & Co.; in Brooklin, owned by G. Allen & Co.; in Brooksville, owned by E. C. Chatto & Co.; in Belfast, owned by J. C. Condon and by J. C. Mayo. The first is known to be abandoned, and no returns have been received from the others since 1873.

A considerable amount of oil is also tried out by individuals who carry on a small business of this description in connection with other occupations. The amount thus produced in 1874 was estimated by Mr. Eben B. Phillips at from 50,000 to 75,000 gallons.

Factories in Massachusetts.

230. In Massachusetts there are no important factories; the Cape Cod Oil Works, at Provincetown, and the North American Oil Works, at Wellfleet, try out a small quantity of menhaden oil annually, but this is merely incidental, their chief source of supply being bodies of stranded blackfish and porpoises.

A small quantity of oil is tried out by the fishermen on Cape Cod, chiefly, perhaps, from the refuse remaining after the fish have been "slivered" for bait.

Near Wood's Holl, Mass., is the factory of the PACIFIC GUANO COMPANY, which at the time of its establishment in 1863 was engaged largely in the fisheries and oil pressing, but has now discontinued this branch of the business. At Dartmouth is the factory of ERSKINE PIERCE, and at Fall River that of JOB T. WILSON, which is referred to below in the Narragansett Bay list.

Factories in Rhode Island.

231. In Narragansett Bay are thirteen factories, specified in the following list kindly furnished by Mr. Church:

THE ATLANTIC OIL AND GUANO COMPANY, operating 3 presses.
JOB T. WILSON & Co., at Fall River, Mass., operating 3 presses.
WM. J. BRIGHTMAN & Co., at Tiverton, R. I., operating 2 presses.
ISAAC BROWN & Co., at Tiverton, operating 2 presses, good condition.
CHARLES COOK, at Tiverton Four Corners, operating 2 presses.
AMASSA SIMMONS, at Tiverton Four Corners, operating 1 press.
ISAAC G. WHITE, at Tiverton Four Corners, operating 2 presses.
BENJ. MANCHESTER, at Tiverton Four Corners, operating 1 press.
ANTHONY MANCHESTER, at Tiverton, operating 1 press.
OTIS H. ALMY & Co., at Tiverton Four Corners, operating 1 press.
NARRAGANSETT OIL AND GUANO COMPANY, operating 2 presses.
JAMES MANCHESTER, at Tiverton, operating 1 press.
THOMAS F. GRAY, operating 2 presses.

Mr. Pryer gives the names of the following manufacturers not included in Mr. Church's list. Some of them are doubtless concerned in the titled companies already mentioned:

JOHN SOUTHWORTH, Portsmouth, R. I.
W. H. H. HOWLAND, Portsmouth, R. I.
WILCOX MANCHESTER, Tiverton Four Corners, R. I.

Rhode Island has no factories west of Narragansett Bay.

Factories in Connecticut.

232. Another group of factories is located between the eastern boundary of Connecticut and the Connecticut River. In 1877 these were five in number, as follows:

GURDON S. ALLYN & Co., on Mason's Island, between Stonington and Noank, running three gangs.

LEANDER WILCOX & Co. (formerly J. GREEN & Co.), on Mint Head, also east of Noank, running two gangs.

WALEY & Co., at Poquonnock Bridge, east of the Thames River, running one gang.

QUINNIPIAC FERTILIZER COMPANY, on Pine Island, Groton, at the mouth of the Thames River, running four gangs.

LUCE BROTHERS, at Niantic.

Several other factories were formerly operated in this vicinity, namely, the QUIAMBOG OIL COMPANY, on Noyes Neck (one gang), burnt down in 1876; the GARDNER OIL COMPANY and REUBEN CHAPMAN'S WORKS on Mason's Island (one gang), abandoned.

Luce Brothers, of Niantic, formerly had a floating factory built on the hull of the old railway ferry-boat "Union." In 1876 a new factory was built by them and the floating factory was abandoned.

West of the Connecticut River the factories are not numerous. I learn the names of the following companies:

SALT ISLAND OIL COMPANY, at Westbrook, owned by J. L. Stokes and others, not now running.

J. H. BISHOP, at Madison.

FOWLER & COLBURN, at Guilford.

E. R. KELSEY, at Branford, supplied by weir fisheries.

WELCH'S POINT OIL COMPANY, at Milford.

THE GEORGE W. MILES CO., at Milford, owning a factory on the shore and a floating factory, the "Alabama," built upon the hull of an old man-of-war. This is usually operated on the coast of Maine and is referred to in the list of Maine factories. In 1878 it is the intention of Mr. Miles to work it on the coast of New Jersey.

Factories in New York.

233. At the eastern end of Long Island is another cluster of oil works. The following list was furnished by Capt. Benjamin H. Sisson in 1873:

D. D. WELLS AND SONS.

HAWKINS BROTHERS.

H. CORWIN & CO.

FITHIAN & HORTON.

BENJAMIN PAYNE, GREEN & CO.

B. C. CARTWRIGHT & CO.

VAIL, BENJAMIN & CO.

THE STERLING CO.

Also two floating factories the "Falcon," 2,500 tons, Capt. Geo. F. Tuthill; the "Ranger," 1,500 tons, Capt. F. Frank Price.

Many have since been established and in Mr. Pryers' list (Appendix H) the following manufacturing firms are enumerated, fifteen in number:

W. Y. FITHIAN & CO., at Napeague (Amagansett).

GREEN BROTHERS, at Amagansett.

JOSEPH D. PARSONS, at Springs.

G. H. PAYNE, at Deep Hole, Easthampton.

HAWKINS BROTHERS, at Shelter Island.

B. C. CARTWRIGHT, at Shelter Island.

HENRY E. WELLS, at Greenport.

GEORGE F. TUTHILL, at Greenport.

T. F. PRICE, at Greenport.
J. NORRISON RAYNOR, at Greenport.
W. H. H. GLOVER, at Southold.
G. H. CLARK, at East Marion.
W. W. WARNER, at Good Ground.
W. C. RAYNOR, at Westhampton.
NELSON BURNETT, at Southampton.
On the Great South Bay are four factories:
J. S. HAVENS, at Patchogue.
SMITH, GREEN & CO., at Sayville.
SMITH & YARRINGTON, at Sayville.
SOUTH BAY OIL COMPANY, at Sayville.

On the south shore of Long Island, at Barren Island, a few miles east of the entrance to New York Harbor, at the mouth of Jamaica Bay, are four factories, owned by—

SEAMAN JONES & CO.
HAWKINS BROTHERS.
FRANK SWIFT.*
BARREN ISLAND MANUFACTURING COMPANY.

In these four factories, according to Mr. Seaman Jones, about $200,000 capital is invested, half of it on shore and half in "sailing rigs."

Factories in New Jersey.

234. In 1873 there were said to be one or two oil factories in Southern New Jersey, at Somers Point and Little and Great Egg Harbors. The fisheries in this vicinity are not vigorously prosecuted, and in 1873 the factory at Atlantic City had already been deserted. Mr. Miles informs me that he proposes to operate his floating factory, the Alabama, in New Jersey waters during the coming season of 1878.

According to Mr. Pryer the following factories were in existence in 1877:

GRIFFIN & VAIL, at Port Monmouth.
CAPT. C. DOUGHTY, at Somers Point.
MORRIS & FIFIELD, at Somers Point.
JAMES E. OTIS, at Tuckerton.
CYRUS N. SMITH, at Tuckerton.

Factories on Chesapeake Bay.

235. I am informed by Mr. H. L. Dudley that there are four factories in the Chesapeake Bay between Norfolk and Baltimore. I have not learned the names and locations of all these establishments. One, "THE VIRGINIA OIL AND GUANO COMPANY," of which Mr. O. E. Maltby, of Norfolk, is president and Mr. Dudley agent, is located at New Point Comfort. A second is owned by WILLIAM D. HALL, of Willenbeck,

* Better known by the name of its former owner, Mr. Koon.

Lancaster County, Va., who was formerly connected with the Quinnipiac Fertilizer Company. A third was the MANOKIN OIL WORKS, owned in 1873 by CROCKETT & Co., and a fourth on Tangier Island, owned in 1873 by FORD, AVERY & Co. The Manokin Works are said to be in Pocomoke Bay. A factory was operated near Norfolk in 1872 by Mr. Fitzgerald, but this has since been destroyed by fire.

F. H. HARKER has a factory at Hampton, Va.

Factories on the southern coast.

236. South of Cape Henry there are no factories now in operation. Mr. W. F. Hatch, keeper of Body's Island light, North Carolina, gave the names of the following factories in that vicinity which had at that time already been abandoned:

EXCELSIOR WORKS (cost $30,000).

CHURCH & Co. (cost $5,000).

ADAMS & Co. (cost $5,000).

There is still another abandoned factory near Beaufort, N. C.

At Charleston, S. C., are the works of the Pacific Guano Company, which consumes immense quantities of menhaden scrap. This is however brought from the water by the vessels which carry on their return trip a supply of South Carolina phosphates for the other factory owned by the company, at Wood's Holl, Mass.

A company in Charleston has a charter for establishing a menhaden fishery at the mouth of Charleston Harbor.—(*C. C. Leslie.*)

43.—METHODS OF OIL MANUFACTURE.

The principles involved.

237. The manufacture of menhaden oil is simple in the extreme, consisting of three processes: boiling the fish, pressing, and clarifying the expressed oil. The apparatus absolutely needful is correspondingly free from complication, consisting, for the first process, of a cooking vessel; for the second, a press, and for the third a shallow vat or tank. These were used twenty-five years ago by Mrs. Bartlett, the manufacturer of the first menhaden oil, who produced an article little inferior to the best now in the market. Very few patents for improved methods of manufacture have been granted: Mr. W. D. Hall's patent for steam-rendering is the most important. The principal changes have been in the introduction of labor-saving appliances, which enable manufacturers to carry on their business with the smallest possible force of workmen. Steam is of course an important auxiliary in handling the fish and in working the presses, and is also used to great advantage in heating the cooking-tanks, as well as for pumping the water and oil. The hydraulic press has replaced the old fashioned screw-press in most of the larger establishments, and the size, shape, and arrangement of the bleaching vats, as well as the methods of drawing and pumping the oil from one to the other, have been perfected.

Processes employed in manufacture.

238. The process of oil-making at the larger works is essentially as follows: The fish are conveyed to the upper story of the factory on wooden tramways in cars containing about twenty barrels each, and are dumped into large reservoirs from which the cooking-tanks are replenished from time to time, or are emptied directly into the cooking-tanks, which are filled to the depth of six inches with sea-water. From fifty to seventy-five barrels are placed in each cooking-tank, and then steam is turned on and they are boiled for half an hour or more. In this way about two-thirds of the oil is separated; the remainder is expressed by means of the hydraulic presses, under a pressure of 50 to 150 tons or less; the fish having been placed in circular curbs of half-inch iron, perforated with holes an eighth of an inch in diameter, each curb having a capacity of three to ten barrels. The oil mixed with water is now run into the "drawing-off tanks" while it is still hot, and is passed through several of them, the water separating and sinking to the bottom. The oil is now drawn off into a "settling-tank" of four or five thousand gallons capacity, where it remains a few hours to allow impurities to sink to the bottom. Finally, it is pumped into "bleaching-tanks" (of which Judson, Tarr & Co. have five, each containing four thousand gallons), where it becomes clearer and whiter in the rays of the sun, and after one or two weeks' exposure is ready for shipment.

Processes employed in refining.

239. Boardman & Atkins make the following statements about processes of refining:

"The oil and water running together into the receivers, separate, by the oil rising to the top, whence it can be drawn or skimmed off. Great pains must be taken to separate the oil from the water before the impurities contained in the latter begin to ferment, for if this happens the quality of the oil suffers much. Moreover, in what appears at first to be pure oil there is a variable amount of finely divided fleshy substance that must be allowed to settle, as it will after a while, and the clarified oil drawn off before putrefaction sets in. In order to effect the separation, the oil is commonly passed through a number of settling-vats, and a portion of the impurities deposited in each, and finally before barreling, the oil is, if practicable, exposed some hours to the sunlight in a broad, shallow tank. If all these processes are successfully carried through, the oil is light-colored, sweet, and of prime quality; but if it is exposed at any time to the influence of putrefying animal matter, it becomes dark and 'strong.' The very strongest of oil is made from the 'gurry' or settlings of the oil, after fermentation, by steaming or boiling it over.

"It naturally happens that every manufacturer makes several grades of oil, of very different quality, of which the best is very sweet, fine oil, bringing ten cents a gallon more than a strong article. Notwithstand-

ing this fact, it is said to be the common practice of dealers to pour all grades into the same vat, and this has led manufacturers to take less pains to keep them separate.

"It is a curious fact that oil made from early fish is not so good as that made later. It is called 'weak,' and brings in market five cents per gallon less."*

Gurry oil is sold for one-third less than the other grades.

Perhaps the most satisfactory way of indicating the processes now in use will be to describe three or four of the principal factories in detail.

The factory of The George W. Miles Company.

240. The factory of The George W. Miles Company at Milford, Conn., illustrated in Plate XXV, is said to have been the first one built after the model now universally followed, with the cooking-tanks and oil-presses upon the second floor of the building.

When the fishing fleet comes in, the fish are hoisted from the holds of the vessels into cars, in which they are carried over an inclined tramway to the upper story of the factory building. Here they are turned into tanks, twenty thousand fish in each, and cooked by steam-power. Then the water is drawn off and the cooked fish are placed in perforated iron curbs, which are so arranged upon railways that they can be pushed under a hydraulic press. Each curb-load of fish is subjected to a pressure of sixty or seventy tons, by which the greater part of the oil is extracted. The scrap is then dropped into the cellar below.

The ship "Alabama" is owned by the same firm. It is used as an oil factory, and is usually more productive than the stationary works owned by the same firm. It is illustrated in Plate XXX. For several seasons it has been taken to Maine during the fishing season, where it is usually stationed near South Bristol. It is the intention of the owners to take it to the coast of New Jersey for the season of 1878.

The factory of Judson Tarr & Co.

241. Messrs. Judson Tarr & Co., of Rockport, Mass., kindly furnished the following account of their factory in Pemaquid (Bristol), Me., as it was in 1873:

"The size of the main factory is 30 by 40 feet, with 16-foot posts; the building is two stories high, the upper story being used for cooking and pressing the fish, the lower as an oil-room and for storing fish-scrap. The engine-house adjoining the factory measures 20 feet by 30, with 10-foot posts, and contains three horizontal boilers each of sixty-five horse power. In the upper story of the factory are eleven round wooden cooking-tanks 12 feet in diameter and 4 feet deep; each tank has steam-pipes in its bottom, perforated with small holes to allow the escape of the steam; there are also three hydraulic presses, each with pressure of one hundred and fifty tons, and a small engine of ten-horse power.

* Op. Cit., p. 27.

Connected with the factory are two wharves, the longer 150 by 50 feet in dimensions, the shorter 40 by 80. At the end of the long wharf is placed, on posts 10 feet high, a tank capable of containing 4,000 barrels of menhaden. This tank is sometimes completely filled when all the steamers have discharged their loads after a successful day's fishing. On the wharf is an engine of twelve-horse power connected with three drums, all or either of which may be used; when in full blast one thousand barrels can be transferred from the steamers to the tank in an hour, the process being precisely similar to that of unloading coal from barges.

Also, on the premises of the company, are a main scrap-house, 100 feet by 60, with 15-foot posts, and blacksmith's, cooper's, and carpenter's shops, as well as a boarding-house and stable, all used in connection with the business.

The amount invested in buildings and machinery is between $75,000 and $80,000, and in steamers and fishing gear, such as seines, small boats, &c., is about $60,000 additional.

The utmost capacity of the factory is 2,000 barrels per diem. About thirty-five men are employed at the factory.

The factory of Joseph Church & Co.

242. The Muscongus Oil Works, on Muscongus Point, Maine, the largest in the United States, were visited by Professor Baird in September, 1873. These works were erected in 1872, and are carried on by Joseph Church & Co., of Tiverton, R. I.* The main building is 161 feet long and 40 feet wide. The lower portion is the receptacle of the chum, where about 1,800 tons were in store on the 25th of September, three cargoes of about 190 tons each having been sent away during the year. The establishment is larger than any other in the United States, and is well appointed in every particular, capable of working up more than 3,000 barrels of fish in a day. About forty-five men were employed at these works, and about 5,500 tierces of 40 gallons of oil each had been manufactured during the year. These works are now much more extensive, employing during the past season (1874) seventy fishermen and seventy factory hands, with four steamers and three sailing-vessels. They have invested in buildings and machinery $65,000, and in fishing gear $55,000. During the season 138,000 barrels or about thirty-four millions of menhaden were caught; 200 barrels were sold for bait, and of the remaining 136,000 barrels they manufactured 450,000 gallons (11,250 tierces) of oil and 4,000 tons of chum or guano.

The factory of Kenniston, Cobb & Co.

243. The establishment of Kenniston, Cobb & Co. is selected for description by Boardman and Atkins, who state that though not one of the largest, it is generally conceded to be a model of convenience and efficiency.

* Illustrated in Plate XXIX.

"The main floor of the factory stands a considerable height above the water. Here are all the steam tanks and the press, and in an adjoining building is the boiler and the principal engine. The tanks are of wood, 8 feet square and 4 feet deep, with a capacity of fifty-one barrels, with a board platform on which the fish rest, 4 inches above the bottom. Into the space between the platform and the bottom the steam is introduced. There are tanks arranged in two rows, between which runs the track leading from the landing. Another track passes by all the tanks and leads to the press. On this track run several cylindrical curbs made of wood and iron. The press is hydraulic, and is worked by steam. On a lower level than the steam tanks are series of receptacles for the oil and water, that are brought to them by conductors leading from the tanks and press. Under the main floor is the scrap-house, into which the scrap is dumped through a scuttle in the floor. The track that runs between the rows of tanks leads down a steep incline to the landing, where there is another engine, and an elevator to take the fish out of the boats. The elevator delivers the fish into a hopper that holds fifty barrels, and from this they are drawn into a car that holds seventeen barrels, so that the unloading of the boat may go on without intermission while the car is carrying its load up to the tanks. The car is drawn up by the engine on the landing, and dumps its load into either of the tanks at pleasure.

"Preparation for the fish is made by filling the tank a foot deep with water and steaming it until hot. The fish are at first steamed hard from forty to sixty minutes, then punched and broken up. After simmering for five hours longer the free water and oil are drawn off, and then, if possible, the broken fish stand draining and cooling for several hours. At last they are pitched into the curbs, run under the press, and subjected to a pressure which is gradually brought up to seventy-five tons. This wrings out all the water and oil that it is practicable to extract, and the cheese is now dropped into the scrap-house to remain until the following autumn or winter."*

The factory at Napeague, N. Y.

244. In the American Agriculturist for December, 1868, p. 452, was published a description of the factory at the entrance to Napeague Harbor, near Montauk Point. In Plates XXVI and XXVII are reproduced the illustrations of the factory and its interior arrangements. The following description of the factory was published at the same time:

"The fish are taken to the factory's dock. At the factory the fish are measured either in cars or boxes, and are drawn upon the railway to the tanks, where they are thrown into water, and a full head of steam turned on into the bottom of the tank, which contains some sixteen to eighteen thousand fish. After thirty minutes' cooking, the water is drained off, and a man getting into the tank fills the curbs, which are circular, and

* Op. cit., p. 27.

formed of strong wooden slats, bound and lined with heavy iron. These are rolled under a solid, stationary head, fitting closely the inside of the curb, and against which the fish are pressed, as the curb is slowly but powerfully raised by a hydraulic press. The oil and the water absorbed by the fish in boiling are pressed out through the slats and carried by leaders to the tanks in the shed by the side of the factory, where the oil-man skims, boils, and otherwise prepares it for barreling. As soon as the pressure is taken off, the curb slowly resumes its position on the railway, and is pushed to where a man stands ready to remove the cheese as it falls from the curb, upon the opening of its hinged bottom. This cheese or scrap-cake is ground to different degrees of fineness, to form the fish guano. This substance, being rich in ammonia-producing material, is used by some manufacturers of fertilizers to supply ammonia to phosphates that are deficient in that constituent."

The model of a factory in the National Museum.

245. A complete model of the oil-factory of Joseph Church & Co., at Round Pond, Me., was exhibited in the Department of Fisheries in the United States Government building at the Philadelphia Exhibition. It is now deposited in the United States National Museum.

The cost of an oil-factory.

246. The larger part of the cost of an oil-factory consists in the machinery, as the buildings are always of wood, substantial but cheap. The amount invested in factories by different manufacturers appears to range from $2,000 to $65,000. The average amount invested in the fourteen factories of the Maine Association is $22,600, but the general average will not probably exceed $12,000 or $15,000.

Mr. Church, of Tiverton, R. I., speaking of the establishments on Narragansett Bay, remarks that a factory ready for business, including buildings, tanks, boilers, hydraulic presses, oil-room, &c., of a capacity to cook and press 800 barrels (200,000) in a day, costs not far from $14,000. A hydraulic press costs about $1,200; in 1877, $700.

Mr. Miles, of Milford, Conn., states that boilers cost from $2,000 to $4,000, hydraulic presses with curbs and fixtures $2,000; engines, pumps, shafting, and pulleys, together with the necessary buildings, bring the cost of the factory to from $10,000 to $50,000.

Capt. B. H. Sisson, of Greenport, N. Y., estimates the cost of boilers, engine, piping, hydraulic press worked by steam, steam drying machines, and steam hoisting apparatus, to cost from $10,000 to $25,000 for each factory.

Mr. Dudley states that a factory running three or four gangs of fishermen costs from $20,000 to $30,000.

The capital invested in the factory is one-half of the whole amount. The fourteen establishments of the Maine Association had in 1874 $316,000 in buildings and machinery and $390,000 in "gear"; that is,

in steamers, sailing-vessels, small boats, and nets; an average of $27,800 to each for gear against $22,600 for factory.

In Connecticut, according to Mr. Dudley, about the same proportion holds.

The total amount of capital invested in the several companies is given, by Mr. Jasper Pryer, as follows:

G. S. Allyn & Co	$25,000 00
Wm. J. Brightman & Co	20,000 00
J. H. Bishop	9,000 00
Bristol Oil Works	35,000 00
Brown's Cove Company	23,000 00
Isaac Brown & Co	9,000 00
Barren Island Manufacturing Company	17,500 00
Joseph Church & Co. (Rhode Island)	17,000 00
Do (Maine)	200,000 00
Charles Cook	18,000 00
G. H. Clark	500 00
Fowler, Foot & Co	42,000 00
Fowler & Colburn	47,000 00
W. Y. Fithian & Co	20,000 00
Robert A. Friend	5,500 00
Albert Gray & Co	55,000 00
Gallup & Holmes	70,000 00
Gallup, Morgan & Co	44,000 00
W. H. H. Howland	20,000 00
S. Jones & Co	30,000 00
Kenniston, Cobb & Co	25,000 00
E. R. Kelsey	8,000 00
Loud's Island Oil Company	25,000 00
Luce Bros.	50,000 00
Maddocks Oil Works	130,000 00
The George W. Miles Company (Maine)	59,000 00
Do (Connecticut)	45,000 00
Morris & Fifield	5,000 00
James Manchester	3,000 00
James E. Otis	11,000 00
Erskine Pierce	11,000 00
Quinnepiac Fertilizer Company	110,000 00
Round Pond Oil Works	42,000 00
Suffolk Oil Company	45,000 00
South Saint George Oil Works	37,000 00
Smith & Yarrington	15,000 00
Tuthill, French & Co	21,000 00
Griffin & Vail	10,000 00
Job F. Wilson	40,000 00

Waley & Co	$15,000 00
Isaac G. White	35,000 00
Wells & Co	60,000 00
Leander Wilcox & Co	30,000 00
Cyrus W. Smith	7,000 00
Westbrook Oil Company	1,000 00
Eleven factories in Gardiner's Bay, N. Y.	310,000 00

The total amount here specified is $1,857,500. It should be noted that several companies are not reported.

Organization of the fishing gangs.

247. "In the early days of the business," says Mr. Dudley, "the manufacturers did not own the fishing-vessels, nor were they interested pecuniarily in the fishery; they bought the fish from independent fishermen. This method was found unsatisfactory; the fishermen sold to the highest bidder, and the supply was uncertain. Of late years the company owns the vessels which supply it with fish. The crew work upon shares, as in other fisheries. In the settlement, at the end of the season, a sailing-vessel, with seine and gear, draws one-third of the net proceeds; a steamer, one-half; the remainder is divided by the crew, the captain receiving an ordinary share, in addition to which he is paid a salary by the company, either fixed or proportionate to the success of the season's work. It is not uncommon for a successful captain to receive a "bonus" of $500, or sometimes $1,000. In settling the season's account, the total catch is paid for at a rate proportionate to the yield of oil. In 1876, the Quinnipiac Fertilizer Company paid $1.25 per thousand. The company usually advances pay to the men to the extent of $1 a thousand, and at the end of the season a final settlement is made. The crew of a sailing-vessel will average form $35 to $75 a month; the crew of a steamer somewhat more."

Advantages claimed for floating factories.

248. Floating factories are in use chiefly on Long Island Sound; in whose protected waters they operate to great advantage. They are now going out of use on account of the introduction of steamers. They are usually built upon the hull of some old vessel, and are towed from point to point, gathering the fish from the smacks and working them up into oil and guano as they move. Some of them are fitted up with machinery for very extensive manufacture. Two important objects are attained by the owners of floating factories: the objection to their business arising from the offensive odor is to a considerable extent removed; by following the movements of the fish time and expense are saved, for by bringing the factory to the fish they obviate the necessity of having a fleet of lighters to carry the fish to the factory, which might often require two or three days. There are five of these factories; one owned at Milford, Conn., and four at Greenport, N. Y.

Mr. Goodale's improved method.

249. I quote from Mr. Maddocks's excellent little report the following account of an improved process devised by Mr. Goodale:

"As now generally managed, the scrap remains in large heaps until shipped, in autumn or winter, to the points of manufacture into, or incorporation with, superphosphate. In this time a portion of the oil and water leaks away, so as to leave about 10 to 15 per cent. of the former, and 48 to 53 per cent. of the latter. The elimination of the water is an advantage, but the specified per cent. of oil is lost; and a portion of nitrogen is also lost, resulting from the partial decomposition of the mass, the formation and escape of ammonia. It were better, if practicable, to drive off the water at once upon withdrawal from the press, so as to prevent the loss in question.

"What has hitherto prevented the driving off of the water immediately by artificial heat has been the presence of so much *oil*, together with the gelatinous or gluey matter which is developed during the cooking, chiefly from the skins and bones. These render the process of drying the scrap a very difficult and tedious one, so much so that comparatively little has been put into market in that desirable form. The recent discovery of an easy and simple process for removing the larger part of the oil, and also at the same time the gelatinous hinderance to drying, gives promise of a speedy change in this respect.

"While pursuing investigations relative to utilizing the menhaden as a source of concentrated food, before referred to, Mr. S. L. Goodale, well known as a chemist as well as for his eminent services to the State as secretary of the board of agriculture, found, by thoroughly washing the scrap as it came from the press, with sufficient hot water and agitation, that the oil globules were liberated from their entanglements in the fleshy tissues, and also from the creamy mixture with the gluey matter into which they were forced by the pressing, so that the greater part of it could be readily recovered by draining and re-pressing; and also that after such washing the scrap would bear heavier pressure than at first without 'squirting.' By this easy process the oil product is largely increased, the scrap is left free from the gluey hinderance to drying, and contains less water to be dried out.

"It may appear strange that so simple a method should not have been discovered sooner, but such is the fact. Work had been done on both sides of it. Re-pressing had been tried, using extra strong curbs, with very powerful pressure, but it failed to give satisfactory results. Re-cooking had been resorted to, which resulted in injury to the oil, and in the development of an additional amount of the gelatinous matter. It is now seen that a simple thorough washing in hot water accomplishes the desired end with neither of these objectionable results. Scrap made by this process last August (1877), and dried in the open air, was lately analyzed at the agricultural experiment station of Connecticut, and the statement of the director, Prof. S. W. Johnson, of New Haven, shows

the proportion of moisture to be reduced to 11.45 per cent., or about one-fifth that contained in the scrap fresh from the press, and the proportion of *oil* to 4.65 per cent., thus proving that the content of oil in the *washed scrap as it came from the press* (before drying it) had been reduced to less than 2½ per cent. According to these figures, the proportion of oil hitherto lost is, by the new process, reduced from an average of, say, 15 per cent. of the weight of the scrap as it commonly issues from the press, to about 2 per cent.; the balance, say, 12 or 13 per cent., is saved. Let it be assumed, however, that only 10 per cent. can be realized in practice, and that the annual outturn of scrap from the factories of the Maine Association is only 40,000,000 pounds. This would give an annual saving of 4,000,000 pounds of oil, or 533,000 gallons, worth at current prices at market for 1877, 40 cents per gallon, $213,200."

Proposed chemical methods.

250. Other methods of extracting the oil from fish scrap have been proposed, but their adaptability is not yet so certainly proved as to warrant their adoption by manufacturers.

The proposed plans involve the use of the fumes of benzine, or bisulphide of carbon, which are brought into contact with the fish in air-tight chambers. The oil is absorbed by these substances, and collects in tanks in the floors of the chambers. Any surplus of benzine or bisulphide of carbon which may remain in the oil is expelled by distillation.

The *naphtha* process for extracting the oil, remarks Mr. Maddocks, consists in subjecting the scrap, in an inclined iron cylinder, to the action of vapors of naphtha, which combine with the oil, and the latter in a state of solution filters away at the lower end of the cylinder. The naphtha is then recovered by evaporation. The process is slow, costly, and dangerous.

Proposed mechanical methods.

251. It has been suggested that a recently invented filter-press, the invention of Mr. John Bowing, is well adapted for the extraction of oil from the menhaden and the formation of the residue into cakes. It is probably too small for the extended operations of manufacturers, but may be very serviceable for the use of refiners. Mr. C. B. Norton, 25 Astor House, N. Y., is the American agent.

44.—VALUE OF FISH FOR MANUFACTURING PURPOSES.

Prices of fish at different seasons.

252. The price of fresh menhaden cannot be definitely stated, since it varies from week to week with the abundance and fatness of the fish and the needs of individual manufacturers.

Many factories rely entirely upon their own "gangs" for their supplies; some others buy the fish of the vessels engaged in the trade,

though this practice is less common than it formerly was. Still every factory buys fish in greater or less quantity, and the answers to question 47 of the circular are important in exhibiting the variations in abundance at different points on the coast. Perhaps it may not be amiss to quote fully from the letters, it being quite impossible to tabulate the facts.

Mr. William H. Sargent, of Castine, Me., says: "For four years past the average price has been 65 cents per round barrel.*

Jason Luce & Co., of Menemsha Bight, estimate that menhaden average from 225 to 240 in a barrel.†

In the report of the committee on statistics from the United States Association for the meeting of 1875, the estimate was put at three barrels to the thousand fish, or 333 fish to the barrel.

Captain Tuthill estimates 22 cubic inches to each fish, Captain Sisson 21, making three and one-half barrels to the thousand. In Long Island Sound the fish are sold by the thousand; farther east, always by the barrel.

Mr. Condon, of Belfast, estimates the price for 1873 at 60 cents; Mr. G. B. Kenniston, of Booth Bay, at 75 cents, stating that in previous years the price has ranged from 50 cents to $1.25. Mr. B. F. Brightman says that in 1872 and 1873 the average has been 65 cents, but that when oil was high they have brought $1. Mr. J. Washburn, of Portland, estimates the price at $1 for 1873; during the war, much higher. Mr. Eben B. Phillips estimates the price at from 60 to 70 cents in 1873, 56 in 1874, and about 60 in previous years. Fall fish, for trying, bring 40 to 50 cents in Wellfleet, Mass., according to Mr. Dill. At Nantucket, according to Mr. Reuben C. Kenny, the fish are worth from 50 to 75 cents as taken from the nets; only about half are used in the manufacture of oil.

Mr. Church gives the average price on Narragansett Bay at 40 cents, and to this correspond very nearly the estimates of the southern shore of Cape Cod and the Vineyard Sound, which find market for their menhaden at the Narragansett factories.

Captain Crandall, of Watch Hill, R. I., thinks $2 to the thousand a fair estimate for 1873 and 1874. Captain Beebe, of Niantic, Conn., agrees with this, giving $2.50 for previous years. Mr. R. E. Ingham, of Saybrook, says $1.25 to $2. Mr. Miles says that in 1873 the prices ranged from $1 to $2.50, according to the yield of oil. Mr. F. Lillington, of Shatford, puts it, for 1875, at from $1.50 to $2. Captain Sisson, of Greenport, says that in 1873 the price was $2.25; in previous years, $1.75; in 1874 the price was lower. Collector Havens, of Sag Harbor,

* A "round barrel" is a barrel of undressed fish, and weighs about 200 pounds. The number of fish in a barrel necessarily varies with their size. Estimates range from 180 to 280; but that made by Mr. Fairchild, at the meeting of the "United States Menhaden Oil and Guano Association," in 1874, is perhaps fair, putting four barrels to a thousand fish, or 250 fish to a barrel.

† Report United States Commission Fish and Fisheries, 1871-'72, p. 35.

N. Y., estimates it at 30 cents per barrel. In the vicinity of Atlantic City, N. J., M. A. G. Wolf gives the price at $1.25 to the thousand; and Mr. Albert Morris, of Somers Point, at 39 cents per barrel (about $1.50 to the thousand). Mr. Hance Lawson, of Cresfield, Md., states that the Chesapeake factories pay 15 cents per bushel.* Mr. Dudley says that in 1877 the average price in the Chesapeake was 50 cents a thousand.

Prices proportionate to amount of oil contained in fish.

253. These prices are simply those paid for fish used in the manufacture of oil and guano, the prices of those sold for bait or food being given under other heads. No satisfactory conclusions can be drawn from these statements, except the very general one that the fish are more valuable on the eastern than on the southern coast of New England; in Maine bringing from $2.40 to $3.20 to the thousand; on Long Island Sound, $1 to $2.25. As the expense of capture is necessarily as great in Southern as in Northern waters, we must seek the reason of the difference in price either in the methods of manufacture, the abundance of the fish, or in the intrinsic value of the fish for the purposes of the manufacturer.

Oil yield of Northern fish.

254. On the first arrival of the schools in Northern water the fish are thin and do not yield a large quantity of oil; but they rapidly gain until the time of their departure in fall, so that the late fishing is by far the most profitable. It is the general opinion of fishermen that Northern fish yield a larger proportionate amount of oil than Southern.

Mr. Sargent, of Castine, Me., says that three quarts of oil to the barrel is the smallest yield he has ever known from the first school, and six gallons the most from the last school. When the fish are very poor, about the 1st of June, it takes 250 to make one gallon of oil; when poor, in July, 200; when fat, in August, 150; when very fat, in October, 100. About one ton of scrap is obtained in making three barrels of oil. Mr. Condon states that when the fish arrive in the spring they will produce but one gallon to the barrel, while in October the yield is four or five gallons; the average for the season being three gallons. Mr. Friend states that the least yield, in June, is two quarts to the barrel; the greatest, in August, four gallons. Mr. Kenniston states that May fish yield three pints to the barrel; October fish, six gallons and one-half. These are no doubt intended as the extreme figures. The average yield is two and one-half gallons to the barrel, an estimate in which Mr. Brightman concurs, though placing the lowest at three quarts; the highest, in August and September, at four gallons. He estimates the yield of a ton of scrap at thirty to forty gallons, according to the season. Judson Tarr & Co. put the early fish at less than a gallon, the September fish at four gallons to the barrel. Mr. Babson thinks that the early

* About 50 cents per barrel, or $2 to the thousand.

fish yield about a gallon, the last four gallons; an estimate in which he is confirmed by Mr. E. B. Phillips.

Mr. Erskine Pierce, of Dartmouth, Mass., states that in 1877 the average yield at his factory was 1¼ gallons to the barrel.

According to Mr. Church, the fish are fattest generally in the fall, though after a warm winter he has known them after first arrival to yield 2½ gallons. After a cold winter the opposite is true; and he has seen them so poor in the summer that out of one hundred barrels of fish not a pint of oil could be extracted. The first 18,000 barrels taken by Church & Co., on the coast of Maine, in 1873, did not make over 14,000 gallons of oil (about three quarts to the barrel). On Narragansett Bay, in 1873, the yield was 1½ gallons less than on the coast of Maine; on Long Island Sound, half a gallon.

Mr. Reuben Chapman informed me that at his factory, on Mason's Island, opposite Noank, Conn., the yield of early fish was sometimes as low as a gallon to the thousand, later in the season reaching fourteen or even eighteen gallons; which would be equivalent to five or six gallons to the barrel.

Mr. Maddocks, writing of the Maine fish, states: "The yield of oil sometimes doubles, per head, in thirty days after their coming. The fish taken on the coast of Maine yield a considerably larger supply of oil than those taken at points farther south, around Long Island, off the Jersey shore, &c. The amount of oil per barrel of fish is there about one gallon, against two and a half here, for the whole season in each case."

And again: "The amount of oil realized varies from one gallon per barrel of fish early in the season to four or five gallons in September. The scrap contains, on the average, as it comes from the press, 55 to 60 per cent. of its weight in water, and sometimes more. This is, of course, worthless for fertilizing purposes. It also contains from 12 to 20 per cent. of fat or oil, which is equally worthless for manure."

Mr. Dudley considers that the first taken in Long Island Sound yield, on an average, about 4 gallons to the thousand. At Pine Island it is somewhat greater; one season averaged 3½, another 6½. In 1877 the average to June 12 was 5 gallons; to November 1, 3 gallons. On November 1 the fat fish made their appearance, and the average has since doubtless greatly increased. There is usually an increase in the yield of oil after July 1, but since 1874 this has not been the case in Southern New England. Mr. Dudley has cooked fish which would not yield a quart of oil to the thousand. Again, in November, the yield has been 18 gallons. It is the opinion of Mr. Dudley that dark oil only is yielded by fish taken in brackish water; light oil by those taken outside.

The George W. Miles Company, of Milford, states that the largest amount made by them in one factory in any one year was in 1871, when they produced 100,000 in about fifty working days; the largest quantity in the shortest time was 21,000 gallons in seventy-two hours, or 7,000

gallons to each day of twenty-four hours. In 1872 they produced 60,000 gallons, and in 1873 105,000 gallons in their two factories, one factory not operating all the time on account of a pending lawsuit.

According to Capt. J. L. Stokes of the Salt Island Oil Company, the average yield of oil is four gallons to the thousand, 9,000 fish making a ton of scrap. Captain Beebe and Mr. Ingham put the highest for the region about the mouth of the Connecticut River at eight gallons, or perhaps three gallons or less to the barrel.

Mr. Miles writes: "All depends upon the quality of the fish, whether fat or poor. In July, August, and September we only get fish that come into the Sound to feed, and they fatten after they get here. If they are poor, we have the largest catch in June and July; if they are increasing in fat or yield of oil, we cannot capture them successfully until August and September. The fat fish in the Sound are usually wild and hard to take until late, perhaps owing to the fact that their food is plenty and low in the water. When the season is unusually dry, the fish are sure to be fat; but in a wet season they are found to be below the average in yield of oil. After the fish get here, if their food is plenty, they grow fat very fast. In the past season (1873), in May and June, one million of fish would make only 800 gallons; in August, the yield was from 8 to 10 gallons per thousand, and in September, 10 to 12."

At Greenport, in 1873, the average yield, on Captain Sisson's estimate, was 8½ gallons to the thousand; the smallest yield, half a gallon in spring and late fall; the greatest, 22, in September and October; 8,000 fish make a ton of green scrap. Mr. Havens puts the lowest yield at one quart to the barrel, the highest at 4 gallons, an estimate much below Captain Sisson's, which would make over 6 gallons to the barrel.

Hawkins Bros. estimate the lowest yield at one gallon to the barrel in midsummer, and 4½ in October and November, putting the average quantity of fish to the gallon at one-third of a barrel on Gardiner's Bay, one-half at Barren Island, and 85 gallons to a ton of scrap on Gardiner's Bay, 57 at the island.

At Atlantic City, N. J., according to Mr. A. G. Wolf, the average yield is 4 gallons to the thousand, the greatest in November, 11; a ton of scrap corresponding to 40 gallons of oil.

On Great Egg Harbor, states Mr. Morris, July fish yield one quart of oil to the barrel; those of October and November yielding 4 gallons. A gallon of oil is the average to each barrel of fish, and 45 gallons to a ton of scrap.

The yield to each barrel of fish was thus estimated by Rhode Island manufacturers in 1877: Joseph Church & Co. and W. H. H. Howland, 1 gallon; Charles Cook, Job T. Wilson, Isaac G. White, and James Manchester, 1¼ gallons; Isaac Brown & Co., $1\frac{1}{35}$; and William J. Brightman, $1\frac{1}{3}$.

Connecticut manufacturers are estimated as follows: The George W. Miles Company, 2¾ gallons to the thousand; Leander Wilcox & Co., 3

gallons; G. S. Allyn & Co., 3⅛ gallons; Waley & Co. and Luce Brothers, 3¼ gallons; the Quinnipiac Fertilizer Company, 3⅓ gallons; J. H. Bishop, 3½ gallons; and Fowler & Colburn, 3¾ gallons.

New York manufacturers are estimated as follows: The Barren Island Manufacturing Company, G. H. Clark, W. Y. Fithian & Co., 2½ gallons to the thousand; Smith & Yarington, 2¾ gallons; S. Jones & Co., 4½ gallons; eleven factories in Gardiner's Bay, 3 gallons.

New Jersey manufacturers are estimated as follows: Morris & Fifield, 2 gallons to the thousand; James E. Otis, Griffen & Vail, Cyrus H. Smith, 2½ gallons.

Maine manufacturers in 1877 were reported as follows: Albert Gray & Co., 1½ gallons to the barrel; Gallup, Morgan & Co., $2\frac{9}{5\,9\,4}$ gallons; Fowler, Foot & Co., 2⅛ gallons; Suffolk Oil Company, 2¼ gallons; R. A. Friend, 2½ gallons; Gallup & Holmes, 2⅓ gallons; Loud's Island Company, 2¾ gallons.

M. Maddocks declares that on the coast of Maine "one hundred and ninety-five pounds of fish make a barrel. One barrel yields about two and a half gallons of oil or eighteen and three-quarter pounds. One barrel yields about eighty pounds of chum or scrap."

Oil yield of Southern fish.

255. Mr. Kenniston makes the following statement: "Corresponding with the successive appearance of the menhaden from South to North there is a progressive improvement in size and fatness. When they arrive in Chesapeake Bay, in the spring, they are thin and lean, and appear to be sluggish and stupid, so that they are easily caught—can almost be taken out by the hand along the shore, which many of them follow closely. Between Virginia and Maine the increase in weight is thought to be one-third. In the fall the increase still continues, but the order of it is reversed, the fish appearing to grow larger the farther South they go, and on reaching Virginia again are twice as heavy as in the spring, and have so gained in strength, swiftness, and wariness that they are very hard to catch."*

Mr. Dudley tells me that from his experience of two years he knows that the first runs of fish in the Chesapeake are fat. This is in March and April.

Mr. A. C. Davis states that the June fish at Beaufort yield from ¾ to 1 gallon, those in October and November 4 to 5 gallons.

Mr. W. F. Hatsel, of Body's Island, states that the average yield is 1½ gallons to the barrel, 75 gallons to the ton of scrap.

Comparison of yield in different localities.

256. These statements indicate in a general way that the yield of Northern is greater than that of Southern fish, though the disparity is not so

* Boardman and Atkins, op. cit., p. 6.

great in the latter part of the season. Mr. Davis' estimate for Beaufort is, however, not much below the average of the coast south of Maine, and it is quite possible that the apparent disparity of the yield on the Southern coast (of which we are not really entitled to judge with the meager returns before us) would be in part explained by differences in the modes of manufacture. Florida menhaden are many of them very fat in the winter season, and there is no apparent reason why the manufacture of oil and guano may not be successfully carried on on our Southern coast.

The official returns of manufacturers may add some additional facts in reference to the yield of fish in oil and guano and the comparative advantages of location.

The following table and statement, quoted from Mr. Maddocks, give a comparative view of the manufacture as carried on by the Maine Association and by all the rest of the United States for the year 1876, the latest for which the data are at hand for the whole country.

Locality.	No. of men.	No. of vessels.	No. of steamers.	Total capital.	Barrels fish used.	Gallons oil manufactured.	Tons crude guano manufactured.
Other States...	1,629	291	3	$1,767,000	826,885	848,727	29,831
Maine.....	1,129	29	43	983,000	709,000	2,143,273	21,414

The most striking fact brought out in the comparison is that Maine realized, from 46 per cent. of the fish, 71 per cent. of the oil. To this it may be added that from the use of $983,000 capital Maine turned out a total product of $1,071,449 value, whereas the rest of the country realized $637,600 from $1,767,000.

45. STATISTICS OF THE MANUFACTURE OF OIL AND GUANO.

Returns for the State of Maine.

257. The number of gallons of oil produced at the factories of the Maine Association during the past five years is as given below:

1873	1,204,055
1874	1,931,037
1875	1,514,881
1876	2,143,273
1877	1,166,213
Total	7,959,459

Table showing average number of vessels employed in fisheries of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	5	3	3	2	.....
Judson, Tarr & Co	Pemaquid, Me	2	1	.....	.....	.....
Albert Gray & Co	Round Pond, Me	1	1	1	1	1
Jos. Church & Co	....do	2	3	2	2	2
Gallup, Morgan & Co	East Boothbay, Me	3	2	2	1	.....
W. A. Wells & Co	South Bristol, Me	2	2	1	.....	.....
Gallup & Holmes	East Boothbay, Me	3	4	2	.....	.....
Kenniston, Cobb & Co	Boothbay, Me	4	5	5	4	.....
Atlantic Oil Company	....do	6	3	.....	.....	.....
Round Pond Oil Works	Round Pond, Me	3	6	3	4	4
Bristol Oil Works	....do	.....	.....	2	2	.....
Suffolk Oil Works	....do	5	4	.....	3	1
Loud's Island Oil Works	....do	2	2	2	3	2
R. A. Friend	Brooklin, Me	.....	1	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	1	1	.....
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	5	.....	.....
John Hastings	Round Pond, Me	.....	.....	3	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	2	3	3
George W. Miles & Co	....do	.....	.....	2	.....	.....
Job T. Wilson	Blue Hill, Me	.....	.....	.....	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	.....	.....
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	3	.....
Maddocks' Oil Works	Boothbay, Me	.....	.....	.....	.....	.....
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	.....

Table showing amount of capital employed by manufacturers of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	$90,000	$90,000	$90,000	$110,000	$90,000
Judson, Tarr & Co	Pemaquid, Me	110,000	120,000	.....	.....	.....
Albert Gray & Co	Round Pond, Me	28,000	55,000	50,000	45,000	55,000
Jos. Church & Co	....do	120,000	120,000	145,000	155,000	200,000
Gallup, Morgan & Co	East Boothbay, Me	19,000	24,000	31,000	35,000	44,612
W. A. Wells & Co	South Bristol, Me	27,000	35,000	40,000	40,000	60,000
Gallup & Holmes	East Boothbay, Me	22,000	25,000	50,000	54,000	70,000
Kenniston, Cobb & Co	Boothbay, Me	27,000	30,000	25,000	25,000	25,000
Atlantic Oil Company	....do	65,000	100,000	140,000	135,000	.....
Round Pond Oil Works	Round Pond, Me	16,000	18,000	20,000	12,000	21,000
Bristol Oil Works	....do	28,000	20,000	22,000	16,000	35,000
Suffolk Oil Works	....do	55,000	55,000	.....	80,000	45,000
Loud's Island Oil Works	....do	6,500	8,000	8,000	8,000	25,000
R. A. Friend	Brooklin, Me	.....	6,500	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	28,000	38,000	42,000
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	90,000	.....	.....
John Hastings	Round Pond, Me	.....	.....	23,000	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	36,000	48,000	42,000
George W. Miles & Co	....do	.....	.....	57,000	57,000	59,000
Job T. Wilson	Blue Hill, Me	.....	.....	24,000	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	110,000	100,000
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	15,000	23,000
Maddocks' Oil Works	Boothbay, Me	.....	.....	.....	.....	130,000
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	37,000

Table showing average number of tons of crude guano produced by the manufacturers of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	1,500	2,600	2,500	1,450	.....
Judson, Tarr & Co	Pemaquid, Me	1,800	2,150	.....	.....	.....
Albert Gray & Co	Round Pond, Me	750	1,350	1,680	1,300	800
Jos. Church & Co	....do	2,100	4,000	4,500	6,000	5,400
Gallup, Morgan & Co	East Boothbay, Me	680	900	1,010	1,100	700
W. A. Wells & Co	South Bristol, Me	700	900	510	1,000	562
Gallup & Holmes	East Boothbay, Me	470	790	900	1,230	1,500
Kenniston, Cobb & Co	Boothbay, Me	615	850	714	483	.....
Atlantic Oil Company	....do	1,800	2,450	2,000	1,595	.....
Round Pond Oil Works	Round Pond, Me	450	850	550	660	150
Bristol Oil Works	....do	600	800	800	800	600
Suffolk Oil Works	....do	1,300	950	.....	850	740
Loud's Island Oil Works	....do	200	500	400	.....	275
R. A. Friend	Brooklin, Me	.....	205	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	500	825	800
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	1,375	.....	.....
John Hastings	Round Pond, Me	.....	.....	400	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	450	825	562
George W. Miles & Co	....do	.....	.....	850	1,121	725
Job T. Wilson	Blue Hill, Me	.....	.....	250	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	2,000	1,000
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	175	.....
Maddocks' Oil Works	Boothbay, Me	.....	.....	.....	.....	1,000
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	352

Table showing average number of barrels of fish taken by fleet belonging to Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	49,000	82,000	83,000	48,000	.....
Judson, Tarr & Co	Pemaquid, Me	61,000	67,000	.....	.....	.....
Albert Gray & Co	Round Pond, Me	25,000	46,000	53,000	45,000	27,000
Jos. Church & Co	do	86,000	138,000	153,000	201,000	182,000
Gallup, Morgan & Co	East Boothbay, Me	22,000	29,472	29,545	34,763	23,760
W. A. Wells & Co	South Bristol, Me	22,913	30,000	28,000	30,000	19,200
Gallup & Holmes	East Boothbay, Me	15,000	25,000	32,000	40,000	51,847
Kenniston, Cobb & Co	Boothbay, Me	18,000	28,389	21,323	14,474	.....
Atlantic Oil Company	do	43,000	64,000	56,000	51,878	.....
Round Pond Oil Works	Round Pond, Me	16,500	27,000	18,000	22,000	5,500
Bristol Oil Works	do	22,000	33,000	24,000	25,653	22,500
Suffolk Oil Works	do	41,000	29,000	.....	26,916	22,200
Loud's Island Oil Works	do	8,000	15,000	12,300	13,000	9,600
R. A. Friend	Brooklin, Me	.....	8,000	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	16,583	27,960	27,170
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	43,620	.....	.....
John Hastings	Round Pond, Me	.....	.....	14,000	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	16,000	26,230	17,721
George W. Miles & Co	do	.....	.....	25,000	37,000	20,000
Job T. Wilson	Blue Hill, Me	.....	.....	10,400	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	60,000	64,031
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	5,000	.....
Maddocks' Oil Works	Boothbay, Me	.....	.....	.....	.....	51,610
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	13,000

Table showing average number of gallons of oil produced by manufacturers of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	135,000	260,000	20,000	146,000	.....
Judson, Tarr & Co	Pemaquid, Me	175,000	200,000	.....	.....	.....
Albert Gray & Co	Round Pond, Me	70,000	153,665	135,000	129,000	44,000
Jos. Church & Co	do	250,000	450,000	446,000	600,000	365,781
Gallup, Morgan & Co	East Boothbay, Me	55,000	88,264	75,017	111,018	47,880
W. A. Wells & Co	South Bristol, Me	62,000	93,000	76,000	87,000	40,000
Gallup & Holmes	East Boothbay, Me	45,000	71,000	86,000	135,555	121,600
Kenniston, Cobb & Co	Boothbay, Me	51,800	84,108	56,656	39,500	.....
Atlantic Oil Company	do	120,000	193,000	140,000	139,000	.....
Round Pond Oil Works	Round Pond, Me	43,255	87,000	45,000	72,000	8,500
Bristol Oil Works	do	55,000	102,000	70,000	80,000	53,500
Suffolk Oil Works	do	120,000	83,000	.....	82,500	51,000
Loud's Island Oil Works	do	20,000	44,000	30,000	28,000	15,680
R. A. Friend	Brooklin, Me	.....	22,000	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	48,428	89,000	65,000
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	114,380	.....	.....
John Hastings	Round Pond, Me	.....	.....	37,000	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	36,400	85,000	39,872
George W. Miles & Co	do	.....	.....	71,000	124,700	45,000
Job T. Wilson	Blue Hill, Me	.....	.....	28,000	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	180,000	130,000
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	15,000	.....
Maddocks' Oil Works	Boothbay, Me	.....	.....	.....	.....	118,000
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	21,000

Table showing average number of steamers employed in fisheries of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	3	4	4	4	.....
Judson, Tarr & Co	Pemaquid, Me	4	4	.....	.....	.....
Albert, Gray & Co	Round Pond, Me	1	2	3	3	4
Jos. Church & Co	do	4	4	5	7	8
Gallup, Morgan & Co	East Boothbay, Me	.....	1	.....	2	2
W. A. Wells & Co	South Bristol, Me	1	1	2	2	3
Gallup & Holmes	East Boothbay, Me	.....	.....	2	3	4
Kenniston, Cobb & Co	Boothbay, Me	.....	.....	.....	1	.....
Atlantic Oil Company	do	1	3	6	6	.....
Round Pond Oil Works	Round Pond, Me	.....	.....	.....	.....	.....
Bristol Oil Works	do	2	2	1	1	3
Suffolk Oil Works	do	1	1	.....	2	2
Loud's Island Oil Works	do	.....	.....	.....	.....	1
R. A. Friend	Brooklin, Me	.....	.....	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	1	2	3
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	3	.....	.....
Job T. Wilson	Blue Hill, Me	.....	.....	1	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	4	5
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	.....	.....
John Hastings	do	.....	.....	.....	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	1	2	2
George W. Miles & Co	do	.....	.....	2	2	2
Maddocks' Oil Works	Booth Bay, Me	.....	.....	.....	.....	6
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	2

Table showing aggregate number of men employed in fisheries of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	80	80	96	60	(*)
Judson, Tarr & Co	Pemaquid, Me	60	50	.....	.....	.....
Albert, Gray & Co	Round Pond, Me	15	24	40	50	50
Jos. Church & Co	....do	60	70	100	120	140
Gallup, Morgan & Co	East Boothbay, Me	27	27	37	†35	28
W. A. Wells & Co	South Bristol, Me	25	20	32	30	40
Gallup & Holmes	East Boothbay, Me	36	50	†50	40	60
Kennistou, Cobb & Co	Boothbay, Me	40	50	50	50	(*)
Atlantic Oil Company	....do	60	60	60	60	.....
Round Pond Oil Works	Round Pond, Me	30	30	30	40	50
Bristol Oil Works	....do	20	20	30	30	40
Suffolk Oil Works	....do	60	50	.....	50	28
Loud's Island Oil Works	....do	20	20	20	20	42
R. A. Friend	Brooklin, Me	.....	10	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	20	30	30
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	80	.....	.....
John Hastings	Round Pond, Me	.....	.....	30	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	36	38	42
George W. Miles & Co	....do	.....	.....	50	25	30
Job T. Wilson	Blue Hill, Me	.....	.....	10	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	50	65
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	30	(*)
Maddocks' Oil Works	Boothbay, Me	.....	.....	.....	.....	66
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	26

* Not operated. † Hodgdon's Mills, E. B.

Table showing aggregate number of men employed in factories of Maine Association.

Name.	Address.	1873.	1874.	1875.	1876.	1877.
L. Brightman & Sons	Round Pond, Me	30	40	45	40	(*)
Judson, Tarr & Co	Pemaquid, Me	27	30	.....	.....	.....
Albert Gray & Co	Round Pond, Me	17	20	30	30	30
Jos. Church & Co	....do	50	70	80	50	60
Gallup, Morgan & Co	East Boothbay, Me	9	13	†17	15	15
W. A. Wells & Co	South Bristol, Me	15	16	17	18	12
Gallup & Holmes	East Boothbay, Me	10	12	†18	18	20
Kennistou, Cobb & Co	Boothbay, Me	11	10	12	17	(*)
Atlantic Oil Company	....do	24	20	25	25	.....
Round Pond Oil Works	Round Pond, Me	15	15	16	15	15
Bristol Oil Works	....do	15	16	20	13	15
Suffolk Oil Works	East Boothbay, Me	16	16	.....	15	18
Loud's Island Oil Works	Round Pond, Me	10	12	9	12	12
R. A. Friend	Brooklin, Me	.....	14	.....	.....	.....
Tuthill & Co	South Bristol, Me	.....	.....	11	14	13
J. G. Nickerson & Co	Hodgdon's Mills, Me	.....	.....	13	.....	.....
John Hastings	Round Pond, Me	.....	.....	18	.....	.....
Fowler & Foote	South Bristol, Me	.....	.....	18	14	13
George W. Miles & Co	....do	.....	.....	15	20	15
Job T. Wilson	Blue Hill, Me	.....	.....	13	.....	.....
Pemaquid Oil Company	Pemaquid, Me	.....	.....	.....	40	‡30
Brown's Cove Oil Company	Round Pond, Me	.....	.....	.....	12	(*)
Maddocks' Oil Works	Boothbay, Me	.....	.....	.....	.....	20
South Saint George Oil Works	South Saint George, Me	.....	.....	.....	.....	12

* Not operated. † Hodgdon's Mills. ‡ Bristol, Me.

Table showing statistics of the manufacture of oil and guano in the State of Maine.

	1871.	1872.	1873.	1874.	1875.	1876.	1877.
Number of factories	.....	.....	13	14	17	17	18
Number of sail-vessels	.....	.....	38	37	36	29	13
Number of steamers	.....	.....	17	22	31	43	48
Number of fishermen	.....	.....	533	561	771	758	727
Number of factory hands	.....	.....	249	304	373	371	300
Number of men—total	.....	.....	782	865	1,144	1,129	1,027
Capital in factories	.....	.....	$278,500	$310,000	$397,000	$431,000	$459,812
Capital in gear	.....	.....	$335,000	$390,500	$482,000	$552,000	$623,800
Capital—total	.....	.....	$613,500	$700,500	$879,000	$983,000	$1,083,612
Number of fish (bbls)	.....	.....	429,413	621,861	635,771	709,000	557,145
Number of fish (M)	.....	.....	143,137,666	207,287,000	211,923,666	238,333,000	185,715,000
Gallons of oil	.....	.....	1,204,055	1,931,017	1,514,881	2,143,273	1,160,213
Tons of guano	.....	16,000	12,965	19,295	19,395	21,414	16,660

Returns for the United States.

258. The following table, compiled from data furnished by Mr. Jasper Pryer, shows in detail the statistics of manufacture by some of the principal establishments:

	Number of men employed.		Number of vessels.		Fish caught.		Quantity of products.		Tons guano dried.	Capital.
	In factory work.	In fishing.	Sailing-vessels.	Steamers.	Barrels.	Number.	Gallons oil.	Tons guano.		
MAINE.										
Bristol Oil Works	15	40	.....	3	22,700	.....	53,500	600	.....	$35,000
Albert Gray & Co	30	50	1	4	27,300	.....	44,000	800	.....	55,000
Joseph Church & Co	60	140	2	8	152,700	.....	365,781	3,400	.....	200,000
Round Pond Oil Company	13	30	.....	3	30,413	.....	65,000	800	.....	42,000
Loud's Island Oil Company	12	42	2	1	9,600	.....	15,650	275	.....	25,660
Pemaquid Oil Company	30	65	.....	5	65,539	.....	130,000	1,900	.....	100,000
Wells & Co	12	40	.....	3	19,700	.....	40,000	562	.....	60,000
Tuthill, French & Co	15	50	4	1	5,500	.....	8,500	150	.....	21,000
Fowler, Foot & Co	13	42	3	2	12,060	.....	30,872	562	.....	42,000
Suffolk Oil Company	18	28	1	2	21,400	.....	51,000	740	.....	45,000
Gallup & Holmes	20	60	.....	4	51,947	.....	121,000	1,500	.....	70,000
Gallup, Morgan & Co	15	22	.....	2	23,910	.....	47,880	700	.....	44,612
Maddocks' Oil Works	20	66	.....	6	53,110	.....	118,000	1,600	.....	130,000
Robert A. Freud	7	23	2	.....	6,000	.....	1,500	135	.....	5,500
The George W. Miles Company	15	30	.....	2	21,000	.....	45,000	72,500	.....	50,000
MASSACHUSETTS.										
Erskine Pierce	10	10	4	.....	15,000	.....	19,000	450	.....	11,000
RHODE ISLAND.										
Job T. Wilson & Co	15	40	9	1	53,000	.....	66,250	1,500	.....	40,000
William J. Brightman & Co	14	30	6	1	50,000	.....	61,031	1,500	.....	20,000
Isaac Brown & Co	15	40	12	.....	13,563	.....	12,350	461	.....	9,000
Charles Cook	10	20	3	1	26,000	.....	32,500	780	.....	18,000
Isaac G. White	14	20	.....	2	20,000	.....	22,500	540	.....	35,000
James Manchester	8	10	3	.....	4,000	.....	5,060	120	.....	3,000
W. H. H. Howland	20	30	6	1	.....	13,000,000	43,000	1,100	.....	20,000
CONNECTICUT.										
G. S. Allyn & Co	15	45	9	1	.....	13,000,000	41,200	1,300	200	25,000
Leander, Wilcox & Co	16	30	9	.....	.....	9,000,000	27,000	1,000	.....	30,000
Waley & Co	7	18	4	.....	.....	4,500,000	14,600	200	60	15,000
Quinnipiac Fertilizer Company	25	40	6	1	.....	13,000,000	43,000	11,100	600	110,000
Luce Brothers	30	50	12	1	.....	23,000,000	76,500	900	1,100	50,000
J. H. Bishop	8	15	4	.....	.....	5,000,000	18,200	530	.....	9,000

R. P. Kelsey	8	10	3			4,800,000	22,000	600		8,000
The George W. Miles Company	20	40	12			15,000,000	43,000	1,100	600	45,000
Fowler & Colburn	20	45	12	*5		13,123,400	42,250	1,411		47,000
Westbrook Oil Company	6				7,000		8,750	210		1,000
NEW YORK.										
Eleven factories in Gardiner's Bay	139	228	69	4		131,500,000	204,500	14,600	2,500	310,000
G. H. Clark	4	4	2			600,000	1,600	60		500
W. Y. Fithian & Co	11	22	6			10,000,000	25,000	12,000		20,000
Smith & Yarrington	15	20	4			8,000,000	22,000	800		15,000
Barren Island Manufacturing Company	22	40	12			13,150,000	33,854	1,160	200	17,500
S. Jones & Co	22	48	12			14,686,725	36,266	1,545		30,000
NEW JERSEY.										
Griffin & Vail	12	11	6			9,000,000	22,500	1,000	50	10,000
James E. Otis	9	11	3			2,501,000	5,000	250		11,000
Cyrus H. Smith	8	9	2			3,406,000	7,400	350		7,000
Morris & Fifield	6	8	2			1,053,000	2,375	105		5,000

*Fishing off Sandy Hook.

The following table shows the aggregate statistics for the United States for a period of five years:

Table showing statistics of the manufacture of menhaden oil and guano in the United States in the years 1873, 1874, 1875, 1876, *and* 1877.

[Compiled from the Annual Reports of the United States Menhaden Oil and Guano Association.]

	1873.	1874.	1875.	1876.	1877.
Number of factories in operation	62	64	60	64	56
Number of sail-vessels employed	383	283	304	320	270
Number of steam-vessels employed	20	25	39	46	53
Number of men employed in fisheries	1,109	871	.....	.....	.....
Number of men employed in factories	1,197	1,567	.....	.....	.....
Total number of men employed	2,306	2,438	2,633	2,758	2,631
Amount of capital invested	$2,388,000	$2,500,000	$2,650,000	$2,750,000	$2,047,612
Number of fish taken	397,700,000	492,878,000	563,327,000	512,450,000	587,624,125
Number of fish taken (estimated in barrels)	1,193,100	1,478,634	1,877,767	*1,535,885	1,958,747
Number of gallons of oil made	2,214,800	3,372,837	2,681,487	2,992,000	2,425,589
Number of tons of guano made	36,299	50,976	53,625	51,245	55,444
Number of gallons of oil held by manufacturers at the end of the year	484,520	648,000	125,000	264,000	94,000
Number of tons of guano held by manufacturers at the end of the year	2,700	5,200	1,850	7,275	2,840
Value of oil, at 37 cents	$819,476	$1,247,950	$992,140	$1,107,040	$897,838
Value of guano, at $11	$399,199	$560,736	$589,875	$503,695	$609,884
Total value of manufactured products	$1,218,675	$1,808,686	$1,582,015	$1,670,735	$1,607,722

* The Oil, Paint, and Drug Reporter for January 9, 1877, gives this as 1,708,166.

A comparison of the yield of the whale and other fisheries.

259. In 1875, the total amount of sperm oil from the American whale fisheries was 1,000,951 gallons; of other whale oil, 1,414,186 gallons; in all, 2,505,137 gallons. The amount of menhaden oil for the same year was 2,618,487 gallons, an excess of 176,350 gallons. In 1874, the amount of menhaden oil was 3,372,837 gallons, exceeding that of whale oil by 1,115.597 gallons.

In 1876, 2,990,000 gallons of menhaden oil were made, and in 1877, 2,426,000, For the year ending June 30, 1877, the production of whale oil was 2,140,047 gallons, and for the year 1877, 2,151,765 gallons.

In the "Oil, Paint, and Drug Reporter" for January 14, 1874 (page 4), the following statement is made:

"It is asserted that while the amount of oil produced is equal to that derived from the whale fisheries in this country, the menhaden interest is ahead of the whale, for though the menhaden oil sells at a less price per gallon, for every barrel of oil made there is three-quarters of a ton of scrap, which readily commands $15 per ton at the factory."

This is not true. In 1874, for instance, the value of the sperm oil alone was $1,250,987; that of other oils from the whale fishery, $775,919. Total value of oils from the whales, $2,026,906; the value of the total products of the whale fishery, $2,291,896.

By way of further comparison, the cod and seal-oil fishery of Newfoundland and Labrador may be instanced. The latest figures at hand show the product of the seal-oil fishery to be 1,500,000 gallons, and of the cod-oil fishery 900,000.

Comparison of yield of nitrogen from Guano Islands.

260. The refuse products of the oil-factories, together with the fish used in a crude state for manure, are estimated to have yielded in 1875 over 10,000,000 pounds of ammonia in the best possible organic forms. This quantity of ammonia is equivalent to at least 60,000,000 pounds of Chincha Island guano, formerly imported from Peru, the gold value of which would be not far from $1,920,000.

In addition to ammonia, the phosphate of lime derived from this source and convertible into agricultural products amounted to nearly 1,430,000 pounds, which is the equivalent of nearly 60,000,000 pounds of Peruvian guano.

Associations of oil and guano manufacturers.

261. The Association of the Menhaden Oil and Guano Manufacturers of Maine was formed in the year 1870. The objects were such as are usually sought by organizations of the sort—harmony of action on points affecting the common welfare of the business, social acquaintance, and the communication of information as to improved processes, etc. The annual meeting is held the second Tuesday in January of each year. The United States Menhaden Oil and Guano Association was organized in 1873. The annual reports of these societies are given in full in Appendix L.

46. THE USES OF MENHADEN OIL AND THE OIL MARKET.

The uses of menhaden oil.

262. The uses of menhaden oil are manifold. It is chiefly employed as a substitute for the more costly and popular oils and to adulterate them. It is sold largely to tanneries for currying leather. After the hide has been "dressed," *i. e.*, after its coarser fleshy parts have been pared off, the oil, mixed with tallow, is applied. This is technically called "stuffing," and results in qualifying any residue of alkali left from the "liming" process, and in filling the pores, and softening the leather. Mr. L. C. d'Homergue states that this oil is largely used in the tanneries of Russia.

A considerable quantity is used as a burning oil in coal-mines to fill the small lamps, one of which is fastened to the cap of each miner. It is then mixed with paraffine or some of the heavier oils. Some is also sold to be used in the manufacture of rope. A small quantity is used annually for lubricating purposes, but, on account of its gummy nature, it is not much in favor among machinists.* It is used in adulterating linseed oil, and is also sold as a substitute, its cheapness and durability

*Mr. Isaac Bow, of Springfield, Mass., devoted several years to experimenting, with a view to the preparation of a good lubricating oil from menhaden oil, but his success was not satisfactory.

rendering it especially valuable for rough outside work and for painting ships. Mixed with other oils it is found to be very serviceable for the painting of interiors, and its use is attended with decided economy, its price being about one-half that of the best linseed oil. Some of the most pure is said to be put into the market as olive oil.

Most of that which is exported is used in the manufacture of soap and for smearing sheep after they have been sheared to keep off ticds. Mr. L. C. d'Homergue states in the Manufacturer and Builder that a bright fish oil, cut with some alcohol and mixed with paint, forms a far more lasting covering than linseed oil.

The "Oil, Paint, and Drug Reporter" for October 21, 1874, implies that much of the whale oil now sold is really menhaden oil. "It is well known that the chief uses for menhaden oil is for currying leather, but with the low prices ruling of late and the scarcity of whale-oil it has found new channels, and very much of the whale-oil sold probably consists of two-thirds or more of menhaden, for it comes when crude nearly as handsome as any whale, and in appearance when bleached is quite equal. It is reported as a fact about the street that one concern alone sells more 'winter-bleached whale-oil' than is caught of crude, and they do not by any means get all the crude."

The markets.

263. The principal market for menhaden oil is in Boston and New York; some is also sold in New Bedford, and considerable quantities are shipped to London, Liverpool, and Havre direct.

Grades of oil.

264. Several grades are recognized. The "Oil, Paint, and Drug Reporter" usually quotes under the heads of "select light strained," "select light," "choice brown," and "inferior to dark," and "gurry."

The prices of oil.

265. The highest price ever obtained for menhaden oil was $1.40 a gallon—this was a war price. In Appendix K is given a table showing the current weekly prices of the different grades of oil in the New York market for a period of nearly seven years. This has been compiled from the "Oil, Paint, and Drug Reporter," complete files of which I have been enabled to consult through the courtesy of the editor, Mr. W. O. Allison. This table includes all reliable information regarding the prices current of menhaden oil, and its value is enhanced by the addition of a weekly commentary upon the causes of fluctuation in price and the state of the market, also compiled from the "Oil, Paint, and Drug Reporter." Since the interest in the causes of rise and fall of price is of merely commercial interest, it does not seem to be necessary in this place to discuss the subject in detail. See Appendix K.

Table showing highest and lowest prices of menhaden oil for the years 1871 to 1877.

Years.	Select light.	Choice brown.	Inferior to dark.	Gurry.	Strained.	Pressed.	Select light, strained.	Bleached.
1871	53 to 55	50 to 52½	47½ to 50	35 to 40	60 to 62½	.....	.....	.....
1872	40½ to 41	39½ to 40	35 to 38	20 to 25	58 to 60	.....	.....	.....
1873	62½ to 65	60 to 62½	55 to 57½	45 to 50	60 to 65	64 to 66	.....	.....
1874	40 to 42½	40 to 41	36 to 38	25 to 30	58 to 65	45 to 50	.....	.....
1875	60 to 62	59 to 60	52 to 58	48 to 50	.....	55 to 57½	.....	.....
1876	32½ to 35	30 to 32	29 to —	.....	.....	.....	.....	.....
1877	45 to 47½	45 to 46	42½ to 45	.....	.....	.....	52½ to 55	.....
	32½ to 35	35 to 35½	32 to 34	.....	.....	.....	40 to 42	.....
	45 to 47½	43 to 44	38 to 40	.....	.....	.....	49 to 50	55 to 56
	32 to 33	31 to 32	20 to 30	.....	.....	.....	38 to —	44 to 45
	48 to 50	46 to 48	36 to —	.....	.....	.....	50 to 52½	55 to 60
	32½ to 33	32½ to 33	34 to 36	.....	.....	.....	40 to 41	45 to 47
	46 to 47	45 to 46	40 to 42	.....	.....	.....	48 to 50	53 to 54
	33 to 34	33 to 34	30 to 32	.....	.....	.....	38 to 40	42½ to 45

Reviews of the markets.

266. in January, 1874, the manufacturers composing the "United States Menhaden Oil and Guano Association" had on hand 484,520 gallons of oil, or about 21 per cent. of the amount manufactured in 1873; in January, 1875, 648,000 gallons, or about 19 per cent.; in January, 1876, 125,000, or over 4 per cent.; in January, 1877, 264,000, or over 8 per cent.; and in January, 1878, 94,000, or over 4 per cent. These figures seem to indicate that the demand for oil quite keeps pace with the supply.

The following editorial on the value of menhaden oil appeared in the Oil, Paint and Drug Reporter, October 21, 1874:

"Prices for menhaden oil have ruled very low this year, and it has probably been relatively the cheapest grease in market. This fact, together with a poor run of fish part of the season, caused several of the weakest of the manufacturers to close their works, and the natural result has been less than an average season's production, except in Maine. The Maine season ended some time since, and the fall catch of the other States, which is usually the best, has thus far been comparatively nothing, and as it will soon close cannot be improved much. To-day we should estimate the stock in the hands of fishermen as fully one quarter less than last year, and with one exception the dealers in this city are almost without stock.

"The entire failure of the Arctic whaling-fleet, the high price of all other grease, and the advance in the price of Newfoundland cod oil point to advanced prices for menhaden. We said early in the season that menhaden oil was cheap at 40 cents, and it ought not to have gone below that price. At the present time some parties talk of 50 cents as the point the market will reach, but we hope that manufacturers will not hold for such high prices; this would be as much too high as 35 cents was too low, and as soon as you get an article above its real value something takes its place and you cannot get it into the same channels until it becomes so low that it is forced back."

N.—MENHADEN AND OTHER FISH AND THEIR PRODUCTS AS RELATED TO AGRICULTURE.

By W. O. Atwater.

Introductory note.

267. Mr. Goode has placed in my hands a number of documents, manuscripts, and letters concerning the use of fish, and particularly menhaden, as fertilizers, with a request for a statement of the more important facts and principles that have to do with the application of these materials to the improvement of agriculture.

The time allowed for this work is, unfortunately, so short as to forbid anything more than a hasty putting together of the data immediately at hand, in the form of a brief review of the history and a still more incomplete outline of the results of scientific investigation and practical experience concerning the preparation, properties, and uses of fish as a fertilizer and as food for stock. I hope that this may serve to explain the chief practical bearings of the subject, to show its importance, and lead to its more thorough investigation hereafter.

The employment of fish products in agriculture offers a singularly forcible illustration of the slowness with which the worth of some of the most valuable materials is recognized, and of the need of scientific investigation and experiment to aid practical skill in utilizing them most profitably.

The loss to the agriculture of our country at large, and particularly our sea-board States, from the waste of fish that might be utilized, the wrong manufacture of the materials that are saved, the export of the best products to Europe, the uneconomical use as fertilizers of what we save and keep at home, and from the almost entire neglect to devote the products to their most profitable purpose, feeding stock and enriching the manure of the farm, if it were capable of accurate estimate, could not fall short of some millions of dollars annually. This is due mainly to the fact that the principles that underlie the right economizing of fish are not generally understood, and, for that matter, are not yet fully learned. It is only lately that science has joined with practice in studying and improving the manufacture and use of fish products for agricultural purposes. The best work in investigation has been done in Europe; its results come to us but tardily. Manufacturers hesitate to apply and farmers are still slower to use them. Everything that brings new knowledge or extends the understanding of what is known must, then, be most valuable.

47. MENHADEN AND OTHER FISH IN A FRESH STATE USED AS A FERTILIZER.

Use among the Indians and early colonists.

268. Professor Trumbull tells us that the Indian names of *Brevoortia*, "menhaden" and "poghaden" (pogy), mean "fertilizer," that which manures, and that the Indians were accustomed to employ this species, with others of the herring tribe (aumsûog and munnawhateaûg), mostly the alewife (*Pomolobus pseudoharengus*), in enriching their corn-fields. Thomas Morton wrote in 1632, of Virginia: "There is a fish (by some called shadds, by some allizes) that at the spring of the yeare passe up the rivers to spawn in the ponds, & are taken in such multitudes in every river that hath a pond at the end that the inhabitants doung their grounds with them. You may see in one township a hundred acres together, set with these fish, every acre taking 1,000 of them, & an acre thus dressed will produce and yeald so much corne as 3 acres without fish; & (least any Virginea man would inferre hereupon that the ground of New England is barren, because they use no fish in setting their corne, I desire them to be remembered, the cause is plaine in Virginea) they have it not to sett. But this practice is onely for the Indian maize (which must be set by hands), not for English grain: & this is, therefore, a commodity there."*

This passage is very interesting, showing the use of fish fertilizers in Virginia two hundred and fifty years ago or more, and, from what is known of the habits of the herring family in Virginia rivers and the persistency of local names, there can be little doubt that many menhaden were used among the fertilizing fish, though "shadds and allizes" doubtless includes the shad (*Alosa sapidissima*), the mattowocca (*Pomolobus mediocris*), the alewife (*Pomolobus pseudoharengus*), and the thread-herring (*Dorosoma cepedianum*), all of which are common in spring in the Potomac and other rivers which empty into Chesapeake Bay.

In Governor Bradford's "History of Plimoth Plantation" an account is given of the early agricultural experiences of the Plymouth colonists. In April, 1621, at the close of the first long dreary winter, "they (as many as were able) began to plant their corne, in which service Squanto (an Indian) stood them in great stead, showing them both y^e^ manner how to set it and after how to dress & tend it. Also he tould them, axcepte they got fish & set with it (in these old grounds) it would come to nothing; and he showed them y^t^ in y^e^ midle of Aprill, they should have store enough come up y^e^ brooke by which they begane to build, and taught them how to take it."†

* New England Canaan; or New Canaan, containing an abstract of New England. Composed in three Bookes. * * * Written by Thomas, of Clifford's Inn, Gent. Upon ten Yeers knowledge & Experiment of the Country. Printed by Charles Green, 1632. Force's Historical Tracts, Vol. II, .?

† Coll. Mass. Hist. Soc., III, 4th series, 1856, p. 100.

An allusion to the practice of the Indians in this respect may be found in George Mourt's "Relation or Journal of the beginning and Proceedings of the English Plantation settled at Plimoth, in New England, by certain English Adventurers both Merchants and others." * * * "London, 1622": "We set the last spring some twenty acres of Indian corn, and sowed some six acres of barley and peas, and, according to the manner of Indians, we manured our ground with herrings, or rather shads, which we have in great abundance and take with great ease at our doors. Our corn did prove well, and God be praised, we had a good increase of Indian corn, and our barley indifferent good."* * * *

Again, in Edward Johnson's "Wonder-working Providence of Sion's Saviour in New England, Being a Relation of the firste planting in New England in the yeere 1628, London, 1654," written in 1652, the author says: "But the Lord is pleased to provide for them [the colonists] great store of fish in the spring-time, especially alewives, about the bignesse of a herring. Many thousands of these they used to put under their Indian corne, which they plant in Hills five foot asunder; and assuredly when the Lord created this corne, hee had a speciall eye to supply these his peoples wants with it, for ordinarily five or six grains doth produce six hundred."†

Use at the beginning of the present century and later.

269. Menhaden do not appear to have been much used by agriculturists of Cape Cod in the beginning of this century, though the old record shows that the horse-shoe crab and sea-weed were extensively applied.

In 1792 the Hon. Ezra L'Hommedieu, of New York, published a paper in the New York Agricultural Transactions‡ which gives somewhat more accurate data and directions concerning the use of fish as a fertilizer. He says: "Experiments made by using the fish called menhaden or mosbankers as a manure have succeeded beyond all expectation. * * * In dunging corn in the holes, put two in a hill on any kind of soil where corn will grow, and you will have a good crop." He recommends them as a top-dressing for grass. "Put them on a piece of poor loamy land, at the distance of fifteen inches from each other, * * * and by their putrefaction they so enrich the land that you may mow about two tons per acre." But he adds, very wisely, "how long this manure will last has not yet been determined." He gives, in his quaintly interesting way, an account of "an experiment made the last summer by one of my near neighbors, Mr. Tuthill, in raising vegetables with this fish manure," which is worth citing as an illustration of the curious combinations of truth and error, which, in their lack of definite knowledge of the laws of plant-growth and the action of manures, the theorizers of that time invented.

* Coll. Mass. Hist. Soc., 2d series, IX, 1832, p. 60.

† Coll. Mass. Hist. Soc., 2d series, III, 1816, 158.

‡ See Appendix O.

"About the first of June he [Mr. Tuthill] carted near half an ox-cart load of those fish on twenty feet square of poor, light land, being loam mixed with sand. The fish he spread as equally as he could by throwing them out of the cart; being exposed to the weather, they were soon consumed. He then raked off the bones, to prevent their hurting the feet of the children who might go into the garden, and ploughed up the piece and planted it with cucumbers and a few cabbages. The season was extremely dry, and but few cucumbers grew in the neighborhood except what grew on this small piece, and here the production exceeded anything that had before been known. By his own computation and that of his neighbors, this twenty feet square of ground produced more than forty bushels of cucumbers, besides some fine cabbages. I measured the ground myself, and have no doubt of the quantity adjudged to have grown on the same."

Mr. L'Hommedieu's theoretical explanation of this is clear and simple. The fish "enrich the land by their putrefaction." When this process has ceased he questions whether much more good can be expected from them, and doubts if they will make a lasting manure; nor does he find any fault with his neighbor for raking away the bones instead of covering them with earth to prevent their pricking his children's bare feet. In the decomposition a good deal of "effluvia" is evolved, which is evidently absorbed by the leaves of the plants, and contributes to their growth. But "by putting these fish on the land for manure, exposed to the air until they are consumed, there can be no doubt that a considerable part of the manure is lost by the effluvia which passes off the putrefied substance, as is evident from the next experiment." This was made by "Mr. Joseph Glover, a farmer in Suffolk County," who had evidently learned the art of composting fish with earth, and practiced it in a way which some farmers nowadays might improve their ways by imitating.

"He first carts earth and makes a bed of such circumference as will admit of being nine inches thick; he then puts on one load of fish, then covers this load with four loads of common earth, but if he can get rich dirt he covers it with six loads, and in that manner makes of fish and earth a heap of about thirty loads. The whole mass soon becomes impregnated and turns black. By experience he finds that fifteen ox-cart loads of this manure is a sufficient dressing for one acre of his poor land, which produces him thirty bushels of the best wheat by the acre."

Now it happened that Mr. Glover made a heap of fish and earth "in the manner above related near a fence where a field of wheat was growing on the opposite side. The wheat near the heap soon changed its colour, grew luxuriant, and at harvest yielded near double the quantity to the other parts of the field." The improvement in the wheat near the heap, Mr. L'Hommedieu thinks, must be due to the "effluvia arising from the putrefaction of the fish and absorbed by the leaves of the wheat."

President Dwight, of Yale College, visiting Eastern Long Island in 1804, speaks with much approval of the menhaden as a fertilizer, and thus describes the introduction of its use:

"Their agriculture has, within a few years, been greatly improved. For a considerable period before the date of this journey the land had become generally impoverished by a careless husbandry, in which the soil was only exhausted, and no attempts were made to renew its strength. * * * Within this period the inhabitants, with a laudable spirit of enterprise, have set themselves to collect manure wherever it could be found. Not content with what they could make and find on their own farms and shores, they have sent their vessels up the Hudson and loaded them with the residuum of potash manufactories, gleaned the streets of New York, and have imported various kinds of manure from New Haven, New London, and even from Hartford. In addition to all this, they have swept the Sound, and covered their fields with the immense shoals of white-fish with which, in the beginning of summer, its waters are replenished. No manure is so cheap as this, where the fish abound; none is so rich, and few are so lasting. Its effects on vegetation are prodigious. Lands which heretofore have scarcely yielded ten bushels of wheat by the acre, are said, when dressed with white-fish, to have yielded forty. The number caught is almost incredible. It is here said, and that by persons of very fair reputation, that 150,000 have been taken at a single draught. Such, upon the whole, have been their numbers, and such the ease with which they have been obtained, that lands in the neighborhood of productive fisheries are declared to have risen, within a few years, to three, four, and, in some cases, to six times their former value."*

Elsewhere he speaks with equal favor of its use in Connecticut, remarking that it is remarkably favorable to vegetation of every kind, which is the object either of agriculture or horticulture:

"Within the last twenty years the inhabitants of this [Branford] and other townships along the coast have employed for the purposes of manure the white-fish, a species of herring remarkably fat and so full of bones that it cannot conveniently be eaten. In the months of June and July these fish frequent the Sound in shoals, and are caught with seines in immense multitudes. Ten thousand are considered as a rich dressing for an acre. No manure fertilizes ground in an equal degree; and none seems more universally favorable to the productions of the climate. Wheat, particularly, grows under its influence in the most prolific manner, and is peculiarly safe from blasting.

* * * * * * *

"The following is a strong instance of the fertility of land manured with white-fish: Mr. David Dibble, of Killingworth, from 5½ acres of land dressed with this manure, had in the year 1812, 244½ bushels of rye,

* Dwight's Travels, III, 1822, p. 305. Journey to Long Island, 1804, Letter II.

almost 45 bushels to an acre; the most exuberant crop of this grain which I have known in New England." *

In 1819, Rev. D. D. Field spoke of the use of fish as manure as follows:

"The most efficacious manure in the vicinity of the Sound consists of the white-fish which visit the shores in numerous numbers in June and the first part of July. These began to be used for manure in Middlesex in 1801 and 1802. They are carried as soon as taken and spread upon the land and plowed in; or are thrown into heaps, mixed and covered with earth or turf and suffered to pulverize; and are then spread upon the ground as suits the convenience of the farmers. In either mode the effect even on dry and poor land is wonderful, and though it was at first apprehended by many that after two or three crops they would leave the land poorer than they found it, experience has hitherto proved this apprehension to be groundless.

* * * * * * *

"Eight thousand are requisite to dress an acre. They have been sold lately for a dollar and a half per thousand." †

Dr. DeKay in the Natural History of New York, 1842, says:

"The use of this fish as a manure is well known in the counties of Suffolk, Kings and Queens, where it is a source of great wealth to the farmer who lives upon the sea coast. They are used in various ways: For Indian corn, two or three are thrown on a hill; for wheat, they are thrown broadcast on the field and plowed under, although it is not uncommon to put them in layers alternately with common mold, and when decomposed spread it like any other compost. Its effects in renovating old grass fields, when spread over with these fish at the rate of about two thousand to the acre, are very remarkable."

In 1853, Mr. Ker B. Hamilton, governor of Newfoundland, in a "Dispatch to the Duke of Newcastle" on "the Refuse of the Cod Fishery of Newfoundland as convertible into a Portable Manure," says:

"In this island the manure universally applied to the soil is fish, consisting of the superabundant herrings and caplins in the process of decomposition, and generally without any earthy admixture; and the heads, bones, and entrails of codfish, after having been decomposed and formed into a compost with clay or peat-bog earth. This manure * * * when applied to the thin, gravelly, unpromising soil (on the Island of Newfoundland) yields crops of grass and potatoes which, in growth and productiveness cannot be surpassed elsewhere." ‡

Messrs. Boardman and Atkins, in their excellent report on "The Menhaden and Herring Fisheries of Maine," § to which we shall have frequent

* Dwight's Travels, III, 1822, p. 513, 514, 516.

† A | Statistical Account | of the | County of Middlesex, | in | Connecticut. | = | By David D. Field. | = | Published by the Connecticut Academy of Arts and Sciences, | Middletown, Conn. | Printed by Clark & Lyman. | .... | April, 1819. 8 vo, p. 153.

‡ Jour. Roy. Ag. Soc., 1st ser., XIV, 1853, p. 393.

§ Agriculture of Maine, 1875-6, page 1.

occasion to refer, say: "More than thirty years ago, before fish oil had become a marketable commodity, the farmers of our eastern coast [Maine] were in the habit of using the fish whole in different forms. In some cases, two or three fish were put in a hill for corn, and covered before the corn was planted; in others they were covered by being thrown into the furrow as the land was being plowed, while in instances less frequent they were made into a compost and applied as a top-dressing. These were the ruder forms of using fish as a fertilizer, and generally practiced before the manufacture of oil and the consequent accumulation of fish scrap."

A method similar to the above was formerly in use among the farmers of New Jersey. Prof. George H. Cook, in his report on the geology of that State, says the practice there was to plow a furrow alongside the rows of corn, deposit the fish, and then turn the furrow back again, covering them. In this way the farmers carried their corn through to maturity, and good crops were gathered from the poorest and lightest soils in the State. A Massachusetts correspondent of the "Country Gentleman" (vol. 5, page 152) says the application of fish compost "appears to ameliorate the effects of drouth."

Use at the present day.

270. Mr. Goode states: "even at this day the fish are often applied to the soil in a crude state, though the manufactured fertilizers are superseding it in most localities. Gov. Caleb Lyon tells me that two or three times every summer Staten Island is visited by smacks loaded with menhaden, which are quickly bought up by the farmers. In planting corn, they put two or three fish in each hill, and so with potatoes; when they plant potatoes in rows, a continuous line of menhaden is placed in the bottom of the furrow, head to tail. In 1871, according to Mr. J. M. K. Southwick, many menhaden were sold for manure in Rhode Island at 30 cents a barrel. During the five years previous he had sold about 75 barrels for this purpose."

Until very lately it has been, certainly, and for aught I know is still, the custom of farmers on the Connecticut coast to use whole fish as a top-dressing.

48. Fish scrap as manure.

The inception of its use.—Experience in Maine.

271. As a result of the profitable utilization of fish for the manufacture of oil, the use of the whole fish as a fertilizer has gradually and almost entirely ceased, and given place to the refuse from which the oil has been expressed or otherwise extracted. This is known in its crude state as "fish scrap," "fish pomace," or "chum," and when more carefully prepared, as "dry fish," "dry ground fish," and "fish guano." Still farmers have been slow to avail themselves of this more concentrated material. Messrs. Boardman and Atkins, in the report referred to, say:

"Its use in Maine even in this way, notwithstanding the results were almost always satisfactory, except in some instances where it was used in too large quantities, did not seem to extend to any great extent back into the interior; and even along the coast where farmers could get the scrap for the hauling, not half of them made any use of it. When the business of extracting oil from menhaden was first engaged in along the coast of Hancock County, and especially in Union River Bay, the works were situated on shipboard, and the scrap was thrown overboard into the bay. The result of this was to drive out all the deep-water fish, as mackerel, cod, &c., and this was continued for many years. On the first establishment of oil works at Bluehill Falls and other places the scrap was given away, and farmers could get a scow-load any time they wished. It is said that the farmers in the town of Brooklin first utilized the scrap by applying it to the land, and during days when no catch of menhaden would give work at the factories, the men would cart the scrap away and spread it as a top dressing on grass lands. It was used green from the press, and on the sandy soil of that town its good effects were most marked. Afterwards, it began to be composted with muck or with fine loam, and was applied to potatoes and grass with excellent results. As a top dressing to mowing fields it was spread on after haying, and in this way was generally used fresh. Too large an application was found to induce too rapid a growth of grass and to cause it to rust, and it also gave a fishy flavor to the hay, not relished by cattle; but these matters were gradually learned from experience in its use, and as gradually mastered and overcome. As its value became known its price advanced, and for several years, from about 1858 to 1864, it went up to $6.00 per ton."

Experience in Connecticut.—Mr. Clift.

272. At a meeting of the Connecticut Board of Agriculture in December, 1873, Rev. Wm. Clift, of Mystic Bridge, gave a lecture on "Marine Manures."* This was followed by a discussion, in which a number of the best farmers of the State took part, and is interesting, as showing what the practical experience of men who have used fish scrap as rationally as intelligent farmers do anywhere, says of its uses and value. Mr. Clift said:

"Along the shores [of the Long Island Sound] where I have lived for the last twenty-five or thirty years, very large quantities of white-fish, or menhaden, are taken for the purpose of making oil. Formerly they were taken simply for the purpose of making manures, and were caught in very large quantities all along our shore and over on Long Island, in large seines, which were generally owned by companies composed of farmers. These fish were carted by the farmers quite long distances, spread broadcast over their fields, and left to putrefy in the open air, and then along in the fall they would be plowed in for rye and for other

* Report of Conn. Board of Agriculture, 1873, p. 197.

crops. This, of course, was a very wasteful process, as a large part of the ammonia which the decaying fish furnished went off into the air; still, it was a very valuable manure used even in that way. Not only were white-fish taken, but very large quantities of sharks, and some valuable food-fishes were oftentimes taken in connection with these fish, which were caught expressly for manure. Latterly the oil has become exceedingly valuable, so that the companies now take the fish for the purpose of procuring the oil, and the refuse, what remains after the oil has been expressed, is sold for manure. I suppose about forty millions of white-fish are taken annually along the shore of Fisher's Island, in the sound, between New London and Stonington, a distance of not more than ten miles, probably, and there are some six or eight companies that have been organized for the purpose of taking these fish. These companies are quite prosperous, and a source of quite large income, not only to those who are engaged in fishing, but to other people. They make a market for the wood of the farmers in all that region. It is quite a common thing for the farmers to exchange their wood for this fish scrap. About two cords of wood, delivered on the shore, will buy a ton of this fish scrap. * * * Sometimes they get it in season for the farm [spring?] crops or turnips, and always in season for the rye crop in the fall. The price is from $13 to $16 per ton. * * * A great deal of it goes up the Connecticut River. The tobacco raisers know the value of fish scrap, and it is sent quite a distance into the country. * * * The farmers all along the coast use the fish scrap in what is called a 'fish pie.' The scrap is drawn to the farm, a few furrows are turned up near where they want to use the fish scrap the next year, a layer of scrap is put over these furrows, then a layer of sods and so on, forming a compost heap four or five feet high. Probably eight or ten times as much earth as scrap is used, in bulk or weight. After it has lain a few weeks in this condition, it is forked or shoveled over, so that it is all intimately mixed, and the scrap very nearly absorbed by the soil, and in that condition it is fit either to be spread upon the ground for rye or for corn crop the next season. It is also used in connection with stable manure. The scrap is carted into the yard where the stable and yard manure is heaped up, and mixed with that; it adds very greatly to the value of yard manure. They will put, perhaps, one ton of the scrap to ten tons or more of yard manure; and then, after it has remained two or three weeks, it is carted off for top-dressing for corn or potatoes, or the ordinary crops of the farm. I have used fish scrap for the last three years on the rye crop, and find it exceedingly beneficial and economical. The soil where I use it is a gravelly loam, very well underdrained, but it has been pretty well exhausted by long cropping. I spread about half a ton of this manure to the acre, and get a very satisfactory yield of rye from this light dressing. It costs me about seven or eight dollars an acre for the manure, and I get in return for it about fifteen bushels of rye to the acre, and

nearly a ton of straw. The straw sells with us for about twenty dollars a ton, and rye is worth from ninety cents to a dollar a bushel; so that for a very small expenditure for manure I get very satisfactory crops of rye. * * * A year ago last summer I used a ton of fish scrap on half an acre of land. It was nothing but gravel. There was hardly any vegetable matter; none but what had grown out of the gravel, and, perhaps, a little washed from the surrounding land. I did not pay anything for the land; the owner did not consider it worth anything. I got a glorious crop of corn, cabbages, and potatoes on that little piece of land, by the use of a ton of fish scrap."

With regard to the value of green and dried scrap and the loss in drying, Mr. Clift says:

"As it comes from the press, after all the oil has been pressed out of it that can be gotten out by the strongest hydraulic pressure, there is still a great deal of moisture in it—40 or 50 per cent. As it lies on the platform under cover, there is, of course, a constant loss of moisture, but there is also a loss of ammonia, which is very valuable, so that I am not able to say whether the fish-scrap is any more valuable after it has lain a month or two in the house than when it first comes from the press. I think I should prefer to take it as it comes from the press. I think the ammonia which is lost is worth more than will be gained by the evaporation of the water. Fish-scrap, at $12 to $15 per ton, is the cheapest manure we can buy. It is the only commercial fertilizer I have bought for the last six or eight years. I do not invest in superphosphates or bone-dust. I would invest in the latter if I could get a pure article, but when it is half plaster of Paris I do not know what I am buying. But this article, when it comes from the factory, is generally fish scrap and nothing else. It always produces just about the same result. You can depend upon it. If you apply one or two tons to the acre, you know what you will gain by its use if it is properly put into the soil and you have a fair season. I think it is a perfectly secure investment for the farmer to make."

Experience of Mr. Hall and Mr. Loveland.

273. Some of the discussion which followed is worthy of note. Mr. Hall, of Wallingford, remarked:

"My experience in regard to fish-scrap is that when it comes from the press it is about 65 per cent. water. Now if that is worth $12 to $15 a ton to carry back ten or twenty miles into the country, when you come to add the freight and the inconvenience of handling it to the freight, I should consider the dried the cheapest. I have used a great many tons myself, and I have always used the dry as the most economical. I have been so situated I could have either, but I preferred the dry; and as Mr. Clift has said, by analysis, it was a cheap manure at the prices at which it was sold." Mr. Clift replied: "Mr. Hall means a different thing by dried fish guano, from what some gentlemen do by 'dried fish.' He

means the article spread upon a platform, and made as dry as it can be in that way. What is termed 'dried fish' is another thing. It will take from two to two and a half tons of fresh fish to make a ton of dry, and after that has lain in a tight building for some time, it will take two tons of that to make a ton of the dry guano. When the green manure is spread out and immediately dried in the sun, there is no loss of ammonia, but when it is kept in a pile, of course putrefaction begins, and as it advances there is loss of ammonia. There is no considerable loss of ammonia by drying in the sun and of course the dry manure, finely ground, is very much more valuable than that which is dried in a heap where there is a great loss of ammonia."

Mr. Loveland said of his experience with fish-scrap:

"I would say that I have had considerable experience with fish-scrap, having used it for the last eight or ten years. I bought it as it is prepared by the companies at Milford, where it is produced as a superphosphate, and sold at the rate of $45 a ton. I have used it with Bradley's superphosphate, with Coe's and with Wilson's on tobacco and other crops, and wherever I have used it in connection with these high-priced manures, I have found that the fish manure was fully equal to them; it bore up its crop as well as any of the commercial fertilizers in the market. I have bought it in the green state mostly, in bags and barrels, and it has cost me about $23 a ton to get it up to the north part of the State. I have not used this fish-scrap much by spreading it upon lands in its raw state, nor by putting it into the hill, as they do in Lyme, and on the coast, in raising potatoes and the like. I have seen some instances in our town where it has been spread upon the ground in a raw state, and then the tobacco set, and the effect has been to stop the growth of the tobacco. It has been too powerful in that condition for the tobacco to grow upon it; and where it has been used in that way, I have never seen half a crop of tobacco. My method has been to compost it, invariably, and I believe that is the true method of using such a fertilizer as that. It is a fertilizer having all the elements of an organized body. It contains all of the fish that we desire; the oil that has been taken out we hold to be of no use in agriculture. Coming to us in the green state from the factory, it has not lost any of its ammonia to speak of, and in that state it must be a perfect manure, because there is no adulteration in it. In composting it, I have used muck, treated with lime and salt—about four cart-loads of muck to four or five hundred pounds of the fish, building up a large pile of it, in that proportion, which, after a while, begins to heat, and the whole mass is leavened and brought into oneness of condition. The fish-scrap fertilizes the whole mass with its elements, and it may then be spread upon natural grass-land or cultivated ground, and will invariably produce a very fine crop. It never has failed with me to produce a good crop, and where I have manured grounds in that way and seeded them down, I have got good crops of grass for years in succession afterwards."

Statements by Professor Cook, of New Jersey.

274. Prof. G. H. Cook, of New Jersey, in his report as secretary of the State Board of Agriculture, writes:*

"The supply of material for fish guano is almost unlimited in this State, and it only needs capital and skill to build up a business of great importance to the State and profit to the manufacturer. On the coasts of Long Island and of Maine, where the business has been carried on for the oil which could be got from the fish, the residuum has been sold at various prices, from $15 to $30 a ton, and has been a very popular fertilizer with those who have used it. It is sought for by the manufacturers of superphosphate of lime, to mix with their product, and there can be no doubt that it is very beneficial in such a mixture, giving quickness to its action, while the superphosphate would add to the duration of efficiency. When this source of manure is properly worked, it can be made to supply all the guano needed in the State."

Professor Cook says, also:†

"While the most common mode of using these fish is in the hill or furrow for corn, they are often employed in a compost with barn-yard manure and a little lime. *Those who have tried such a mixture say that it is superior to any guano in the market.* When applied on corn the crop is considered as certain. Some farmers mix them with muck and apply the compost upon wheat. This fertilizer is wonderfully rapid in its effects, showing changes in the growth of a crop in a few days after it has been applied. But it is not a lasting manure. In a year or two this stimulating effect is gone, and a second application is necessary. For producing quick results it is so efficient that all farmers who have tried it unite in testifying to its value."

Further experience in Maine.—Messrs. Hinkley, Kenniston, Smith, and Collins.

275. On pages 47 to 55 of the report of Messrs. Boardman and Atkins, referred to, are some "Practical Notes on the Use of Fish Scrap as a Fertilizer," which contain a number of items of experience of Maine farmers worth quoting:

"Hon. J. T. Hinkley of Bluehill, in a private letter, writes: 'I have never used but it in one way. I mix it with fine dirt or sand, and use it as a top dressing on grass-land. A dressing of one ton of chum mixed with five times that amount of dirt is about the quantity I would put on one-half acre of land, and from that I have a good crop of grass for four to five years without injury to the land. * * * There is an objection here to dressing too heavily with scrap, as it injures the quality of the hay; but using it at the rate of one ton to the acre, in a compost of three parts loam, will produce no effects of this nature.' Now to correct the error

* First Annual Report of the New Jersey State Board of Agriculture, 1874, page 44.
† Geology of New Jersey, 1868, p. 498.

into which a good many farmers are led by statements that the application of fish-scrap, or other active special manures, like guano or superphosphate, damaged the land, rendering it unproductive and sterile; it may be stated here that the real cause of this sterility does not come from the application of these so-called *forcing* manures which are applied to the land, but from the taking off of the large crops which follow their application. They exhaust the soil by drawing from it elements which the manure put on does not contain, and which repeated applications of the same fertilizer would not supply; it is in fact the crop taken off, not the manure put on, which injures the land. But it must also be remembered that after land has been brought up to a condition of productive capacity by the use of fish-scrap or special fertilizers, it can be kept so only by the application of stable and barn-yard manure, or the manure made by consuming the hay grown upon the soil thus improved. This should invariably and in all cases be given back to the land, or the time will speedily come when it will refuse to 'discount.'"

"Mr. William Kenniston, of North Boothbay, furnishes some interesting statements regarding the use of scrap upon his farm. He has used it more or less for the past eight or ten years, and says he 'could not farm without it.' He hauls it from the factory generally late in the fall, as it is dryer then and less objectionable to handle, and composts it with yard and stable manure, muck, and loam. When one year old this is hauled out and spread, in the fall or winter, wherever it is most convenient to do so, at the rate of about eight cart-loads to the acre. In using the scrap without being composted, as he has sometimes done, he regards one ton of well-dried scrap better than three just as it comes from the press. The dry scrap is much easier and better to handle, and may be used on grass at the rate of three tons to the acre; but the raw scrap from the press should invariably be composted. In 1867 he used five tons of scrap mostly in a green state. It killed the corn, the grain lodged and was damaged, and grass has lodged on the piece ever since, although no manure has been applied since. He had spread it on grass fields both in the spring and fall, but preferred the latter. Mr. Kenniston believes if the scrap was packed in barrels just as it came from the press it would stand transportation by steamer or rail to almost any part of the interior of Maine without becoming offensive.

"The farmers in Machias purchase herring chum from Lubec, whence it is brought in small schooners. It is usually packed in barrels of from 220 to 280 pounds each, at $11.50 per ton, but is not used in very large quantity. Lobster chum, from the canning factories at Englishman's River, is also made use of to some extent as a top-dressing. It is obtained in scows and boats at about $4.50 per ton, delivered in Machias and vicinity. One ton of it is composted with ten loads of common loam, and this amount spread upon an acre. Applied to grass land in the fall, the results are most satisfactory."

"Mr. H. T. Smith, of Machias, has perhaps made a larger use of fish-scrap, as a fertilizer, in different ways, than any farmer in that place or vicinity. His usual practice is to obtain the scrap (generally herring scrap) in the fall, and apply it in the spring. When grass land is in fair condition he uses about one-fourth of a ton per acre, and never more than one and one-fourth ton per acre. It is, of course, less expensive to apply it directly to the land as it comes from the press, but it is often composted, using three parts of earth to one of scrap. For grain, Mr. Smith has plowed under seven hundred pounds to the acre, from which he has grown very heavy crops of barley, oats, and wheat. Mr. Smith says: 'I have paid $80 per ton for superphosphate, and if given my choice had rather have one ton of fish scrap than one ton of superphosphate. If barrelled as soon as it comes from the press (he is speaking of herring scrap, which, it will be remembered, is treated with salt before being pressed), it has no unpleasant odor, and is not offensive to handle. There is nothing equal to it for the land. It is as valuable as night-soil, and is good for grass, grains, corn, garden crops, anything that grows out of the earth.'"

"Capt. Jason Collins, of the steamer 'Star of the East,' thus relates, in a private letter, his experience in the use of fish scrap as a fertilizer: 'My experience in the use of fish chum does not reach over many years, but I have applied it to barley and on grass. The amount used per acre for barley was 1,500 pounds, which was mixed with two parts loam to one of chum. This was spread on and harrowed in. In the fall of 1873, I had five acres plowed up, on which I put 2,000 pounds to the acre. It was harrowed and rolled in the fall, and the following spring, about the last of March, I think, it was sown to grass-seed alone. The grass was cut the last of August, and it was very heavy. I have also used it for turnips and potatoes, and it has done well for each crop. In the fall of 1873 I also had chum spread on some six acres of grass land, as a top-dressing, at the rate of three-fourths of a ton per acre, mixed with loam in the same proportions as that used for barley. It did first-rate. This fall (1874) I shall use more, which I shall compost and lay over until another fall, as in that form it will be better about handling. From all I can learn, and from my own experience, I am satisfied that late fall is the best time of the year to apply it as a top-dressing for grass lands; and the amount should be from three-fourths of a ton to a ton per acre. It is best if used as a compost, as I have stated. For hoed crops it must be used very carefully, and should in all cases be thoroughly composted. In regard to its price, it cost me $12 per ton green, in bulk, and have had it brought from Boothbay to Gardiner in lighters. When in barrels it costs $15 per ton, but it is cheap at that price, and I shall buy no other fertilizer until I find something better for less money. At $12 per ton it is cheaper than it is to haul stable-manure, even if the manure is given to you. Perhaps I have not used it long enough to speak of its effects upon the land, but during my experience with it I have witnessed

no ill effects, although if used in too great quantities the grain will grow rank and lodge. I can hardly yet tell what it will do in a long run, but am satisfied with it after a five years' trial.'"

Other testimony.

276. "Numerous testimonials similar to the above could be given from correspondents and from agricultural reports and journals, but enough has been stated * * to show the great value of fish scrap as a fertilizer when composted or judiciously applied in connection with animal manure. Remark: Too much stress can hardly be put upon this qualification in regard to its use. An instance is mentioned in a former volume of this report* of a farmer who first began to use the scrap; composted it in the fall with three times its quantity of earth. The next spring the mixture had so much the appearance of common earth, and the party had so little faith in its efficacy, that a shovelful to the hill was applied for corn. It came up well, grew for a time looking green and thrifty, but soon began to grow pale, finally died, and the crop was a failure. But the effect of this application was noticeable for many years afterwards, and even with no other application of manures of any kind the land continued to bear an immense burden of grass. In the discussion to which reference has been made, before the Connecticut Board of Agriculture, Mr. Fowler, of Guilford, gave a word of caution which he thought should be exercised in the application of fish scrap. He said: 'My experience has satisfied me it will not answer to use fish alone as a fertilizer for a term of years. It forces the crop and finally leaves the land in very bad condition, very hard and sterile, and it will usually show a pretty heavy crop of sorrel after harvest. But if it is used as it should be invariably, in connection with stable or barn-yard manure, it is perfectly safe to use every year for a term of years for any crop.'"

49. THE MANUFACTURE OF FISH MANURES.

Early attempt at manufacture.

277. The first attempt to manufacture a portable manure from fish is said to have been made by Mr. Lewis, at New Haven, Conn., in 1849.† The white fish, or menhaden (*Brevoortia tyrannus*), was employed, and after a good deal of experimenting a manure produced which contained, according to analyses by Professor Norton, as high as 10.23 per cent. of nitrogen. The enterprise was, however, for some cause, discontinued.

The De Molon process.

278. The next effort in this direction seems to have been in 1851 or 1852, by De Molon, a Frenchman, who, in company with other parties, is

* Hon. S. L. Goodale, Agriculture and Geology of Maine, 1861, page 49.

† See communication by Prof. S. W. Johnson to the Country Gentleman, July 1857, and article on Marine Manures, by S. L. Goodale, Agriculture and Geology of Maine, 1861, pp. 50–56.

said to have put up a manufactory at Concarneau, in the department of Finisterre, for the manufacture of guano from the refuse of the sardine fishery, and one on the coast of Newfoundland, at Quirpon, near the eastern entrance of the Strait of Belle Isle, for the utilization in similar manner of the refuse from the cod fishery. According to the *Chemie Industrielle*, the establishment at Concarneau, in 1854, employed sixteen operatives and worked up daily eighteen or twenty tons of refuse into four or five tons of manure. The composition of this article is noted by Payen at 11.6 per cent. of nitrogen and 10.3 per cent. of phosphoric acid, with only 2.5 per cent of fat. Other analyses gave about 12 per cent. of nitrogen and 6.7 per cent. of phosphoric acid. The Quirpon establishment was reported as able to produce 8,000 or 10,000 tons of manure annually.

A manufactory of fish guano by the De Molon process was reported as in operation at Lowestoft, in England, in 1856. The same process was said to be employed in 1857–1861, by the Oceanic Oil and Guano Company at Southold, Long Island, N. Y. A pamphlet put out by this company describes the process as follows:

"The raw fish, in quantities of one and two-third tons (or about 5,000 fish), are placed in the inner chamber of a revolving cylinder, the vacuum between the inner and outer chamber being heated by steam at about 80 pounds pressure. Before letting in the steam the cylinder must be put in motion, so that each fish, as the cylinder revolves, is constantly changing its position. The cooking at this pressure of steam requires but ten minutes, during which time a uniform temperature is maintained by means of one head of the inner cylinder being perforated so as to allow the escape of the steam generated from the water contained in the fish, which prevents the dissolution of the gelatine and all the soluble parts, and they are therefore retained in the fish. When the heat in the inner cylinder has arrived at the temperature to produce steam from the fish, it escapes through the perforated head, and thus enables the fish to receive a temperature just sufficient to open the cellular tissues and give an easy and speedy egress to the oil.

"After the fish are thus steamed, they are put into strong bags, prepared in size to fit the top of the press-head, in layers of eight inches of thickness; between each layer or bag is placed a strong iron plate. In this manner the press is filled, when they are subjected for about five minutes to a powerful hydraulic pressure. After the oil has ceased to run, the remains are then put through a strong picker, which reduces the cakes to small particles for the drying process. It is then dried by heated air or by platforms exposed to the sun."

Early manufacture in Rhode Island.

279. Prof. Charles T. Jackson, writing in 1854, remarks:

"In this country a company has been formed, in Rhode Island, for the manufacture of fish manure, and the fat menhaden of Providence River

and Long Island Sound will be used to produce both oil and fish-cake, and the latter, being duly prepared so as to render it inodorous, will be sent into the agricultural market as an artificial guano. I have no doubt of the high fertilizing effects which this guano is capable of producing, nor of the economy of the manufacture proposed."*

Manufacture in Canada.

280. Mr. Hunt, in the Report of the Geological Survey of Canada, under date of March, 1858, says:

"Mr. Duncan Bruce has lately been endeavoring to introduce the manufacture of fish-manure into Canada; but he conceived the idea of combining the fish offal with a large amount of calcined shale, under the impression that the manure thus prepared will have the effect of driving away insects from the plants to which it is applied." * * * Analyses of this manure, by Mr. Hunt, showed it to contain about 3 per cent. of ammonia and something more than 3 per cent. of phosphoric acid; and so of less than half the manurial value of a well-made article from pure fish alone.

Manufacture of "cancerine" in New Jersey.

281. Professor Cook, State geologist of New Jersey, in his report for 1856, states that—

"An establishment for making a concentrated manure from king-crabs or horse-feet had been erected at Goshen, in Cape May County, by Messrs. Ingham & Beesley. Several hundred tons of this substance were made last year and sold under the name of *cancerine*. It is a powerful fertilizer, and in its composition, as well as in its effects, has considerable resemblance to guano." The average per cent. of ammonia and phosphoric acid in "cancerine," as shown by three analyses by Professor Cook, was 9.92 per cent. of ammonia and 4.05 per cent. of phosphoric acid, and he estimates its value at $31 per ton; and further says, "the results of trials with it have fully sustained its value as determined by analyses."

Early manufacture in Maine.

282. Mr. Goodale says further, in the report referred to:

"Until within a few months, I was not aware that any attempt had been made in our State to manufacture a portable manure from fish; but I have recently learned of several. In Boston I found an article for sale under the name of 'fish-guano,' which by inquiry was ascertained to have been made by a Mr. Fowler, at Lubec. I learned subsequently that he had manufactured a quantity two or three years previously, but that either from not finding a ready sale, or from other causes, had discontinued its manufacture. It is understood to have

* Report of the Commissioner of Patents for the year 1854—Agriculture.—Washington * * * 1855, p. 107.

been made by drying the fish after pressure, when it was ground and a portion of gypsum mixed with it. As offered for sale, it was a grayish powder, in which portions of bone could be distinguished.

"Learning that a somewhat similar article had been sold and used in some of the Penobscot towns, from Mr. C. G. Alden, of Camden, I called upon him, and found that he had made last year, for the first time, about a hundred barrels, at Long Island, in Blue Hill Bay, which he sold readily at $1.50 per barrel of about 150 pounds, and learned that it gave entire satisfaction. It was prepared from pogy chum by simply drying it in the sun, and when packed he added a peck of gypsum to each barrel. Some barrels were examined which had just been made (August, 1861), and the article appeared to be in a good state of preservation, except that it was slightly moist and gave off free ammonia. Mr. Alden intimated that the lack of sufficient capital alone prevented his entering into its manufacture upon a much more extended scale. He hoped, however, to prepare five hundred barrels or more the present season.

"At Eastport I found fish guano manufactured upon a larger scale. Messrs. U. S. Treat & Son, well known for their enterprise, perseverance, and success in the artificial propagation of fish, after preliminary trials for some years past, prepared about one hundred and fifty tons during the season of 1860, nearly the whole of which was shipped to Connecticut. He makes it under a patent held or claimed by the Quinnipiac Company of Connecticut. It is manufactured almost entirely from herrings, of which they formerly cured a large amount, but now find it more profitable to make it into guano. They are caught in weirs (about Treat's Island, on which they reside), and are thence taken to a railway running into the water and dipped into a car, drawn up by a windlass. When the car comes to be opposite one of a tier of tanks near the track, a gate or door in the car is opened and the fish slide in; salt is added in the proportion of one bushel to each hogshead (of four barrels) of fish. After pickling for about twenty-four hours, they are moderately heated in open kettles, when they are pressed to obtain the oil, of which they yield about 8 per cent., and to express as much of the water as possible; after which the cake or chum is broken up, spread on a platform of boards, and dried in the sun. It is subsequently ground and packed in bags of two bushels each, and which contain eighty pounds—twenty-five bags or about fifty bushels to the ton of two thousand pounds. He sells it for $15 per ton; and the cost of the bags, delivering or shipping, are extra charges.

"The platform in use last year for drying is about eighty by one hundred and twenty feet square, slightly inclined to the sun, with a storehouse on the lower side. Another was in process of erection when I was there, as also another railway and other conveniences for extending their operations.

"The patent held or claimed by the Quinnipiac Company is understood to be 'for drying by solar heat upon an elevated platform.' If a patent be granted for this, why not for drying salted fish upon an elevated flake, or for drying clothes on an elevated line, by solar heat? From various sources, I learn that the fish guano prepared by this method gives high satisfaction.*

"Prof. S. W. Johnson, of Yale College, chemist to the Connecticut State Agricultural Society, informs me that the article prepared by the Quinnipiac Company is the most popular fertilizer sold in that State.

"To sum up in a word the results of my investigations and experiments regarding the manufacture of a portable, inoffensive, and efficient manure from fish or fish offal, I may say that I deem the same practicable; that no costly machinery or complicated processes are required; that all which is necessary is, first, to cook the fish sufficiently to coagulate the albumen contained in it; then to express as much of the oil and water as may be, and to dry the remainder as quickly and thoroughly as possible. A pickling of the fish first with salt would probably facilitate the operation.

"It is confidently hoped that the waste of such enormous quantities of fertilizing material as have hitherto been thrown will not much longer go on, but that they may be converted to use, feed our hungry fields, and fill our barns with plenty."

Early manufacture in France.

283. Turning again to the manufacture of fish manures in Europe, we note that the process of De Molon, referred to above, is described by Deherain (*Wurz Dict.*, ch. I, 1236) as follows: "The fish are first boiled, then pressed to force out the water and oil; the residue is then dried and ground in a mill." De Molon's first factory was at Concarneau, Department of Finisterre. He seems to have established others on the English coast and in Newfoundland, in company with Thurneyssen. From disconnected statements in different works to which I have had access, the industry on the French coast seems to have suffered from lack of material. A company, "Credit Mobilier," into whose hands the enterprise fell, attempted to use city refuse with it, but through business complications, stock speculations, etc., the whole undertaking failed.

About the same time that De Molon introduced his method of manufacture in France, Pettit and Green patented another process in England (1852), the peculiar feature of which was "the use of sulphuric acid, which was added to change its consistence." After treatment with the acid, the fish was dried in hot air.

*According to Mr. Boardman, Mr. C. G. Allen, of Camden, Me., was engaged in 1862 in making fish guano from "pogy chum," by drying it in the sun. (Rept. U. S. Dept. Ag., 1862, p. 57.)

Early manufacture in England.

284. From an article in the "Farmers' Magazine" (London) for August, 1859, by Samuel Osler, of Great Yarmouth, who claims to have discovered a method preferable to that of De Molon or Pettit, a few paragraphs are quoted by Mr. Goodale:

"The enormous consumption of guano, its high price, and extensive adulteration, have led to a desire of an auxiliary or substitute. The most obvious source is the fishery. * * * What we require is a simple, cheap, and effectual mode of separating the parts which are needless for manure—the water, gelatine, and oil, the two latter sufficiently pure to be commercially valuable, and leaving the fiber, bones, and scales in a state fit for keeping and for use. It has been ascertained by experiment, and confirmed by actual working, that the refuse and waste fish may be thus converted, and the gelatine and oil collected by a process which I have discovered. The machinery and the process are simple, inexpensive, and effectual. The principle of the manufacture is founded upon the fact that when fish or flesh is subjected to a long-continued and moderate heat the fluids separate, dissolve the gelatine, and leave the fibrous and bony solids. This is easily shown by putting meat or fish into a flask and setting it in boiling water, corking the flask when fully heated. The fluids will gradually separate, while the flesh will, after a time, be left a dry and insipid residuum."

Mr. Osler gives the results of several analyses by Professors Way and Voelcker and Dr. Stoeckhardt, by an average of which it appears to contain about 12 per cent. ammonia and 7 per cent. of phosphates.

Other European manufacture.

285. In the Paris International Exhibition of 1855, among the specimens of artificial manure was one, "*engrais poisson*," prepared from fish, which, "after being steamed, were pressed into cakes and dried." It was "said to contain from 10 to 12 per cent. of nitrogen, and from 16 to 22 per cent. of phosphate (= 7½ to 10 per cent. phosphoric acid). The price was about $35 per ton.

On the coast of the North Sea, at Varel, in Oldenburg, immense numbers of a kind of small crab (*Crangon vulgaris*), called in German *Granaten*, or *Granälen*, are taken, dried, ground without any steaming, and thus made into what is called "Granat guano."

On the coast of the Baltic Sea, at Labagiehnen, near Labiau, in East Prussia, considerable fish refuse has been manufactured into a fertilizer.

The following are analyses of the articles just named:

	Nitrogen, per cent.	Phosphoric acid, per ct.
Fish guano, Pettit	9.1	7.6
Fish guano, Green, No. I	9.1	1.6
Fish guano, Green, No. II	13.8	0.2
Fish guano, De Molon and Thurneyssen	11.6	10.1
Granat guano	11.2	2.2

These figures are taken from a report by Professor Schmidt, of Dorpat, on the "Artificial fertilizers at the second Baltic agricultural exhibition, June, 1871," who adds that none of the articles seem to have attained enough importance to secure a place in the wholesale market.

The Norwegian fish guano.

286. By far the most important of European fish-waste products, in fact the only one that has been made in large enough quantities to bring it into very general and widespread use, is the Norwegian fish guano, manufactured from the waste of the fisheries on the Lofoden Islands, and elsewhere on the Norwegian coast.

In the Polar Sea, near the 70th parallel, north latitude, off the extremely wild, rough, and dangerous coast of Northern Norway, near the famous and dreaded maelstrom, lies a group of islands, rough, rocky, and precipitous, the peaks of some shrouded in eternal snow, about 40 in number, and bearing the name Lofoden. The neighboring mainland is inhabited by nomadic tribes of Laplanders. The islands have neither four-footed beasts nor food for them to live upon; but the sea about them teems with fish, and the air with sea-fowl. But few human beings are there, except during the fishing season, from February until April, when from 12,000 to 14,000 fishermen come, with 3,000 to 4,000 boats; bring scanty supplies of coarse bread, dried fish, and bacon; live in miserable huts, sleep in sheep-skins; and with lines that have sometimes as many as 3,000 hooks apiece, catch from 18,000,000 to 20,000,000 codfish per annum. These fish are cut up; the sides are dried and sold as "stock-fish" all over the world. A part of the residue is used in the northern regions as cattle food. The heads and backs were formerly thrown into the sea or left to rot upon the rocks. Of late years, however, they are gathered, dried upon the rocks by the sun's heat, ground in factories that are scattered about in sheltered bays, and thus made into the Norwegian fish guano. A business circular concerning the Lofoden fishery products says that the cods' heads and backbones are collected mostly by women, children, and infirm persons, who cannot take part in the fishing, dried either on the bare rocks or on poles, and then ground, put in bags of about 2½ cwt., and shipped; the material delivered at Hamburg at the rate of about £9 per (long) ton. The circular adds that "it has been a great benefit to the Lofoden fisheries to get rid of this waste which formerly spoiled the bottoms of the fish banks, and infected the habors, where in some places it used to lie knee-deep upon the beach." Another account states that the gathering of the refuse has already become an important industry for the poor people there.

The earliest notice I have seen of the Norwegian fish guano is by Stoeckhardt* in 1855, who then reported the manufacture as started on

* *Der Chemische Ackersmann*, I, 1855, s. 236. See articles by Stoeckhardt and by Meinert in same journal, I, 1856, s. 118; V, 1859, 44; VI, 1860, 59; IX, 1863, 117; XV, 1869, 43; XVI, 1870, 43 and 53; XVI, 1871, 245; and *Landw, Centralblatt*, 1874, 613; and by Vohl. Dingler's *Polyt. Jour.*, CCXV, 1875, 460.

the Lofoden Island by Dr. Scheibler and Herr Fröhlich. In 1856, Stoeckhardt informs us that a joint stock-company had been formed at Christiana for the manufacture of the guano, and had taken the patent from Dr. K. Hansen and F. C. Schübler. (The Dr. Schiebler above?) The company consisted of these two gentlemen and three others, Messrs. Fröhlich, Broch, and Heftye. In 1859, he reports the manufacture as having finally begun in the past season (1858) on a large scale. In 1860, the guano was offered for sale in Germany, by Mr. Meinert, of Leipsic. In 1863, Mr. Meinert states that, "unfortunately," the fish guano has become so popular in Norway, Sweden, and Denmark, that a large part of the supply has been retained there, and not enough will reach Germany to supply the demand. In 1869, Meinert reports to the "Ackersmann" that the manufacture has attained such a degree of perfection that an article can be offered of uniform composition, and containing 8 to 10 per cent. of nitrogen and 10 to 15 per cent. of phosphoric acid.

In 1870, it was stated that the refuse of 4 to 5 million codfish was worked up into guano, while that of the remaining 14 to 15 million was still allowed to go to waste.

In 1871, Meinert, whose accounts of his journeys to Lofoden, published in the "Chemische Ackersmann," are well worth the reading, reports the success of attempts, undertaken by himself, to make guano from whole fish, from kinds whose inferior value for human food had caused them to be sold at very low prices or to be used in Norway for cattle food. From these "waste fish" 200 tons of guano had been prepared, of so good quality that a content of 11 to 12 per cent. nitrogen and 5 to 6 per cent. phosphoric acid. The high proportion of nitrogen is due to the use of the whole fish. It finds rapid sales at higher prices than the ordinary guano.

In 1874, the "Landwirthschaftliches Centralblatt" (XXII, 613) speaks of the Norwegian guano as follows:

"The Norwegian guano, as is well known, is made of the heads and backs of the cod.* These fish are taken from January to May, all along the coast from Finmark to Hammerfest, lat. 68–71 N., but especially on the Lofoden Islands. During the season 2,000 fishermen are engaged. The catch of cod has averaged during the past ten years, according to statistical reports, from 18,000,000 to 22,000,000. The sides of the fish are dried either on lines upheld by posts or upon the rocks. Those prepared in the former way are sold in Spain, Italy, &c., under the name stock-fish; the others are sent to Russia and Sweden, under the name of *Klippfisch*.† The refuse was formerly thrown into the sea or left to the sea fowls, except the small quantity used as fodder

*The *Dorsch, Gadus callarias*, common Cod, and *Kabeljau, Gadus molva vel morrhua*, Ling, are both said to be taken at Lofoden. Sometimes one and sometimes the other is named as the principal fish of those fisheries. [They are the same. G. B. G.]

†*Stock*, rod, stick; *Klippe*, rock; so cod. Anglo Saxon *gad* or *goad*, a rod, and the Latin *gaudus* has a corresponding Sanscrit root, *cad* or *gad*, a rod. See paper by J. C. Brevoort, on the names of codfish.

for cattle and sheep. The heads (some as large as small calves' heads) and the backs of the cod (*Dorsch*) form the chief raw material for the fish guano. They are dried in the air on the rocks, then torn up by machines, and finally ground to a product resembling coarse bone meal. Since, however, not inconsiderable quantites of cod are also caught along the Norwegian coast southward from Lofoden, as far as Aalesund, the preparation of fish guano has offered the inhabitants a new and useful industry; the demand has increased every year and since the supply has not sufficed even for the German market, a considerable number of larger or smaller factories have sprung up all along the west coast of Norway. Competition soon led to the manufacture of a more finely ground product, and to the utilization of a large portion of the available material for preparation of fish guano. Nevertheless, a good deal of the material was still allowed to go to waste, so that the production of the guano is capable of further development. Recognizing this fact, Dr. A. Meinert, son and business partner of the original German importer, has, in connection with some German merchants, established two new factories in Norway, one in Lofoden, the other in Hammerfest. The former was completed during the past summer (1874). The guano from these establishments is first steamed, then dried and ground to a fine dust, and is consequently very similar in its action to Peruvian guano."

The report adds that, on account of the difficulty of transporting fish guano to Sweden, factories have been put up in that country also, to supply the home demand.

The most remarkable enterprise in this direction is one for the manufacture of guano from whale refuse, on the boundary between Norway and Russia, beyond the North Cape, in the latitude of 70°. It was undertaken in 1870–1873, by Capt. Svend Foyn, who is described as "the greatest whale fisherman of our time." With his fleet of steam and sailing vessels he visits the coast of Greenland in February to catch seal, and thence sails in March to the North Polar sea in pursuit of whales. He captured, in 1869, thirty-two whales and expected to be able, by use of improved vessels and appliances, to take fifty per annum. A whale, according to Captain Foyn, weighs on an average 230,000 pounds (115 tons); each fish furnishes about 80,000 pounds of fat, several hundred pounds of whalebone, and 100,000 pounds raw stock for fish guano. Fifty whales are expected to produce 2,500 tons of the latter, containing 8 per cent. of nitrogen and 12 per cent. of phosphoric acid. The enterprise seems to have halted somewhat from the great difficulties to be overcome, but at last accounts still promised success.

The distance from markets and industrial centers, the wildness of the coast, the inclemencies of the weather, and the length of the arctic winter night, have all combined to make the successful manufacture of

the Norwegian products a very difficult matter. The bulk of the products have, I understand, been sold in Germany by Mr. Meinert, who has from the first had control of the trade in that country. Mr. Meinert has managed the business in such a straightforward and rational manner as to secure not only a large personal profit but also the confidence of the agricultural public. This he has done by personally aiding and encouraging the manufacture of an article of high grade and uniform quality, by selling it on the basis of guaranteed analysis, and thus recommending to the good sense of the most enlightened farmers.

According to Déharain (*Wurz Dict. Ch.* I, 1236), a Frenchman, M. Rohart, has established a manufactory of fish guano at Lofoden. This is probably the one referred to by Herr Meinert as "an incomplete imitation" of the previous manufactories there, and in aid of which the French Government gave a subvention of 100,000 francs. That so large a gift should be made to aid this enterprise is proof of the importance ascribed to it by the French Government.

According to the "Revue Scientifique," August 25, 1875, M Levy has lately started an establishment at the French island of St. Pierre, in the Gulf of St. Lawrence, for the purpose of utilizing the gurry and offal of the codfish, &c., taken on the banks of Newfoundland. All the heads, entrails, &c., are gathered in, and after the extraction of the oil the residue is made into gelatine and fertilizers.

How important such an industry may be made appears from the fact that the waste material of the fisheries of that region is estimated at 120,000,000 pounds per annum.

Manufacture of glue and removal of oil in preparation of Norwegian fish guano.

287. It is worthy of note, that in the European factories the liquid coming from the steamed or boiled fish, and containing considerable nitrogenous matter in solution, is utilized for the manufacture of a low quality of glue, while in this country the practice is to throw it away.

The Norwegian guanos have generally smaller percentages of fat than occur in the menhaden guanos in this country. But even this small amount is objected to by many, on the ground that it retards the fertilizing action. According to Vohl, this objection has been removed by Radde, of Hamburg, by the manufacture of so-called fatless, evaporated, polar fish guano, in which a minimum of 8 per cent. of non-volatile nitrogen and of 12 per cent. of phosphoric acid is guaranteed, and actual analysis of a sample gave a considerable excess above this minimum. This article is in the form of a fine dry powder, of a yellowish color, with a comparatively feeble odor. It absorbs water rapidly, and when moist putrefies readily at 52°, with copious formation of ammonia. It yields on ignition 37 to 38 per cent. of ash.

Success of fish guano as a fertilizer in Europe.

288. A few words upon the use of fish guano in Europe may be in place here.

In 1855 Professor Stoeckhardt, of Tharand, wrote* of fish-refuse as a manure:

"Fish forms the basis of all natural guanos, since it forms the sole food of the sea-birds (and seals, &c.), from whose excrement guano is formed. * * * What is accomplished naturally here by the digestive processes of the bird, pulverization, fine division and concentration, must be done artificially by the ingenuity of the chemist. If the chemical and mechanical operations necessary for working over the crude material rapidly, on a large scale, into a product of good quality and at low price, can be devised, then it is for the interest of agriculture to be put as quickly as possible in possession of this product, whose office it may be to break the monopoly held by guano."

After describing at length the manufacture, composition, and fertilizing effects of materials prepared from fish, he warmly recommends them to the farmers of Germany as the "guano of the future."

At this time the fish guano was just coming into the European market; but little was known from experience or experiment as to its actual value for farming. In 1869, after it had stood the tests of repeated chemical analyses, gone through the trial of manifold field experiments, and run the gauntlet of practical farmers' experience, with ever-increasing popularity and favor, Stoeckhardt wrote again:

"Fish guano has entirely fulfilled the prophecy which I made for it fourteen years ago, at its first entrance into the commercial world, * * * and it is to be desired in the interest of agriculture that its manufacture may assume ever-increasing dimensions." * * *

The manufacture of fish fertilizers in the United States.

289. We may now return to the manufacture of fish fertilizers in the United States.

At present nearly all the material in our market is made from the menhaden, which after the extraction of the oil leaves a residue which is prepared in various forms for fertilizers.

The attempt of Mr. Lewis in East Haven, Conn., in 1848, to make a concentrated fertilizer from menhaden has been referred to. The first practical success in this direction was attained by Mr. W. D. Hall in 1853. "He discovered how the oil might be extracted from the fresh fish in a few hours' treatment, leaving the 'pomace' or 'scrap' in such a condition of half-dryness that it could be stored or barreled and transported at once, or could be further dried by exposure to the sun and converted by grinding into 'fish guano.'" The history of the manufacture of oil from menhaden since that time is given very fully in Mr. Goode's report on the menhaden.

* *Der Chemische Ackersmann*, 1855, *I.* 236.

Fish refuse and kinds of fertilizers made therefrom.

290. It is of interest for us to consider here the "scrap" or pomace left from the manufacture of the oil, and its uses.

The fish-refuse enters our markets in several different conditions. The following have come under my observation:

1. "*Crude stock*," "*green scrap*," "*chum*," *or crude pomace.*
2. "*Half dry scrap*" *or half dry pomace.*
3. "*Dry scrap*" *or dried fish.*
4. "*Dry ground fish-scrap*," *dry ground fish or* "*fish guano.*"
5. *Fish guano from which the most of the fat has been extracted by special processes.*
6. *Acidulated fish.*
7. "*Fish and potash salts.*"
8. *Fish mixed with superphosphates in the form of* "*ammoniated*" *superphosphates, sometimes called guanos.*

No. 1 is the raw material as it comes from the press.

No. 2 is the form it assumes after partial drying. More or less fermentation is apt to take place during the drying. This is often accompanied by considerable loss of nitrogen in the form of ammonia. Large quantities of this "half dry scrap," "half dry pomace," or "fish pomace," as it is variously called, are used by farmers along the coast where menhaden are taken.

No. 3 is the coarse scrap dried by the sun's heat or artificially. This also is used in large quantities by farmers near the coast.

No. 4 is prepared by grinding the dried scrap. It makes a reasonably fine, dry, quick acting, and excellent fertilizer.

The green scrap or crude guano generally contains 55 to 60 per cent. of water. The half-dry scrap contains 40 to 50 per cent. of water. The dry guano contains 10 to 20 per cent. of water.

The following measurements and estimates are said to be in use among menhaden manufacturers:

1 ton (2,000 pounds) is reckoned the weight of 3,000 fish.

2½ tons of fish yield 1 ton (40 per cent.) of green scrap, chum, or crude pomace.

3 tons of fish yield 1 ton (33 per cent.) of half dry scrap.

5 tons of fish yield 1 ton (20 per cent.) of dry scrap or guano.

One thousand menhaden, weighed by Mr. Dudley, president of the Quinnipiac Fertilizer Company, at Pine Island, June 12, 1877, weighed 685 pounds. Mr. Dudley has kindly furnished the following statements:

"We take them from the fishermen at so much per thousand, reckoning 22 cubic inches per fish. One thousand fish, measuring 22,000 cubic inches, weighs 667 pounds (3,000 to the ton).

"6,000 to 7,000 fish make 1 ton of 'green scrap' from the press. The last I weighed took 6,700 for a ton. Green scrap contains 55 to 65 per cent. of moisture.

"10,000 fish, on the average, yield 1 ton of half dry scrap, containing 40 to 50 per cent. of water.

"15,000 fish, on the average, make 1 ton of sun-dried scrap, containing 10 to 20 per cent. of moisture."

"In regard to prices for the past ten years, we have sold fish scrap or half dry fish, as it is called in Connecticut Valley, in car-load lots in bags, free on board cars at New London or New Haven, as follows:

"1869, $20 to $24 per ton; 1870, $23 to $25 per ton; 1871, $20 to $25 per ton; 1872, $16 to $19 per ton; 1873, $18 to $20 per ton; 1874, $19 to $23 per ton; 1875, $15 to $17.50 per ton; 1876, $17 to $20 per ton; 1877, $14 to $17 per ton; 1878, $17 to $18 per ton.

"Prices in bulk at factory are usually about $3 per ton lower than at New Haven, owing to cost of packages, labor, and freights. Dry ground fish guano was retailed ten years ago at $55 per ton, now at $40 to $42.50; wholesale, $5 per ton less."

Methods of manufacture and need of improvement.—Statements by Prof. C. A. Goessman.

291. The following statements from the Third Annual Report of the Massachusetts State Inspector of Fertilizers, Prof. Goessman, who has given a great deal of attention to the subject of fish manures, are of special value in this connection. Professor Goessman gives an analysis of a sample of dried fish scrap obtained at the chemical works under the charge of Hon. S. L. Goodale, at Booth Bay, Me., where large quantities of fresh scraps were delivered direct from the press of an adjoining fish-rendering establishment. It was deemed a particularly fair sample of a well-rendered and carefully-dried menhaden fish. It contained 10 per cent. of water, 70.75 per cent. organic matter, 18.25 per cent. ash, 8.46 per cent. phosphoric acid, and 8.14 per cent. nitrogen.

"About one third of the entire phosphoric acid proved to be soluble in citrate of ammonia. Ether abstracted at ordinary temperature 18 per cent. more of a thick, highly-colored, oily mass.

"The following rules of rendering the fish were stated as being customary in the establishment above mentioned: the fish were boiled for about one-half to three-quarters of an hour, by means of steam of from 70 to 80 pounds' pressure, in large wooden tanks with false bottoms; and subsequently, after the soup had been withdrawn, subjected to a pressure of about 115 to 120 pounds per square inch. The fish mass, in consequence of its gelatinous condition, retains usually still from 50 to 55 per cent. of moisture. In a large fish-rendering establishment near New York City, I noticed that the boiling of the fish was continued only 25 minutes, with steam of 50 pounds' pressure, and the rendered fish mass subsequently treated with 160 pounds' pressure per square inch.

"The soup, which contains besides the oil more or less of the glue-producing, soluble nitrogenous matter of the flesh and the bones, is at present discharged after, by means of settling-tanks, the oil has been care-

fully removed. This practice causes a considerable waste of nitrogen. The yield of oil differs, often widely, even during the same season, being, it was stated, usually highest during autumn. The rendering begins usually in May or June, and closes late in the fall. The quality of the fish refuse in general, independent of its moisture and mechanical condition, depends, quite naturally, to a large extent, on the following circumstances:

"First. On the kind used and whether entire or in part.

"Second. On the peculiar mode of rendering.

"Third. On the time when the fish are caught.

"Fourth. The course pursued in keeping and preparing the refuse for the general market.

"Each of these circumstances exerts an influence of its own on the composition of the fish guano.

"Judging from general appearances, but little attention is paid thus far to the first three conditions; the influence of the last one is, more or less, fully understood, yet not satisfactorily controlled. A main difficulty, no doubt, arises from the irregular arrival of large quantities of fish at one time during the season; and the means, which are at present usually employed to meet this difficulty, are, quite frequently, inadequate to the demand. Many manufacturers of fish-oil consider it, therefore, apparently a safer proceeding to dispose at once of their crude stock at low rates than to run the risk any longer. Without questioning the soundness of their course of action, in case of limited pecuniary means, there seems to be no valid reason why improvements should cease here as long as it is daily demonstrated that it pays well to collect animal refuse matters from all over the country and to work them into valuable concentrated fertilizers.

"Nobody familiar with the nature of a good fish guano considers it less efficient for agricultural purposes than any other animal refuse matter of a corresponding percentage of phosphoric acid and nitrogen. In fact, all true guanos, the Peruvian not excepted, owe their most valuable constituents, in a controlling degree, directly or indirectly to the fish.

"Our fish guano consists of the entire body of the menhaden fish, which has been deprived purposely of its main portion of fat, and, incidentally, more or less completely of its soluble nitrogenous matter. The more the flesh predominates, the more the fat has been abstracted without the application of an excessive heat, as far as time and degree are concerned, the higher will be the commercial value of the residue of the press in case of an equal percentage of moisture. The flesh of the fish, like that of our domesticated animals, contains on an average 15 per cent. of nitrogen. The same close approximate relation exists between the bones and the textures of these otherwise widely differing classes of animals; for the fish-bones and the scales consist, mainly, of a varying quantity of cartilaginous (nitrogenous) matter and of (tricalcic phosphate) bone phosphate.

"To produce a fish guano which contains in a given quantity the largest possible amount of nitrogen, must be the principal aim of the manufacturer. It brings the highest pecuniary compensation; for one percentage of nitrogen is commercially equal to 4 per cent. of phosphoric acid.

"During the past, it is true, there has been little inducement for considerations of this kind on the part of the manufacturer, because practically there has been scarcely any serious discrimination on the part of the consumers regarding the exact relative chemical composition of the various fish guanos offered for sale.

"The future prospect of this branch of home industry depends, in an unusual degree, on the exertions which hereafter shall be made, on the part of the manufacturers, to meet the present more exacting conditions of the trade in fertilizers.

"To derive any full benefit from the capital invested renders it advisable, for all parties pecuniarily interested in the fish guano manufacture, to favor a closer scientific investigation into the changes which the menhaden fish undergoes during the customary mode of rendering.

"Loss of nitrogenous matter, in consequence of misapplication of heat, seems to be not always compensated for by an increase of the yield in oil.

"The latter, when left in the fish mass in an undue proportion, reduces, to say the least, the commercial value of the guano by adding a worthless matter, which may affect seriously the analytical results, as far as its percentage of nitrogen is concerned. To heat the fish to a higher temperature, or for a longer period of time than is required to secure the largest possible amount of oil, reduces, invariably, the commercial value of the fish mass for agricultural purposes. A few subsequent analytical statements, regarding the composition of fish, and the degree of the changes which they may suffer by steaming and rendering, may serve as a practical illustration of my previous remarks.

"A well-dried and finely-ground fish guano is one of our best substitutes for Peruvian guano, and ranks equally high with the best quality of animal dust from our butcher refuse establishments. It deserves the liberal patronage of farmers wherever a rich nitrogenous phosphate is called for.

"I have shown in a previous report, that, as a general rule, the high grades of superphosphates are cheaper than our low grades; the same rule applies to nitrogenous materials.

"The recent changes in our fertilizer trade tend to stimulate improvements in the modes of their manufacture, by rendering true merits prominent, which, as a natural consequence, secures a reliable patronage only to the best quality. We are not yet suffering from an overstocking of our fertilizer markets on account of overproduction of home-made fertilizers obtained from suitable home resources.

"Millions of dollars are annually sent abroad still, for the importa-

tion of materials, which, in their crude form, are by no means better than what we have in abundance at home.

"The manufacture of fertilizers has become in the same degree an art, as agriculture itself has justly assumed the claim of being a science.

"The production of fish guano, although respectable already, as far as quantity is concerned, is thus far but incidental to the menhaden fish-rendering industry.

"It remains still an open question whether our resources for the manufacture of fish guano do not extend beyond that branch of industry."

Statements of Mr. Maddocks.—Manufacture in Maine.

292. From the fifth report of the secretary of the association of the menhaden oil and guano manufacturers of Maine, Mr. L. Maddocks, which is devoted to "The Menhaden Fishery of Maine," the following quotations are taken. The manufacturing processes are those prevalent on the Maine coast, particularly in the region of Booth Bay:

"The fish [as brought in by the fishing vessels] are discharged into a car running upon a rail-track to the second story of the factory, and thence poured into tanks below, holding sixty to seventy-five barrels. These are filled one-third with water, steam turned on, and the fish cooked an hour, or until the albumen is coagulated, and the oil-cells broken. The cooked mass, after draining, passes into presses worked by hydraulic power, and is subjected to the pressure of a hundred tons per square inch, the oil and water flowing out and being collected in vats. The oil is then drawn off, clarified by settling, barreled, and is ready for market. The residue, called chum or scrap, is usually stored in the lower story of the factory until taken away by the purchasers, chiefly the manufacturers of ammoniated superphosphate of lime.

"The following figures will give more definiteness to the statement:

"One hundred and ninety-five pounds of fish make a 'barrel.'

"One barrel yields about two and a half gallons of oil, or eighteen and three-quarter pounds."

"One barrel yields about eighty pounds of fresh chum or scrap.

"These are average results of the manufacture as now conducted in this State. The amount of oil realized varies from one gallon per barrel of fish, early in the season, to four or five gallons in September."

"The scrap contains, on the average as it comes from the press, 55 to 60 per cent. of its weight in water, and sometimes more. This is of course worthless for fertilizing purposes. It also contains from 12 to 20 per per cent. of fat or oil, which is equally worthless for manure.

"As now generally managed, the scrap remains in large heaps until shipped, in autumn or winter, to the points of manufacture into superphosphate. In this time a portion of the oil and water leaks away, so as to leave about 10 or 15 per cent. of the former, and 48 to 53 per cent. of the latter. The elimination of the water is an advantage, but the

specified per cent. of oil is lost, and a portion of nitrogen is also lost, resulting from the partial decomposition of the mass, the formation and escape of ammonia. It were better, if practicable, to drive off the water at once upon withdrawal from the press, so as to prevent the loss in question."

Goodale's new process.

293. I have spoken of fish guanos from which the most of the fat has been extracted by special processes (Class No. 5, of page 000). One of these is Mr. Goodale's, of which Mr. Maddocks speaks as follows:

"What has hitherto prevented the driving off of the water immediately by artificial heat has been the presence of so much oil, together with the gelatinous or gluey matter which is developed during the cooking, chiefly from the skins and bones. These render the process of drying the scrap a very difficult and tedious one, so much so that comparatively little has been put into the market in that desirable form. The recent discovery of an easy and simple process for removing the larger part of the oil, and also at the same time the gelatinous hinderance to drying, gives promise of a speedy change in this respect. While pursuing investigations relative to utilizing the menhaden as a source of concentrated food, before referred to, Mr. S. L. Goodale, formerly secretary of the board of agriculture, discovered that it was chiefly by the agency of the gelatine that the remaining oil was held in the scrap. He found by thoroughly washing new scrap with sufficient hot water, and agitation, that it lost its jellyish consistence and slimy feel, and that the oil globules were liberated from their lock-up in the tissues, so that the greater part could be easily recovered by draining and repressing, and also that after such washing it could be pressed much drier than before.

"We can now readily understand why it is that oil, together with a putrid, watery liquid, leaks away from new scrap not many days after it is removed from the press. It is simply because dissolved gelatine, being more readily putrescible than other animal substances, quickly decomposes, and changes to a thin, offensive liquid, which partly drains off. This decomposition, or the change of consistence attending it, so 'lets the bars down,' that more or less oil escapes, while subjected to no pressure whatever, except its own weight.

"Thus by a very easy process, the oil product may be largely increased, the scrap left free from the gluey hinderance to drying, and with less water to be dried out.

"It may appear strange that so simple a method should not have been discovered sooner, but such is the fact. Work had been done on both sides of it. Re-pressing had been tried, using extra strong curbs, with very powerful pressure, but it failed to give satisfactory results. Re-cooking had been resorted to, which resulted in injury to the oil and in the development of an additional amount of the gelatinous matter. It is now seen that a simple thorough washing in hot water accomplishes the desired end, with neither of these objectionable results.

"Scrap made by this process last August (1877), and dried in the open air, was lately analyzed at the agricultural experiment station of Connecticut, and the statement of the director, Prof. S. W. Johnson, of New Haven, shows the proportion of moisture to be reduced to 11.45 per cent., or about one-fifth that contained in the scrap fresh from the press; and the proportion of *oil* to 4.65 per cent., thus proving that the content of oil in the *washed scrap as it came from the press* (before drying it) had been reduced to less than 2½ per cent. [The percentage of nitrogen was 10.24 per cent., the phosphoric acid 7.50 per cent. These figures refer to the material as dried in the open air.]

"According to these figures, the proportion of oil hitherto lost is, by the new process, reduced from an average of, say 15 per cent. of the weight of the scrap as it commonly issues from the press, to about 2 per cent. The balance, say 12 or 13 per cent., is saved. Let it be assumed, however, that only 10 per cent. can be realized in practice, and that the annual out-turn of scrap from the factories of the Maine association be only 40,000,000 pounds. This would give an annual saving of 4,000,000 pounds of oil, or 533,000 gallons, worth, at current prices at market for 1877, forty cents per gallon, $213,200.

"With reference to drying by artificial means, which is obviously important, no doubt is felt that the apparatus now in operation will effect the work as thoroughly as may be desired, and cheaply and quickly also, provided only the oil and gelatine in the scrap be reduced as above described.

"Two companies belonging to the association have succeeded in drying the scrap in considerable quantities, notwithstanding the obstacles referred to. The scrap is passed through a slightly inclined heated iron cylinder thirty feet long and four feet in diameter, and on the passage is agitated by paddles attached to a revolving shaft, and comes out at the lower end dried to about 25 per cent. of moisture. The process will be greatly promoted in dispatch and efficiency by the application of the new oil-saving method, and the whole manufacture will then be under full control. The scrap can at once, upon withdrawal from the press, be subjected to the drying process by furnace heat, irrespective of the state of the weather, and thus the loss of ammonia by decomposition be forestalled. If the contained moisture is reduced to a per cent. no lower even than 20 or 25, the scrap can be kept on the spot at convenience, and without offense to the senses, or transported as required."

Adamson's process.

294. The other process for extracting fat from fish is that of Adamson. It depends upon the use of hot petroleum, naphtha, or benzine, to dissolve the oil. Whole fish, menhaden, or others, as well as scrap, are said to be arranged in layers, in an inclined iron cylinder, the naphtha or benzine directed upon and passed through them. In the passage the oil is extracted from the fish, which are left in an excellent form for dry-

ing and grinding. The process is said to be easy, simple, and effectual. The main drawback is the necessity for new apparatus and the rejection of a good share of the appliances now used.

Two samples of fish guano prepared in this way and analyzed at the Connecticut experiment station gave, respectively:

	Per cent.	Per cent.
Moisture	4.91	3.67
Oil	2.07	....
Nitrogen	10.78	10.74

Immense waste of fish at present.—Possibilities of future manufacture.

295. The accounts of these new processes at my disposal are meager. They seem, however, to promise well, and, if successful, must revolutionize the manufacture of fish guano. The great desideratum has been a means of removing the oil as entirely as possible, saving the nitrogenous matters and yielding a fine, dry product. This seems to have been found. I understand that the Adamson process is to be used in the manufacture of a fertilizer from the fish that are taken along the coast, but thrown into the sea again on account of their low value for oil or food. The benefit to our agriculture from such an economizing of fish hitherto wasted would be immense. Concerning the number of fish thus lost Mr. Goode writes: "I estimate that the amount of fish annually thrown away from the hundred and fifty-odd weirs on our coast cannot fall much short of ten millions of pounds annually, and probably far exceeds that."

"Acidulated fish" and "fish and potash salts."

296. The "acidulated fish" (class No. 6 on page 219) is prepared by treating the fish scrap with sulphuric acid to render the phosphoric acid more soluble. Unfortunately the constitution of the tissues of the fish is such as to resist the action of the acid, and the desired result is only partly attained. A sample examined under the writer's direction gave 7.09 per cent. of phosphoric acid, of which only 1.76 per cent. was soluble in water.

It will be remembered that Pettitt's process for the manufacture of fish waste into a fertilizer was based upon treatment of the fish with acid, and did not prove a success.

Various efforts in this same direction are reported in this country and in Europe, but none, as I can learn, have been found profitable. The imperviousness of the tissues to the action of the acid has thus far been an insurmountable obstacle to success, and will probably remain so.

The "fish and potash salts" (class No. 7, above) is a mixture, as its name represents, of fish, half-dry scrap apparently, in the specimens I have seen, with German potash salts. The idea is a sound one, in that the salts used, doubtless of the lower grades, like Leopoldshall Kainit, and containing large percentages of chloride of sodium (common salt),

would act as a preservative, and further, the potash supplies a lack in the fish and makes of it a "complete" fertilizer.

The amounts of the "acidulated" fish and "fish and potash salts" in the market are so small as to give them very little importance.

Manufacture of "ammoniated superphosphates."

297. The most important use of fish waste is in the manufacture of nitrogenous, "ammoniated," superphospates. These fertilizers, which constitute by far the largest class in the market, owe their value mainly to the two ingredients, nitrogen and phosphoric acid. For phosphoric acid various fossil and mineral phosphates, particularly those from South Carolina and the Island of Navassa, are employed. Of late, mines of apatite have been opened in Canada, and promise to be a rich and important source of phosphates for this purpose. The waste boneblack from sugar refineries is also used in very large quantities for the same purpose. Bone meal is likewise employed, but to a limited extent. The phosphoric acid in all of these is in insoluble or very slowly soluble forms. To render it more available, the phosphates are treated with sulphuric acid, and thus superphosphates are produced.

Various materials are used to supply nitrogen (ammonia) to superphosphates. Dried blood and meat-scrap from slaughter-houses are, next to fish, the most important materials in common use for this purpose. Formerly a good deal Peruvian guano was employed. In Europe considerable sulphate of ammonia is used, but manufacturers there are learning that they can get nitrogen cheaper in American fish and slaughter-house products, and thousands of tons of our best nitrogenous materials are annually taken from us and sent across the Atlantic to enrich English, French, and German soils.

According to the report of Mr. Maddocks, already referred to, "nine-tenths of the fish scrap turned out at the works of the Maine association are bought by the manufacturers of superphosphate to ammoniate their products, of which 400,000 tons are produced yearly in the United States. They combine it, when dried and pulverized, with South Carolina phosphatic rock, ground bones, with imported guano deficient in ammonia, &c. It is understood that not over one ton of the fish guano is used in connection with three or four tons of the mineral ingredients."

The largest manufacturers of superphosphates in this country are the Pacific Guano Company, whose works are at Wood's Holl, Mass., and near Charleston, S. C. This company use fish and the Charleston phosphate for the manufacture of their superphosphate, the "Soluble Pacific Guano." The Quinnipiac Fertilizer Company, of New Haven, Conn., whose works are on Pine Island, near New London, Conn., and the Cumberland Bone Company, of Boothbay, Maine, are, with the Pacific Guano Company, the best representatives of this most useful industry. The detailed descriptions of their factories and methods of manufacture, prepared by Mr. Goode, are at once too extensive to be

conveniently inserted here, and of too much interest to be condensed, and are therefore given in the Appendix O.

50. CHEMICAL COMPOSITION OF MENHADEN AND OF FISH MANURES.

Analysis of whole menhaden and of flesh and bones of whale.

298. The only analysis of whole menhaden I have noticed is given by Prof. G. H. Cook.* The specimens were taken in the Raritan River the latter part of October.

"Five of the fish weighed four and one-fourth pounds—their average weight being three-quarters of a pound. The oil was first separated by adding water to the fish and boiling until the flesh was reduced to a pulp. The oil was then skimmed off and purified from water and other substances by ether. It then weighed 2.66 ounces, which is equivalent to 3.914 per cent. of the original weight of the fish. The substance of the fish remaining was then strained out and carefully dried in an air bath, at a temperature of 290° F., when the dry mass was found to weigh 11.8 ounces. On account of the solvent power of the sulphuric acid, which was added to the fish, it was thought proper to separate all the mineral matters from the fluid in which the fish had been boiled, add them to the dried fish, excluding of course the sulphuric acid. These weighed 1.1 ounces, and added to the weight of dried fish given above, 11.8 ounces, made for the whole weight of the dried matter 12.9 ounces, which is equivalent to 18.93 per cent. of the original weight of the fish. There was still left in the fluid some animal matter, which could not be satisfactorily separated, and was left out. The water in the fish was 77.15 per cent. as ascertained by deducting the percentage of oil and dried matter from 100. The nitrogen in the dried fish was ascertained by ultimate analysis to be 7.76 per cent., which is equivalent to 9.28 per cent. of ammonia. The mineral substances contained in the fish were freed from the organic matter by pressing, and then separated from each other by the ordinary process of analysis."

Analysis of the fresh fish.

Water	77.150
Oil	3.914
Dried fish	18.936

Analysis of the dried fish.

Lime	8.67
Phosphoric acid	7.78
Silicic acid	1.33
Potash	1.54
Soda	1.02
Magnesia	0.67
Chlorine	0.69
Organic matter and loss	78.30
	100.00

* Geology of New Jersey, 1868, p. 497.

The following analysis by Stöckhardt* of the flesh and bones of the whale may not be without interest in this connection :

I.—*Flesh of the whale.*

	Raw, per cent.	Perfectly dry (including fat), per cent.	Without fat and entirely dry, per cent.
Water	44.50	.....	.....
Fat	22.81	40.70	.....
Flesh	32.10	57.44	96.80
Mineral constituents (ash)	1.04	1.86	3.20
Nitrogen	4.86	8.68	14.69

II.—*Steamed bones of the whale.*

Water	3.84 per cent.	
Cartilaginous mass (glue)	34.60 "	=(3.5 per cent. nitrogen.)
Fat	1.34 "	
Bone phosphate of lime	51.66 "	=(23.66 per cent. phosphoric acid.)
Carbonate of lime	8.56 "	

Analysis of fish fertilizers.

299. The following tables illustrate the composition of some of our more common fish fertilizers. Those in Table A are from analyses reported by the writer.† Those in Table B are reported by Prof. S. W. Johnson:‡

TABLE A.

Kind of fertilizer.	Station number.	Moisture.	Organic matter.	Ash.	Phosphoric acid.	Nitrogen.	Ammonia equivalent to nitrogen.	Oil.
Dry ground fish:		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Ground fish, G. W. Miles	10	18.74	61.82	19.44	7.65	8.06	9.78	6.71
Fish guano, G. W. Miles	28	21.96	50.99	27.05	8.66	6.07	7.36	.....
Charles Island guano, G. W. Miles	80	8.63	71.79	19.41	7.74	8.84	10.73	.....
Allyn's fertilizer	24	.....	.....	16.37	6.17	8.80	10.68	6.35
Allyn's fertilizer	185	6.34	71.31	22.35	7.90	7.88	9.56	7.33
Dry ground fish, Quinnipiac Fertilizer Company	100	14.64	.....	22.23	6.67	7.50	9.11	7.68
Dry ground fish, Quinnipiac Fertilizer Company	140	10.85	68.40	20.75	7.21	7.38	8.97	.....
Dry ground fish, Quinnipiac Fertilizer Company	172	13.45	63.97	22.58	7.55	7.96	9.66	6.63
Acidulated fish, Quinnipiac Fertilizer Company	203	8.22	.....	20.41	8.11	8.25	10.00	8.94
Dried fish scrap:								
"Dry fish," Green Brothers	222	36.53	39.89	23.58	*7.09	4.11	4.99	.....
"Dried fish"	179	11.04	64.01	24.95	10.51	8.60	10.44	3.93
"Dry fish"	182	9.37	.....	19.92	7.10	8.13	9.86	.....
"Fish scrap"	189	11.00	.....	20.17	7.12	7.46	9.05	8.29
"Dry fish"	190	7.74	.....	.....	.....	7.10	8.61	.....
"Dry fish"	196	7.59	.....	.....	.....	7.79	9.46	.....
Half-dry fish scrap:	199	.....	.....	.....	.....	7.65	9.28	.....
Fish scrap, "half dry"	103	40.95	43.06	15.99	6.23	5.33	6.47	.....
Fish scrap, "half dry"	131	25.10	56.17	18.73	7.49	5.49	6.66	11.99
Crude fish pomace:								
"Fish scrap"	197	56.83	.....	.....	.....	3.63	4.41	.....

*Per cent. soluble in water, 1.76; per cent. soluble in ammonium citrate, 2.47.

* Chemische Ackersmann XVI, 1870, 52.

† Report of Connecticut Agricultural Experiment Station, 1876, p. 63.

‡ Report of Connecticut Agricultural Experiment Station, 1877, p. 41.

TABLE B.

Kind of fertilizer.	Station number.	Moisture.	Nitrogen.	Nitrogen in water-free fish.	Oil.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*
Dry ground fish-scrap	2	10.75	8.52	9.54	.....
Dry ground fish-scrap	12	.....	8.21	.....	.....
Dry ground fish-scrap, old, 1876	15	16.59	7.35	8.81	.....
Dry ground fish-scrap, new, 1877	16	23.95	7.30	9.59	.....
Dry ground fish-scrap	17	.....	9.26	.....	.....
Dry ground fish-scrap	18	.....	8.77	.....	.....
Dry ground fish-scrap	22	19.57	7.98	9.92	.....
Dry ground fish-scrap	43	9.03	8.04	8.83	.....
Dry ground fish-scrap	45	11.38	8.51	9.60	.....
Dry ground fish-scrap	46	10.74	8.43	9.44	.....
Dry ground fish-scrap	50	9.76	7.77	8.61	8.94
Dry ground fish-scrap	52	11.19	8.78	9.88	7.30
Average		13.66	8.24	9.36	8.12
Fish by Adamson's process	36	4.91	10.78	11.32	2.07
Fish by Adamson's process	39	3.67	10.74	11.15	.....
Fish by Goodale's process	41	11.45	10.24	11.56	4.64

Waste from faulty manufacture and use of fish fertilizers.

300. An enormous loss results to our agriculture from the waste of fish that might be saved, from faulty manufacture of fish into fertilizers, from wrong use of the fertilizers when made, and from the exportation of the best products to Europe, where their value is better understood. This loss will be prevented in proportion as the nature and uses of fish manures are learned.

51. THE USE OF FISH FERTILIZERS IN AGRICULTURE.

Chemistry of plant nutrition.

301. Not only farmers and merchants, but many manufacturers as well, have a very poor understanding of what constitutes the value of fish as fertilizers, and how they may be most economically utilized. It will be well, therefore, to consider briefly some of the principles that decide the value and usefulness of fertilizers in general, and of fish products in particular.

Fish manures, like other commercial fertilizers, are valuable because they supply plant-food which crops need and soils fail to furnish. Their main value depends upon their content of nitrogen and phosphoric acid. These are the most valuable and costly ingredients of commercial fertilizers.

Plants, like animals, require food for life and growth. A part of the food of plants is supplied from the atmosphere, the remainder is derived from the soil. No ordinary cultivated plant can thrive without a sufficient supply of each of a number of substances needed for its food. With an abundance of all of these in forms in which the plant can use them, and with other circumstances favorable, the plant will flourish and the yield be large. But if the available supply of any one of them

be too small, a light yield is inevitable. For instance, *potash* is an *essential ingredient* of the food of plants. If all the other conditions for a profitable crop of corn or potatoes, or other plants, are fulfilled in the soil, except that potash is deficient, the crop will inevitably fail. But if the potash be supplied the yield will be abundant. The chief use of fertilizers is to supply the plant-food which the soil lacks.

Vegetable and animal substances, and manures and soils as well, contain, besides *water*, two kinds of materials, the so-called *organic matter* and the *mineral matter* or *ash*.

The *organic matter* consists chiefly of the four chemical elements, *carbon*, *oxygen*, *hydrogen*, and *nitrogen*. We do not need to trouble ourselves about the first three of these in fertilizers, because they are supplied to the plant in abundance by the atmosphere and the soil through the leaves and through the roots.

But the nitrogen is an important ingredient of fertilizers. It is, in its pure state, a gas, and makes up about four-fifths of the air. Combined with hydrogen it forms ammonia; combined with oxygen it is known as nitric acid. In these and other combinations it occurs in minute quantities in the atmosphere, and in considerable quantities in soils and manures. Plants are unable to make use of the pure nitrogen of the air, though some, if not all, absorb a very little combined nitrogen from the atmosphere. By far the largest part of the nitrogen of plants is absorbed from the soil through the roots. From the facts that nitrogen is available to plants only in certain combinations, that it is slow to form and easily leaves these compounds, that it readily escapes from manures and soils into the air, and is leached away by water, it is one of the most commonly deficient and hence the most costly ingredients of the food of plants.

The mineral matter or ash of plants is derived entirely from the soil. It consists of several ingredients, known as potash, soda, lime, magnesia, iron, silica, sulphuric acid, phosphoric acid, and chlorine.

Essential ingredients of plant-food.

302. The results of a vast amount of this sort of experimenting prove that no agricultural plant can attain full growth without a sufficient supply, through its roots, from the soil, of *potash*, *lime*, *magnesia*, *iron*, *phosphoric acid*, *sulphuric acid*, and some compound of *nitrogen*. Besides these, chlorine, and perhaps silica, are sometimes, if not always, indispensable, though in very small proportions, to complete development. If any one of these *essential ingredients* be lacking the plant will suffer in growth and development.

Exhaustion of soil by various crops.

303. Crops take from the soil, then, the materials needful for their growth; and these are rightly called "plant-food." Some soils yield large crops many years in succession without manuring. They do this

because they contain large stores of the ingredients of plant-food, as potash, lime, nitrogen, &c., and because these are furnished in available forms, so that the plant can readily use them. As a rule, after cropping for some time, the point is reached where the natural resupply of plant-food is insufficient to produce large crops. In other words, in the so-called "poor," "worn-out," or "exhausted" soils, the natural strength is insufficient for profitable production.

In order to know what fertilizers to use on such soils we must know what ingredients of plant-food are deficient, and what manures will best supply them. An idea of the essential ingredients of plant-food removed from the soil in cropping may be obtained from the table below, which is calculated from the extensive tables of analyses of plants by Wolff.

Materials removed from the soil by various crops.

Crops.	Sulphuric acid.	Phosphoric acid.	Lime.	Magnesia.	Potash.	Nitrogen.
RYE.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Grain, 25 bushels = 1,400 pounds	0.3	11.8	0.7	2.9	7.8	24.6
Straw, 3,500 pounds	3.8	7.3	12.2	3.9	27.3	14.0
Total	4.1	19.1	12.9	6.8	35.1	38.6
OATS.						
Grain, 30 bushels = 960 pounds	0.4	6.0	1.0	1.8	4.2	18.4
Straw, 2,000 pounds	2.6	3.8	7.2	3.2	17.8	11.2
Total	3.0	9.8	8.2	5.0	22.0	29.6
WHEAT.						
Grain, 20 bushels = 1,200 pounds	0.1	9.5	0.7	2.4	6.4	25.0
Straw, 3,000 pounds	3.3	6.6	8.1	3.3	18.9	14.4
Total	3.4	16.1	8.8	5.7	25.3	39.4
CORN.						
Grain, 50 bushels = 2,800 pounds	0.6	16.5	0.8	5.6	10.4	44.8
Stalks, 6,500 pounds	7.8	34.5	26.0	16.9	62.4	31.2
Total	8.4	51.0	26.8	22.5	72.8	76.0
HAY.						
Mixed grasses, 1½ tons = 3,000 pounds	7.2	12.3	25.8	9.0	39.6	46.5
POTATOES.						
Tubers, 150 bushels = 9,000 pounds	5.4	1.44	1.8	3.6	51.3	30.6
TOBACCO.						
Leaves, 1,800 pounds (1,260 pounds dry)	14	7.5	73	17	71	49
Stalks, 1,100 pounds, dry	3	15	15	2	47	33
Total	17	22.5	88	19	118	82

Large quantities of silica, and small quantities of soda, chlorine, and iron, are also removed from the soil by every crop. Iron is necessary to the growth of all agricultural plants, but in very minute quantity. In many cases small amounts of chlorine seem to be requisite. Silica, if needed at all, which is quite doubtful, is required only in extremely

minute proportions. Soda does not appear to be an essential ingredient of plant food. In so far as these latter are *essential* ingredients of plant food, they are furnished in abundance by every ordinary soil.

Ingredients most commonly lacking in worn-out soils, and hence most important in fertilizers; nitrogen, phosphoric acid, and potash.

304. For our present purposes, then, we have to consider only the potash, lime, magnesia, sulphuric acid, and nitrogen. Of this list the magnesia is commonly, though not always, supplied in sufficient quantities in even "worn-out" soils. Sometimes its presence in fertilizers may be of considerable importance to crops. Sulphuric acid and lime are more often deficient, and hence one reason of the good effect so often observed from the application of lime and plaster.

The remaining substances, the nitrogen, phosphoric acid, and potash, are the most important ingredients of our common commercial fertilizers, because of both their scarcity in the soil and their high cost. It is in supplying these that fish guano, phosphates, and bone manures are chiefly useful.

In brief, then, in order that crops may grow, they must have at their disposal an adequate supply, in available forms, of each one of a certain list of essential ingredients of their food. Soils differ in respect to their supplies of these food ingredients. The crop cannot rise above the level of the lowest ingredient in the food supply. The chief use of fertilizers is to fill up the gaps.

Principles to be observed in the manufacture and purchase of fertilizers.

305. The cardinal principle to be observed by the farmer in the purchase of fertilizers is, to—

Select those which furnish, in the best form and at the lowest cost, the ingredients of plant-food that his crops need and his soil fails to supply.

The principle that should guide the manufacturer should be, to—

Economize all available materials in his manufacture so as to furnish the valuable ingredients in the best forms in products of high grade and uniform composition, and at the fairest practicable rates.

The most important ingredients of our fertilizers, because the most rare and costly, are nitrogen, phosphoric acid, and potash. The two first are the most important. These are supplied in large proportions in fish.

Composition, character, costs, and uses of fertilizers in general.

306. It will be to our purpose, then, to note briefly:

1. The composition of some of our more important commercial fertilizing materials, particularly those which, like fish manures, contain nitrogen and phosphoric acid; in other words, the analyses of these fertilizers.

2. The comparative costs and values of the active fertilizing ingredients in these articles; or, in other words, the commercial valuations.

3. The forms of combination in which the valuable ingredients occur, and their consequent agricultural values.

4. Some of the ways in which the fertilizers may be improved, and their values increased.

In the consideration of these topics, which must be brief, some data will be used which may be found in more detail in previous articles and reports by the writer.*

Explanations of chemical terms used in fertilizer analyses.

307. The following explanations of terms used in fertilizer analyses will be of use to those not familiar with such subjects:

MOISTURE.—All fertilizers contain more or less water, which, of course, has no commercial value, and serves to make them heavier and relatively poorer in valuable ingredients. In the analysis, that which is removed by heating to 212° Fahrenheit (or, in some cases, to a somewhat higher temperature) is designated as moisture. By subjecting the dried material to a higher temperature, the organic and volatile matters are driven off, and the ash remains. By treating this ash with strong acids, all that is of any value is dissolved.

SAND AND INSOLUBLE MATTERS.—The residue, which resists the action of both fire and strong acids, consists of silica and other mineral matters. These possess no fertilizing value, and are classified as sand, &c.

NITROGEN. AMMONIA.—In our ordinary fertilizers much or all of the nitrogen exists in unavailable forms. By more or less rapid alterations, by decay or otherwise, which take place in the soil, these are changed to other compounds, which the plant can readily use as food. Of these latter, nitric acid, which contains nitrogen combined with oxygen, is one; ammonia, which consists of nitrogen and hydrogen, and is represented by the chemical formula NH_3, is another. Fourteen parts by weight of nitrogen unite with 3 parts of hydrogen to form 17 parts of ammonia. Accordingly, 14 parts of nitrogen are said to be equivalent to 17 of ammonia, or what is the same thing, 100 parts of nitrogen are reckoned as equivalent to 121 parts of ammonia. In pure sulphate of ammonia all the nitrogen is in the form of ammonia. In Peruvian guano some of the nitrogen exists as ammonia also. In our other ordinary fertilizers there is little or no ammonia. The very common practice of reckoning nitrogen as ammonia in fertilizers which do not contain it in this form is incorrect, misleading, and therefore wrong, and ought to be abolished.

Ammonia combined with sulphuric acid forms sulphate of ammonia; nitric acid combined with soda forms nitrate of soda.

PHOSPHORIC ACID: SOLUBLE, REVERTED, AND INSOLUBLE.—By phosphoric acid is understood the compound of phosphorus and oxygen which is represented by the chemical formula P_2O_5, or PO_5. This, combined with lime, forms phosphate of lime. The phosphate of lime which

*See particularly report of Conn. Agl. Expt. Station in Report of Conn. Board of Agriculture for 1876.

occurs in bones, and in South Carolina and other fossil and mineral phosphates, contains 3 parts of lime to 1 of phosphoric acid. This is often called bone phosphate, and is insoluble in water. When the bone phosphate is treated with sulphuric acid, the latter takes part of the lime to itself, forming sulphate of lime, and leaves the phosphoric acid in the form of a *superphosphate*. This last is soluble in water, is more readily diffused through the soil, and when used as a fertilizer can be taken up by the plant at once, while the bone phosphate is slowly available as plant food. Phosphoric acid which has been rendered soluble often enters into other forms of combination, with lime, aluminia, &c., which, though insoluble in water, are soluble in citrate of ammonia. The terms "reverted," "reduced," and "precipitated" are applied to it when in this form. The reverted phosphoric acid ranks in solubility, in capability of diffusion through the soil, and consequently in value, between the soluble and insoluble. The soluble and reverted are sometimes classed together as available phosphoric acid.

In some analyses the percentage of phosphoric acid is not stated separately, that of "bone phosphate of lime" being given in its stead. Sometimes the expression "soluble bone phosphate of lime" is met with, which is certainly a misnomer. One hundred parts by weight of phosphoric acid unite with about 118 parts of lime to form 218 parts of bone phosphate; 100 parts or pounds of phosphoric acid are said, therefore, to be equivalent to 218 parts of bone phosphate. I lay especial stress on this point, because those not familiar with chemistry are apt to be deceived in comparing analyses in some of which the term phosphoric acid and in others the term bone phosphate is used. It would be more accurate and clear, and in every way better, to discard the term bone phosphate of lime in analyses of fertilizers, and speak only of phosphoric acid.

POTASH, OR POTASSA, is the compound of the metal potassium with oxygen, which is represented by the chemical formula K_2O or KO. This, combined with sulphuric acid, forms sulphate of potash. Potassium and chlorine together form chloride of potassium, or "muriate of potash," as it is called by dealers.

As the analyses and the valuations of the fertilizers to be discussed can be given most concisely and clearly together in tables, explanations of the latter subject may properly be given here.

Valuations of commercial fertilizers.

308. The *agricultural value of a fertilizer*, the gain which will result from its use in a given case, is subject to such varying conditions of soil, climate, culture, and crop, as to preclude the possibility of exact estimate. The *commercial value*, being dependent upon its composition and the state of the market, admits of more nearly correct calculation.

It is customary to make estimates of the commercial values by attributing to each of the important ingredients a certain value per pound;

that is to say, each pound of nitrogen, phosphoric acid, and potash is rated at a certain price, and the value of a ton of the fertilizer calculated on this basis, just as a grocer would make out a bill for a lot of tea, coffee, sugar, by charging a certain price per pound for each, and adding the products to make the amount of the bill. It will be remembered that each per cent. or pound in 100 pounds will be equal to 20 pounds in a ton of 2,000 pounds.

Here, for instance, is an analysis and valuation by Professor Goessmann:

Fish guano.

	Per cent.
Moisture at 100°–110° C	17.50
Organic matter	53.20
Ash constituents	29.30
Phosphoric acid in ash	7.72
Nitrogen in organic matter	6.46
Valuation per ton of 2,000 pounds:	
154.4 pounds of phosphoric acid, at 6 cents per pound	$9.26
129.2 pounds of nitrogen, at 25 cents per pound	32.30
	$41.56

The following statements are from the Connecticut experiment station report for 1876.

The statements and tables given in the other parts of this report will supply sufficient data for judging the values of nitrogen, phosphoric acid, and potash in different forms in which they are most commonly obtained in the markets. The commercial value of a fertilizer of which the analysis is given may be calculated by the following rule:

I. Multiply the per cent. of each valuable ingredient by 20 to get the number of pounds in a ton of 2,000 pounds. Multiply the number (thus found) of pounds of each ingredient by its assumed value per pound. The sum of these products will be the estimated commercial value of a ton of the fertilizer. Or,

II. Multiply the number of "units" (per cent.) of each ingredient by the assumed value per unit, and add the products. The sum will be the estimated value per ton.

What will be fair valuations will depend upon the material by which they are furnished, their market value at the time, the amounts purchased, time of payment, distance from market, &c. For the common superphosphates, bought in ton-lots for cash in our larger cities, the following figures will *not* be *far out of* the way:

	Per pound.	Per unit.
Nitrogen	21 cents.	$4 20
Phosphoric acid, soluble	12½ cents.	2 50
Phosphoric acid, reverted	9 cents.	1 80
Phosphoric acid, ins., from bones, meat, or fish	6 cents.	1 20
Phosphoric acid, ins., from bone-black	5 cents.	1 00
Phosphoric acid, ins., from fossil and mineral phosphates	3½ cents.	65

It must be remembered, however, that the values thus calculated are not agricultural values.

The following rates of valuation were adopted by Professor Goessmann in 1874–'75 and 1875–'76:

	1874–'75. Per pound.	1875–'76. Per pound.
Soluble phosphoric acid	16.25 cents.	12.5 cents.
Reduced	13 cents.	10 cents.
Insoluble phosphoric acid in mineral phosphates	5 cents.	4 cents.
Insoluble phosphoric acid in bones, fish, and animal dust	6 cents.	6 cents.
Nitrogen	30 cents.	25 cents.
Potassium oxide in muriate	8 cents.	6 cents.
Potassium oxide in sulphate	8 cents.	8 cents.

Professor Johnson, in the report of the Connecticut station for 1877, says as follows:

"The following are the trade-values or cost in market, per pound, of the ordinarily occurring forms of nitrogen, phosphoric acid, and potash, as recently found in the New York and New England markets:

	Cents per pound.
Nitrogen in ammonia and nitrates	24
Nitrogen in Peruvian guano, fine steamed bone, dried and fine-ground blood, meat, and fish	20
Nitrogen in fine-ground bone, horn, and wool dust	18
Nitrogen in coarse bone, horn shavings, and fish scrap	15
Phosphoric acid soluble in water	12½
Phosphoric acid 'reverted' and in Peruvian guano	9
Phosphoric acid, insoluble, in fine bone and fish guano	7
Phosphoric acid, insoluble, in coarse bone, bone ash, and bone-black	5
Phosphoric acid, insoluble, in fine ground rock phosphate	3½
Potash in high-grade sulphate	9
Potash in kainit as sulphate	7½
Potash in muriate or potassium chloride	9

"These 'estimated values' are not fixed, but vary with the state of the market, and are from time to time subject to revision. They are not exact to the cent or its fractions, because the same article sells cheaper at commercial or manufacturing centers than in country towns, cheaper in large lots than in small, cheaper for cash than on time. These values are high enough to do no injustice to the dealer, and accurate enough to serve the object of the consumer. * * * The 'estimated values per pound' in the above schedule are similar to those employed by Dr. Goessmann and Professor Atwater in their recent reports."

This method of estimating the commercial values of fertilizers has been long practiced and has its uses, particularly as a forcible means of illustrating frauds, and as the first step in the process of educating farmers and manufacturers. People who are not familiar with chemical terms understand dollars and cents, and are much more impressed by a fertilizers "analyzing" $30 per ton when the price is $45, than by its containing only six per cent. of soluble phosphoric acid when it ought to have twelve.

These calculations are, however, open to serious objections, with the rest, because they not only differ very widely from the agricultural

values, but also in many cases decidedly misrepresent the commercial values. It is on this account that they have so generally fallen into disuse or been discarded in England and Germany.

For the present purpose, another method, which has been proposed in the Connecticut station reports, is more fitting. It consists in comparing the different materials by the costs of the ingredients per pound.*

So weighty a matter as this demands full consideration. I therefore give here a table, in which are stated the composition and prevailing market-price per ton, a considerable number of the more important commercial fertilizers in our markets, and the costs per pound of the nitrogen, phosphoric acid, and potash in each at the prices named. Those designated by Arabic numerals were analyzed under the writer's direction. The others are taken from dealers' price-lists. Where several prices are given for the same article, the lower ones apply to smaller and the higher to larger lots.

*See Appendix for details of method of these calculations and for tables of analyses of a number of commercial fertilizers.

Percentages and costs per pound of valuable ingredients of commercial fertilizers.

Fertilizing materials.	Number.	Nitrogen.	Phosphoric acid.				Potash.	Retail price per ton.	Cost per pound in cents.					
			Available.		Insoluble.	Total.			Nitrogen.	Phosphoric acid.				Potash.
			Soluble in water.	Soluble in ammonium citrate.						Soluble.	Reverted.	Insoluble.	Total.	
NITROGEN.														
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Dolls.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Nitrate of soda, 95 per cent	I	15.65						70 00	22.4					
Do	I	15.65						75 00	24.0					
Do	I	15.65						80 00	25.6					
Do	I	15.65						85 00	27.2					
Do	I	15.65						90 00	27.8					
Nitrate of soda, 97.31 per cent	163	16.02						75 00	23.4					
Do	163	16.00						80 00	25.0					
Do	163	16.00						85 00	26.6					
Do	163	16.00						90 00	28.1					
Sulphate of ammonia, 24.29 per cent. ammonia	II	20.00						90 00	22.5					
Do	II	20.00						95 00	23.8					
Do	II	20.00						100 00	25.0					
Do	II	20.00						110 00	27.5					
Sulphate of ammonia, 24.90 per cent. ammonia	3	20.53						97 50	23.8					
Sulphate of ammonia, 24.92 per cent. ammonia	161	20.51						90 00	22.0					
Do	161	20.50						95 00	23.1					
Do	161	20.50						100 00	24.4					
Do	161	20.50						105 00	25.6					
Do	161	20.50						110 00	26.8					
Dried blood (counting phosphoric acid)	160	11.48				1.35		45 00	18.7					7.5
Dried blood (not counting phosphoric acid)	160	11.48						45 00	19.6					
Do	160	11.50						50 00	21.7					
Dried blood, at $3.50 per unit for ammonia	III								21.3					
Dried blood, at $4.50 per unit for ammonia	III								24.28					

Percentages and costs per pound of valuable ingredients of commercial fertilizers—Continued.

Fertilizing materials.	Number.	PERCENTAGES. Nitrogen.	Phosphoric acid. Available. Soluble in water.	Phosphoric acid. Available. Soluble in ammonium citrate.	Phosphoric acid. Insoluble.	Phosphoric acid. Total.	Potash.	Retail price per ton.	COST PER POUND IN CENTS. Nitrogen.	Phosphoric acid. Soluble.	Phosphoric acid. Reverted.	Phosphoric acid. Insoluble.	Phosphoric acid. Total.	Potash.
PHOSPHORIC ACID—SOLUBLE.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Dolls.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Dissolved bone-black	IV	.....	15.00	.....	.....	.....	.....	33 00	.....	11.0	.....	.....	.....	.....
Do	IV	.....	15.00	.....	.....	.....	.....	35 00	.....	11.7	.....	.....	.....	.....
Do	IV	.....	15.00	.....	.....	.....	.....	36 00	.....	12.0	.....	.....	.....	.....
Do	V	.....	16.50	.....	.....	.....	.....	36 00	.....	10.9	.....	.....	.....	.....
Superphosphate, from South Carolina phosphate	VI	.....	10.50	4.30	.....	.....	.....	30 00	.....	10.5	7.0	.....	.....	.....
Superphosphate, from Canada apatite	VII	.....	15.00	.....	.....	.....	.....	30 00	.....	10.0	.....	.....	.....	.....
Superphosphate, from Philadelphia	VIII	.....	31.00	.....	.....	.....	.....	65 00	.....	10.5	.....	.....	.....	.....
English superphosphate	53	.....	23.98	.....	8.67	.....	.....	61 00	.....	11.5	.....	4.6	.....	.....
PHOSPHORIC ACID—INSOLUBLE.														
South Carolina rock phosphate	IX	.....	.....	.....	.....	28.00	.....	20 00	.....	.....	.....	.....	3.8	.....
Navassa phosphate	45	.....	.....	.....	.....	20.45	.....	20 00	.....	.....	.....	.....	4.9	.....
Caribbean Sea guano, orchilla	125	.....	.....	.....	.....	27.18	.....	25 00	.....	.....	.....	.....	4.6	.....
Spent bone-black	X	.....	.....	.....	.....	32.00	.....	26 00	.....	.....	.....	.....	4.1	.....
Do	X	.....	.....	.....	.....	32.00	.....	30 00	.....	.....	.....	.....	4.7	.....
POTASH (POTASSA).														
GERMAN POTASH SALTS.														
Sulphate, 65 per cent	XI	.....	.....	.....	.....	.....	35.15	55 00	.....	.....	.....	.....	.....	7.8
Do	XI	.....	.....	.....	.....	.....	35.15	60 00	.....	.....	.....	.....	.....	8.5
Sulphate, 70 per cent	XII	.....	.....	.....	.....	.....	37.86	60 00	.....	.....	.....	.....	.....	7.9
Do	XII	.....	.....	.....	.....	.....	37.86	65 00	.....	.....	.....	.....	.....	8.6
Sulphate, 80 per cent	XIII	.....	.....	.....	.....	.....	43.26	65 00	.....	.....	.....	.....	.....	7.5
Do	XIII	.....	.....	.....	.....	.....	43.26	70 00	.....	.....	.....	.....	.....	7.8
Do	XIII	.....	.....	.....	.....	.....	43.26	75 00	.....	.....	.....	.....	.....	8.1

Do	XIII						42.26	80 00					8.4
Sulphate, 39.72 per cent	162						31.72	60 00					9.5
Sulphate, 75.19 per cent	184						40.66	65 00					8.0
Chloride (muriate) 80 per cent	XIV						50.54	45 00					4.4
Do	XIV						50.54	50 00					4.9
Do	XIV						50.54	55 00					5.4
Do	XIV						50.54	60 00					5.9
Chloride (muriate) 84 per cent	XV						53.06	50 00					4.7
Do	XV						53.06	55 00					5.2
Do	XV						54.06	60 00					5.7
Chloride (muriate) 80.08 per cent	33						50.64	60 00					5.9
NITROGEN AND PHOSPHORIC ACID.													
SLAUGHTER-HOUSE REFUSE.													
Meat scrap, Brighton abattoir	151	8.63				3.46		35 00	17.4			7.0	
Brighton animal fertilizer	153	6.53				11.90		40 00	17.7			7.1	
Brighton animal fertilizer, acidulated*	31	5.33	6.37		1.11			40 00	20.9	12.5	5.0		
Do	154	7.60	7.85	0.39				45 00	17.9	10.8	7.1		
Dried blood, meat scrap, and bone, Strong, Barnes, Hart & Co	102	8.08				5.20		40 00	19.7			7.9	
Do	102	8.08				5.20		30 00	14.8			5.9	
Do	142	9.72				3.83		40 00	17.8			7.1	
Do	142	9.73				3.83		30 00	13.3			5.3	
VEGETABLE REFUSE.													
Castor pomace	35	4.80				2.11		25 00	22.1			8.8	
Do	59	4.69				1.91		19 00	16.8			6.7	
Do	105	5.29				2.42		19 00	15.2			6.1	
BONE MANURES.													
Ground bone, J. Lister (Grade of fineness. I)	91	3.63				22.85		35 00	11.6			5.8	
Pure ground bone, L. B. Darling & Co (Grade of fineness. I)	175	3.61				22.16		40 00	13.6			6.8	
Bone sawings, Granby Manufacturing Company (Grade of fineness. I)	193	3.69				26.05		40 00	12.0			6.0	
Ground bone, Thompson & Edwards (Grade of fineness. II)	181	2.67				26.08		35 00	11.2			5.6	
Ground bone, H. J. Baker & Bro (Grade of fineness. III)	94	3.88				23.61		33 00	10.5			5.2	
Bone flour, P. W. Bennett (Grade of fineness. III)	92	3.91				22.05		36 00	12.0			6.0	
Fine ground bone, G. W. Miller (Grade of fineness. III)	93	3.88				21.95		36 00	12.0			6.0	
Ground bone, Peck Bros (Grade of fineness. IV)	58	4.03				19.79		38 00	13.6			6.8	
Coarse ground bone, P. W. Bennett (Grade of fineness. IV)	92a	3.91				22.05		30 00	10.0			5.0	
Coarse ground bone, G. W. Miller (Grade of fineness. VI)	93a	3.88				21.95		30 00	10.1			5.0	
NITROGENOUS SUPERPHOSPHATES.													
Ammoniated bone superphosphate, Russell Coe	128	2.24	11.67	0.92	0.20			40 00	21.0	12.5	8.3	5.0	
Do	135	2.94	12.05	0.34	0.57			40 00	19.1	11.5	7.7	4.6	
Do	168	2.04	12.33	0.46				40 00	20.5	12.3	8.2		
Do	170	3.84	11.05	1.08				40 00	18.3	11.0	7.3		
Average of four samples above									19.7	11.6	7.9	4.8	

Percentages and costs per pound of valuable ingredients of commercial fertilizers—Continued.

Fertilizing materials.	PERCENTAGES.							Retail price per ton.	COST PER POUND IN CENTS.					
			Phosphoric acid.							Phosphoric acid.				
			Available.											
	Number.	Nitrogen.	Soluble in water.	Soluble in ammonium citrate.	Insoluble.	Total.	Potash.		Nitrogen.	Soluble.	Reverted.	Insoluble.	Total.	Potash.
NITROGEN AND PHOSPHORIC ACID.														
NITROGENOUS SUPERPHOSPHATES—Continued.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Dollars.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Soluble nitrogenous phosphate, Quinnipiac Fertilizing Company	101	4.41	7.94	.....	0.46	.....	.....	40 00	22.7	13.6	.....	5.4	.....	.....
Do	146	3.33	8.16	3.39	2.55	.....	.....	40 00	19.6	11.8	7.8	4.7	.....	.....
Do	171	2.40	7.65	2.29	1.91	.....	.....	40 00	23.6	14.2	9.5	5.7	.....	.....
Average of three samples above	.....	.....	.....	.....	.....	.....	.....	.....	22.0	13.2	8.6	3.3	.....	.....
Pine Island guano, Quinnipiac Fertilizing Company	99	5.64	4.05	2.32	1.93	.....	.....	45 00	22.5	13.5	9.0	5.4	.....	.....
Do	173	6.25	4.93	0.96	0.84	.....	.....	45 00	23.0	13.8	9.2	5.5	.....	.....
Average of two samples above	.....	.....	.....	.....	.....	.....	.....	.....	22.7	13.6	9.1	5.4	.....	.....
FISH MANURES.														
Dry ground fish, Allen's	24	8.80	.....	.....	.....	6.17	.....	40 00	17.7	.....	.....	.....	7.1	.....
Do	185	7.88	.....	.....	.....	7.90	.....	40 00	18.1	.....	.....	.....	7.2	.....
Average of two samples, Allen's	.....	8.34	.....	.....	.....	7.03	.....	40 00	17.9	.....	.....	.....	7.2	.....
Dry ground fish, Quinnipiac Fertilizing Company	100	7.50	.....	.....	.....	6.67	.....	45 00	22.1	.....	.....	.....	8.8	.....
Do	140	7.38	.....	.....	.....	7.21	.....	45 00	21.9	.....	.....	.....	8.8	.....
Do	172	7.96	.....	.....	.....	7.35	.....	45 00	20.5	.....	.....	.....	8.2	.....
Average of three samples, Quinnipiac Fertilizing Company	.....	7.61	.....	.....	.....	7.14	.....	45 00	21.5	.....	.....	.....	8.6	.....
Dry fish, unground, Green Bros	179	8.60	.....	.....	.....	10.51	.....	28 00	10.9	.....	.....	.....	4.4	.....
Half dry fish scrap	103	5.33	.....	.....	.....	6.23	.....	16 00	10.2	.....	.....	.....	4.1	.....
Do	131	5.49	.....	.....	.....	7.49	.....	16 00	9.4	.....	.....	.....	3.8	.....
NITROGEN, PHOSPHORIC ACID, AND POTASH.														
PERUVIAN GUANOS.														
Ten per cent. ammonia standard	47	11.33	4.14	8.81	2.42	.....	2.33	60 00	16.0	9.6	6.4	3.8	.....	5.1
Do	108	8.56	5.25	9.79	2.86	.....	3.24	60 00	17.3	10.4	6.9	4.2	.....	5.5

Do	137	7.76	5.27	6.24	4.01	.....	4.36	58 50	18.5	11.1	7.4	4.5	.....	5.9
Do	164	7.92	6.05	5.59	1.39	.....	4.61	57 00	18.9	11.3	7.6	4.5	.....	6.0
Do	191	7.88	5.11	7.10	5.04	.....	3.54	58 00	18.0	10.8	7.2	4.3	.....	5.7
Average of eight samples as above	.....	8.48	5.10	6.43	3.53	.....	3.60	58 00	17.1	10.2	7.3	4.9	.....	6.5
Guaranteed, cargo A	186	5.87	4.55	4.35	7.10	.....	3.45	56 00	21.3	12.9	8.5	5.1	.....	6.8
Do	187	5.79	4.50	5.11	7.49	.....	3.36	56 00	20.9	12.5	8.4	5.0	.....	6.7
Average of two samples above	.....	.....	.....	.....	.....	.....	.....	.....	21.1	12.7	8.45	5.55	.....	6.75
Rectified	37	9.15	10.67	.....	1.71	.....	2.43	60 00	17.9	10.8	.....	4.3	.....	5.7
Do	136	7.82	10.02	2.62	.....	.....	4.34	65 00	19.9	11.9	8.0	.....	.....	6.4
Average of two samples above	.....	.....	.....	.....	.....	.....	.....	.....	18.9	11.35	8.0	4.3	.....	6.05
Peruvian guano, Lobos	243	4.68	8.80	6.68	4.13	.....	4.23	49 00	17.0	10.1	7.3	4.9	.....	6.5
Peruvian guano, No. 2	244	2.60	4.01	7.81	2.12	.....	2.67	39 50	19.8	11.8	8.5	5.7	.....	7.6

Of the above figures it may be remarked:

1. The articles are of the higher grades. The poorer articles with which the markets are infested are not taken into account. The nitrogenous superphosphates, for instance, were among the best of about fifty samples from which the selections were made.

2. The costs of the ingredients vary widely in the different articles. This is illustrated by the following figures, which represent average market-rates:

Fertilizers.*	Costs per pound in cents.			
	Nitrogen.	Phosphoric acid.		Potash.
		Soluble.	Total.	
Nitrate of soda	24 to 25			
Sulphate of ammonia	24 to 25			
Dried blood	19 to 23			
Superphosphates		10 to 11		
Potash salts, sulphates				8
Potash salts, muriates				4¼ to 5
Slaughter-house refuse	15 to 20	10 to 12		
Bone manures, best	10 to 12		5 to 6	
Bone manures, medium	14 to 16		7 to 8	
Bone manures, inferior	18 to 24		9 to 12	
Nitrogenous superphosphates, best	18 to 21	11 to 12½		
Nitrogenous superphosphates, medium	24 to 28	14 to 16	5 to 8	
Nitrogenous superphosphates, inferior	30 to 40	18 to 24	6 to 12	
Peruvian guanos	17 to 21	10 to 12½		5½ to 6½
Dry ground fish guano	18 to 22		7 to 8½	
Dry fish-scrap	10 to 15		4½ to 6	
Half-dry fish-scrap	7½ to 11		3¾ to 4½	

Relative values of different fertilizers.—Fish and Peruvian guanos.

309. From these figures, which represent a somewhat extensive and thorough survey of the northern and eastern fertilizer markets, it appears that, taking into account composition and price, fish manures furnish the active manurial ingredients, nitrogen and phosphoric acid, at lower rates than any other commercial fertilizers except bone manures. But in bone, the fertilizing ingredients act more slowly. Taking the form of combination, the availability, into account, the nitrogen and phosphoric acid in bone can rival those of fish, only when they are wanted for slow and long-continued use, as in "seeding down" with grass.

Next in order of cheapness come Peruvian guanos. In fairness, however, these ought to be compared only with the dried and finely pulverized fish guanos. Indeed, a pound of nitrogen or phosphoric acid is doubtless worth on the average considerably more, agriculturally, in Peruvian guano than in even the driest and finest fish.

* As was remarked, the nitrogenous superphosphates in the table preceding this were the best of some fifty samples of a large number of brands analyzed at this place. In that list, and in those in the appendix, can be seen the data upon which the above figures are based. The analyses from which the tables are made up were made under the direction of the writer, into whose hands not far from three hundred samples of the commercial fertilizers in the Boston, New York, Philadelphia, and Baltimore markets have lately come for examination. Fraudulent articles are excluded from the computation.

This leads us to consider the values of nitrogen and phosphoric acid in different forms of combination. In general, it may be said that nitrogen is in its most readily available forms in sulphate of ammonia and nitrate of soda; that it becomes quickly useful to the plant in Peruvian guano, more slowly so in fish, dried blood, and meat scraps, and is very long in becoming available in leather scraps, hoof and horn shavings, hair, and the like. Soluble phosphoric acid is ready for use at once. The insoluble phosphoric acid of fish guano, meat, and finely steamed bones, acts more or less quickly, but in coarse pieces of bone and in bone black its action is very slow. In the South Carolina, Nevassa, Canada, and other mineral and fossil phosphates, it is of comparatively little value.

The nitrogen and phosphoric acid in coarse fish scraps are less valuable than in fine dry fish, for two reasons: they are more bulky to transport and apply, and are less available to plants when applied.

In 100 pounds of dry guano, there will be say, 10–15 pounds of water, while 100 pounds of half-dry scrap will contain 40–50 pounds of water. To get 100 pounds of dry matter will require on the average, say, 112 pounds of guano and 180 pounds of the half-dry scrap.

Again, the finely ground fish distributed evenly and thoroughly through the soil, is readily decomposed, and thus conveyed where the largest number of roots may have access to it and its materials will be available to the roots when they find it. But the coarse scrap cannot be as well distributed either when it is applied or by natural agencies afterward, less roots will get at it, and when they do find it they will not be able to use it as well as they could the more finely ground and better decomposed guano. Less of the coarse scrap will enure to the benefit of the first crop; and of that which is left over, the phosphoric acid will remain in the soil for subsequent crops, but more or less of the nitrogen will in the process of decomposition be set free and escape into the air, or be leached away by soil-waters beyond the reach of plants, or fixed in unavailable combinations in the soil and thus lost to vegetation.

A great deal has been said about the relative values of fish and Peruvian guano. The following table gives the results of experiments bearing upon this point. The experiments were made upon twenty different beet-sugar farms in and about Germany. The general plan and the details were the same for all. They were carried on by intelligent farmers, under the guidance of Dr. Grouven, director of the experiment station at Salzmünde in Prussia. The figures represent the value in German thalers of the increase in yield over unmanured plots, taking into account not only the increase of the manured crop, but the after effect during two succeeding years. The fish guano was the Norwegian,

which has more nitrogen and much more phosphoric acid than our fish guanos.

Manuring per Prussian morgen.	Gain over unmanured plots, in thaler, per morgen.				Cost of fertilizers per morgen.	Consequent gain from manuring.
	1862.	1863.	1864.	Increase for the three years over unmanured.		
	Fertilizers applied for sugar beets. Average of 20 fields.	No manure; grain and straw; after effect of manuring of 1862. Average of 13 fields.	No manure; sugar beets; after effect of manuring of 1862. Average of 12 fields.			
	Thaler.	*Thaler.*	*Thaler.*	*Thaler.*	*Thaler.*	*Thaler.*
1.6 cwt. Peruvian guano	12.7	2.9	3.9	19.5	7½	12.0
3.2 cwt. Peruvian guano	17.8	4.1	4.0	25.9	15	10.9
6.4 cwt. Peruvian guano	23.8	7.7	7.9	39.4	30	9.4
4 cwt. superphosphate	8.8	1.3	7.8	17.9	8⅝	9.2
6 cwt. superphosphate	9.7	2.4	10.1	22.2	13	9.2
8 cwt. superphosphate	10.6	1.3	8.9	20.8	17½	3.5
3 cwt. fish guano	7.7	0.3	2.5	10.5	9	1.5
6 cwt. fish guano	11.1	1.2	3.0	13.3	18	—2.7
1½ cwt. nitrate of soda	8.7	0.7	0	9.4	8	1.4
3 cwt. nitrate of soda	14.2	1.3	0	15.5	16	—0.5

The German thaler = 72 cents gold, nearly.
The German cwt. or centner = 111 pounds, nearly.
The German morgen = ⅝ acre, nearly.

Comparing the plots which had 3 cwt. each of fish and Peruvian guano it is to be observed that—

1. The Peruvian guano cost nearly twice as much as the fish guano.

2. The gain from the Peruvian guano, over and above the cost, was six times as much as that from the fish.

These results are remarkably favorable for the Peruvian guano. But it is to be noted that these experiments were on two crops of sugar-beets, with one of grain between. With other crops the results might have been very different.

Stoeckhardt, who has given as much attention to this matter as any one, infers, from a large number of field experiments made under his direction, that the fish guano is very nearly as effective as Peruvian.

Aside from its content of potash, of which fish has as good as none, the greater value of Peruvian guano, which is a fish product, must be due in the main to the fact that, as the result of the changes effected in its passage through the bird and subsequently, the ingredients have entered into new, simpler, and more available forms of combination. Taking into account composition, quality, and price, the cheapest fertilizers in the market are Peruvian guanos; next to these come fish manures.

Ways of improving fish manures.—Fermentation.

310. The advantage of these changes in the composition of fertilizers is much better appreciated in Europe than here. Several ways are recommended to bring them about. One of these is by fermentation.

The increasing importance of fish and bone manures in German agriculture has led Dr. Pagel, of the experiment station at Halle, to undertake a series of experiments to gain light upon the best means of preparing these for use. He recommends very strongly the plan of fermenting them with urine: "The method of fermentation furnishes a most excellent means for transforming the nitrogen in manures of organic origin, which is insoluble and slow in its action, into more soluble and consequently more active forms. It is hence peculiarly applicable to ground-bone and fish guano." He recommends to add about 30 quarts of urine to 100 pounds of bone or guano, and cover the heap with plaster (gypsum) or earth to prevent the escape of ammonia. If this is properly done, the mass will ferment, and the temperature rise to a little above 100° Fahr. The completion of the process, for which three or four weeks should suffice, is indicated by the cooling of the heap. Pagel found nearly one-half the nitrogen of fish to be made soluble in water by this process.

Composting fish fertilizers.

311. Another excellent method of utilizing fish is by composting. I can explain this in no better way than by referring to the experience of one of the most intelligent and successful farmers in our State, Mr. D., who lately called upon me to inquire about this subject. Mr. D.'s problem was simply how to get fertilizing materials for his soil in the best and cheapest manner. He proposed this question:

"I understand that the superphosphate manufacturers make their fertilizers of fish scrap and phosphates, treating them with oil of vitriol to make the phosphoric acid and nitrogen more available. Now can't I accomplish the same by composting in my barn-cellar? I understand the elements must go out of their original combinations into others before they can become useful to my plants, and that the acid and the manufacturing help this change along. I can get fish scrap for $17 per ton. Can I not bring this change about in a compost-heap, and will it not be a great saving to me?"

The answer was plain: "Fish scrap at $17 per ton will bring nitrogen at say 10 cents and phosphoric acid at 5 cents per pound. In "ammoniated" superphosphates, you will pay from 20 to 30 cents or more per pound for nitrogen, and from 8 to 20 cents per pound for your phosphoric acid."

"Do I need a phosphate with the scrap; if so, will bone be as good as anything? I can get ground bone from a glue factory at $30 per ton."

"The bone at that price will give phosphoric acid at say 5 cents and

nitrogen at 10 cents per pound. If rightly composted the ingredients will become available speedily and surely. For most soils and crops the increased proportion of phosphoric acid which the bone would add would be very advantageous."

"I am persuaded that my soil wants potash. Should that be put in the compost; and, if so, what is the cheapest way to get it?"

"If you can get fresh ashes cheap they will do very well. If not, the 'muriate of potash,' which contains 50 per cent. 'actual potash,' and can be bought in the larger markets at $45 or less per ton, will be best. But the ashes have the advantage over the potash-salt that they supply all the ingredients of plant food but nitrogen, and further, by virtue of their large amount of lime and alkalies, they aid the decomposition of the matters in the compost very materially. In absence of ashes, lime will serve an excellent purpose."

Mr. D. explained his proposed method of composting, which consisted of mixing muck and mellow earth with the fish, bone, potash-salts, and lime, in alternate layers, in heaps where the urine from the stables would be caught and absorbed. From previous experience he believed that he could secure a moderately rapid fermentation which would keep the heap warm, but not too hot, and after a reasonable time have gone so far as to decompose the fragments of fish and bone and leave the whole heap in a well-rotted and uniform condition. I could only say that this seemed to me an extremely rational, sensible, and profitable way of making manure. And I cannot answer the numerous questions I receive about the best way of composting fish for manure any better than by giving the conversation with Mr. D. substantially as I recall it.

Improving fish for manure by feeding it to stock.

312. The most rational method of utilizing fish for manure, and the one which it seems to me must prove by far the most profitable way of economizing our waste fish products, is by feeding them to stock.

European farmers have learned in their practice what science has explained in theory, that just as the most reliable and useful manure is that produced in the stable and barn-yard, so this manure can be vastly improved by foods rich in nitrogen. English, French, and German farmers have found the feeding of oil cake and meal so profitable that manufacturers, entirely unable to meet the demand from the home supply, ransack the markets of Russia, India, and the United States to obtain it. Our linseed and cotton-seed products are in great demand for foreign export. After our oil manufacturers have pressed out the oil, whose value is well enough understood in the commerical world to keep it at home, the press cake, whose worth our farmers have not yet learned, is sent abroad to enrich the cattle food, manure, and purses of foreign farmers who know what it is good for and how to use it.

What gives the value to these waste products is chiefly their nitrogen compounds.

Of late the importance of animal wastes, flesh, meal, dried blood, and fish has come to be understood, and a good many accurate experiments have been made to test their digestibility, their nutritive value, and that of the manure produced from them. This will be explained in the following section, paragraphs 314–325. I will here only refer in few words to the results of a late series of experiments by Wildt, at Proskau, and by Kellner, at Hohenheim, with Norwegian fish guano fed to sheep. It appears that sheep digest the most of the nitrogenous material of the flesh, and a large part of that of the bone. What is not stored away in the body of the animal is excreted as urea, one of the most valuable forms of nitrogen for plant food. Only a small part of the phosphoric acid is digested, but the remainder is left in a very finely divided form, and hence much better for a manure. Kellner discusses the various methods employed for making the ingredients of fish more available for manure. Treatment with acid and caustic alkalies is unsatisfactory. Fermentation with urine is much better; but the most convenient and profitable way he concludes to be that of passing it through the digestive organs of domestic animals.

Practical conclusions.

313. One very great obstacle to the profit from using fish as manure is the fact that it contains only nitrogen, phosphoric acid, and lime, and does not supply the other soil ingredients of plant-food. Where potash is wanted the fish cannot suffice. Illustrations of this are only too abundant. I have only to look out of the window where I write to see in the distance a farm whose proprietor, some time ago, applied fish to one of his fields at the rate of nearly a ton to the acre, hoping to obtain a good crop of hay. In spite of this heavy and costly dressing the grass failed. At my suggestion he tried a series of experiments with different fertilizers to test the deficiencies of his soil. Wherever potash salts were used the crop was good; without potash it failed. The best results were obtained with a "complete" fertilizer, containing nitrogen, phosphoric acid, and potash, such as could be made from fish and potash salts. The recognition of facts like this often makes the difference between good profit and ruinous failure in farming.

The large amount of nitrogen in fish makes it a "stimulating" manure. It helps crops to get more of the food contained in the soil, and thus to "exhaust" the immediately available supply. Farmers often complain that fish, like Peruvian guano, wears out their land. In Maine they talk of land that has been "herringed to death." In Connecticut we often see grasses leaving and sorrel coming in after such fertilizers are used. Some good farmers say their soil gets hard and "caked" after continuous use of fish. The remedies are, tillage and use of other manures, ashes, lime, potash salts, bone, yard manure, muck, and so on.

The nitrogen in fish makes it particularly good for grass and grain, but excess is apt to make grain "run to stalk" and lodge, and may injure or even kill any crop for which it is used.

Besides grain and grass crops, fish does well for corn, potatoes, garden vegetables, etc. It promotes the growth of tobacco, but is thought by many farmers to injure the quality of the leaf.

The fine, dry fish-guano with little oil is the best. The coarse, wet scrap is inconvenient to handle, and cannot be well diffused through the soil. Concentrated fertilizers ought to be thoroughly mixed with the soil so as to be accessible to the largest number of roots and injure none. Neglect to observe this causes immense waste of fertilizing materials and loss of crops. If the coarse scrap is to be used it is best to compost it. The lumps are thus divided, the material decomposed and changed to more available forms, its value for plant-food increased, and it can be applied so as to secure the greatest benefit with the least waste.

Fermentation with urine, as described above, improves fish greatly.

The best method of all for getting fish into forms most fit for plant-food is to feed it to stock. This brings a two-fold advantage: it supplies the nitrogen (protein albuminoids) that poor foods, such as straw, cornstalks, and poor hay lack, and makes excellent fodder from cheap materials, while the nitrogen and phosphoric acid that are not used at the greatest possible profit to make flesh and bone are left in the manure in much better form for plant-food than they were in the fish.

There is great need of improvement in the manufacture of fish manures. What is wanted is a fine, dry product with as little ballast of water and oil and as much nitrogen as possible.

The chief obstacle to the better economizing of fish in agriculture is lack of information as to the best ways of making and using the products. To get this, careful scientific research and close practical observation are indispensable. Investigations in the laboratory and experiments in the field combined will bring the needed knowledge, and it will be worth a hundred times the cost.

52. Fish as food for domestic animals.

Principles of animal nutrition.—European experiments.

314. Undoubtedly the manure problem is the most important that the agriculture of our older States has to solve. The next weightiest is the food question, how to best economize and improve our fodder materials. Inside this the most important special problem is how to obtain foods rich in nitrogen. Our feeding materials, taking them together, lack nitrogen. In consequence, our animals are insufficiently fed and fail to get the full benefit of the food they do have. The result is underproduction of meat, dairy products, and work, and in turn poor manure and poor crops. European farmers have passed through this costly

and bitter experience ahead of us, and have learned the cause and the cure. Necessity has driven them to study these problems in ways of whose cost, extent, and beneficent results we on this side of the water have as yet only a faint conception. Hundreds, we might almost say thousands, of feeding experiments have been made with horses, oxen, cows, sheep, goats, swine, and other animals. Some of the ablest chemists and physiologists in Europe are devoting their lives to these special investigations. Governments, universities, agricultural schools, societies, and private individuals are giving money by hundreds of thousands of dollars for the work. In the last ten or fifteen years investigation has been especially active. In twenty agricultural experiment stations, and in a large number of laboratories of universities and other schools, the studies are being carried on to-day, and already definite knowledge has been obtained which many thousands of farmers on the other side of the Atlantic are using to their profit, is beginning to come to us and will, with what must be added by our own efforts, prove of inestimable value to our agriculture.

The lessons our foreign brethren have learned so dearly are free to us if we are wise enough to take and use them. Their substance is briefly this:

The advanced agriculture of the present day looks upon the farm or the stable as a sort of manufacturing establishment. Domestic animals are the machines, food in the form of hay, grain, root crops, commercial food materials, &c., are the raw materials, and meat, milk, wool, labor, and progeny the products.

In cattle-feeding, then, the important question is, how, with the foods at hand or obtainable, to get the most valuable product with the least outlay for raw material.

Feeding for maintenance and production.—Ingredients of foods and their functions.

315. Suppose that I have in my stable a cow, standing idle and giving no milk. She will require only food enough to supply the wastes resulting from the changes that are continually taking place in her internal organism, from the continual building over and renewal of all parts of her body. A certain amount of food of a certain quality is necessary, then, to *maintain* her in good "store" condition. This she will need to "hold her own" when nothing else is required of her.

But suppose that I demand of my cow *production*, say in the form of milk. For this purpose she will need more food. And, as everybody knows, the cow should have for the production of milk, not only a larger quantity, but also different quality of food from that which is needed for maintenance alone.

If, instead of milking my cow, I wish to fat her for the butcher, I shall also require production, but of still another sort, of fat and flesh. And if, instead of a cow, I have an ox that is to be kept at work, yet another

kind of production is required, muscular force. And I need not say that for these different kinds of production different kinds and amounts of fodder are requisite.

In the light of modern experimental science the maintenance of the animal and the production of meat, milk, heat, and force are not matter of so much hay, grain, and roots, but of the gluten, sugar, starch, fat, and so on, of which these are composed.

It has been already explained that animal and vegetable substances are composed of water, organic matters, and ash.

The following is, for instance, what is found in 100 pounds of wheat (grain):

		Pounds.
Water		13.5
Organic substances:		
Gluten, fibrin, &c. (containing nitrogen)		13.2
Starch	containing no nitrogen.	59.5
Sugar		2.4
Gum and other extractive matter		4.7
Fiber (cellulose)		3.0
Fatty matters (containing no nitrogen)		1.6
Mineral matter (ash)		2.1
Total		100.0

Corn, hay, potatoes, in fact vegetables generally, contain nearly the same list of ingredients as wheat, but in different proportions. The same is true of animal foods. Meat and milk consist of similar ingredients.

For our present purpose we have to consider only the organic substance. Now notice in the table above that there is a distinction between two classes of ingredients of this organic substance of wheat. The gluten and fibrin contain nitrogen, while the sugar, starch, fiber, fat, &c., contain no nitrogen.

This distinction between the nitrogenous and non-nitrogenous food ingredients is a fundamental one in economical cattle feeding.

Albumen, found pure in the white of an egg, is a representative of several kinds of substances, which consist chiefly of carbon, oxygen, hydrogen, and nitrogen. To these nitrogenous materials we apply the general name, albuminoids. The albuminoids are found in all animals and plants. Muscle or lean meat, casein (curd) of milk, fibrin of blood, gluten, albumen, and fibrin of plants, are examples. Clover, beans, pease, oil-cake, are rich in albuminoids.

Again, there are other animal and vegetable materials that consist of carbon, oxygen, and hydrogen, simply. These are called carbohydrates and fats. Starch, sugar, gum, and cellulose or fiber are carbohydrates. The oily and fatty matters of plants as well as butter, tallow, &c., are fats. Potatoes, sugar-beets, fodder-corn, and straw are rich in carbohydrates and poor in albuminoids.

The distinctions between the ingredients of the animal tissues and

products are similar. Lean meat or muscle and the casein (curd) of milk, like the albumen of the egg, are albuminoid substances and contain nitrogen. The fat of the body and the fat (butter) in the milk, like the oils and fats of plants, contain no nitrogen.

The ingredients of the body are built up from those of the food. The nitrogenous materials, muscle, connective tissue, skin, &c., are formed from albuminoids. The carbohydrates and fats of the food, which have no nitrogen, cannot be transformed into nitrogenous tissues of the body.

To form the fats, both the fats and albuminoids of the food contribute. A large part of the fat meat stored in the body and of the butter given off with the milk is made and must be made of the albuminoids of the food.

Just what work the carbohydrates do in the animal economy is not yet fully settled. They certainly cannot make flesh, and probably do but little at most to make fat. They act as fuel to keep up the animal heat, and doubtless contribute to the generation of muscular force. Just how much of the heat and force produced in the body comes from the consumption of albuminoids, how much from carbohydrates, and how much from fats is still an unsettled problem.

The animal has been compared to a machine. It is, however, a machine that must be kept running whether it produces anything or not. A horse, or cow, or sheep needs food even at rest in the stall. The machine is peculiar also in that it is wearing out continually and very rapidly, and consumes its own material for both fuel and repairs. The tissues of the body are all the while being used up and rebuilt. In the process of using up, heat and force are produced. The animal consumes food to make its flesh and fat and to give it warmth and strength, but it gets warmth and strength from the consumption of its own flesh and fat at the same time.

Now to make up for the continued wasting away of tissues and to maintain the supply of heat, food is necessary. But for this purpose but little of albuminoids is required. Carbohydrates will serve for fuel to keep the body warm. The horse or sheep at rest will get on with comparatively little nitrogen. Maintenance fodder may be poor in albuminoids if it furnish carbohydrates in plenty. Stock may be kept in the barn and even wintered on poor hay, cornstalks, and straw. But when production is required the case is very different. To make lean meat the animal must have albuminoids. Fat meat may be produced from the fat of the food, if there be enough, but practically a large part of the fat must come from albuminoids. The casein and fat (butter) of the milk likewise come from the albuminoids of the food, and for work also more or less of albuminoids are used. The growing colt or lamb, the working horse or ox, the milch cow and the fattening sheep or swine or steer must all have rich food and food rich in nitrogen. The nitrogenous ingredients, the albuminoids of the food, are its most important constituents. They may take the place of the carbo-

hydrates and fats to considerable extent, but their peculiar work must all be done by themselves. Such is the concurrent testimony of a vast amount of experimenting.

Again, of the whole ration consumed only a portion is digested and used to supply the animal's wants; the rest is voided as excrement, and valuable only for manure. It is important, then, that as much should be digested as possible. The value of the food will depend upon the amount the animal digests from it.

Economy in feeding requires, then, that the greatest amount of food be digested, and that this digested material contain sufficient albuminoids.

An excessive proportion of albuminoids is, however, uneconomical. The albuminoids are the costliest parts of the foods. No more should be used than necessary.

Proper proportions of digestible albuminoids, carbohydrates, and fats in the food are the chief requisites of economical feeding.

Digestion of foods by animals, as tested by European experiments.

316. The digestibility of different foods and food mixtures by different animals under varying circumstances has been tested by a very large number of experiments in the German experiment stations. The method consists in feeding animals with rations of known amount and composition, carefully collecting, weighing, and analyzing the excrements, the undigested portion, and subtracting the latter from the former. The following examples will serve for illustration:

In the stables of the station at Weende, under the direction of Professor Henneberg, two full-grown oxen were fed during one period of about two weeks with oat straw, during another period with bean straw, a third with clover hay, a fourth with meadow hay, and so on. During some of these periods a small amount of bean meal was added. The ration was at all times such as to keep the animals in fair and uniform condition. Careful weighings and analyses were made of fodder and excrement, that is to say, of the total and the undigested material, and from these the digestibility of the food was calculated. For instance, in one of the experiments of this series the ox consumed daily 16.9 pounds of meadow hay, or what is called here "English grasses."

There was contained in—	Organic dry substance.	Consisting of—		
		Albuminoids.	Crude fiber.	Other carbohydrates.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
16.9 pounds of meadow hay	14.27	2.12	3.80	6.48
Excrement from same	6.33	.77	1.63	2.06
There was then digested	7.94	1.35	2.17	4.42

In another experiment the daily ration consisted of 17.87 pounds of oat straw, and 1.82 pounds bean meal.

There was contained in—	Organic dry substance.	Consisting of—		
		Albuminoids.	Crude fiber.	Other carbohydrates.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
17.87 pounds of oat-straw	14.27	1.12	6.41	6.74
Of this was digested	7.10	.58	3.64	2.88

The first digestion experiments were made some twenty years ago by Henneberg and Stohman, in the experiment station at Weende in Hanover. Their example has been followed in other places. Four years ago the number of digestion experiments amounted to over one thousand, and they have been increasing rapidly in numbers every year since then. These experiments, each one of which has been conducted with an amount of labor and exactness never equaled by a single experiment in this country, have led to many very interesting and weighty results.

What is essential to economy in feeding.—Albuminoids and carbohydrates.

317. The following are among the most important for our present purpose:

1st. Poor foods, like marsh-hay, late-cut hay, straw, cornstalks, and chaff, contain good percentages of digestible material. Their low feeding value is due, not to their lack of nutritive substance, but to its poverty in nitrogen. By adding to them concentrated foods rich in nitrogen, like oil-cake, cotton-seed, bean and pea meal, or nitrogenous animal matters, such as meat scrap and fish, rations are made equal in every respect to the best grass, young-cut hay, or grain.

2d. The digestion of foods, particularly of mixed rations, depends upon the proportions of its constituents. With too little nitrogen the digestion is incomplete. Adding concentrated foods rich in nitrogen to coarse foods promotes digestion. Excess of carbohydrates decreases it. Oil-cake, meat scrap, or fish added to poor hay or straw secures the most complete digestion of the whole ration. But if potatoes or other starchy food are used in considerable quantity the less of the coarse food will be digested.

There is still another principle of great importance to be noted. Well-manured plants are much richer in albuminoids than poorly manured. Bountiful fertilizing not only increases the quantity of the crop but improves its quality also.

The farmer who keeps his land in good condition gets larger yields; the produce contains more digestible substance for his stock, and the nutritive material is richer in the most valuable ingredients of all, the albuminoids.

Composition and valuations of various food materials.—German tables.

318. Fuller details and tables illustrating the principles here presented, may be found in a series of articles on science applied to farming, in the "American Agriculturist" for 1874–'76, and in a lecture on "The Results of Late European Experiments on the Feeding of Cattle," in the report of the Connecticut Board of Agriculture for 1874. A briefer statement of the subject is given by Prof. S. W. Johnson in the report of the Connecticut Agricultural Experiment Station for 1877. This latter contains a table which is interesting as including, with German analyses and valuations, some analyses of American products; with the rest, two samples of fish-scrap. The table is explained by Professor Johnson as follows:

"The following table of the composition, content of digestible nutritive ingredients, and money value of a few of the most important feeding-stuffs, is taken from the German of Dr. Emil Wolff, of the Agricultural Academy at Hohenheim, and represents the most recent and most trustworthy knowledge on these subjects.*

"The composition of feeding-stuffs, as here stated, is the average result of the numerous analyses that have been made within twenty-five years, mostly in the German experiment stations.

"The quantities of digestible ingredients are partly derived from actual feeding experiments and are partly the result of calculation and comparison.

"The percentages of the three classes of digestible matters, viz, albuminoids, carbohydrates, and fat, form the basis for calculating the money value of feeding-stuffs. The values attached to them by Dr. Wolff are the following, the German mark being considered as equal to 24 cents, and the kilogram equal to 2.2 pounds avoirdupois:

"1 pound of digestible albuminoids is worth $4\frac{1}{3}$ cents.

"1 pound of digestible fat is worth $4\frac{1}{3}$ cents.

"1 pound of digestible carbohydrates is worth $\frac{9}{10}$ of a cent.

"These figures express the present relative money values of the respective food-elements in the German markets. Whether or not these values are absolutely those of our markets, they represent presumably the *relative* values of these elements approximately, and we may provisionally employ them for the purpose of comparing together our feeding-stuffs in respect to money value. These money or market values are to a degree independent of the feeding values. That is, if of two kinds of food, for example Hungarian hay and malt sprouts, the one sums up a value of $0.66 and the other a value of $1.31 per hundred, it does not follow that the latter is worth for all purposes of feeding twice as much as the former, but it is meant that when both are properly used, one is worth twice as much money as the other. In fertilizers we estimate the nitrogen of ammonia salts at 24 cents per pound, and solu-

* From "*Mentzel u. Lengerke's Kalender*," for 1878.

ble phosphoric acid at 12½ cents; but this means simply that these are equitable market prices for these articles, not that nitrogen is worth twice as much as soluble phosphoric acid for making crops. In the future more exact valuations may be obtained from an extensive review of the resources of our markets, in connection with the results of analyses of the feed and fodder consumed on our farms.

"The column headed 'Nutritive ratio' in the table gives the proportion of digestible albuminoids to digestible carbohydrates, inclusive of fat.* * * * To allow of directly comparing the money value of feeding-stuffs with some universally accepted standard, the last column gives a comparison with good average meadow hay taken as 1."

Average composition, digestibility, and money value of feeding-stuffs, as given by Dr. Wolff for Germany for* 1878.

Feeding-stuffs.	Water.	Ash.	Albuminoids.	Fiber.	Carbohydrates.	Fat.	Digestible matters.			Nutritive ratio.	Money value.	
							Albuminoids.	Carbohydrates.	Fat.		Dollars per 100 pounds.	Comparison with meadow hay=1.
Meadow hay, inferior	14.3	5.0	7.5	33.5	38.2	1.5	3.4	34.9	0.5	10.6	0.48	0.74
Meadow hay, better	14.3	5.4	9.2	29.2	39.7	2.0	4.6	36.4	0.6	8.3	0.55	0.86
Meadow hay, average	14.3	6.2	9.7	26.3	41.4	2.5	5.4	41.0	1.0	8.0	0.64	1.00
Meadow hay, very good	15.0	7.0	11.7	21.9	41.6	2.8	7.4	41.7	1.3	6.1	0.74	1.17
Clover hay, extra	16.0	7.7	13.5	19.3	40.4	3.0	9.2	42.8	1.5	5.1	0.84	1.32
Clover hay, average	16.0	5.3	12.3	26.0	38.2	2.2	7.0	38.1	1.2	5.9	0.69	1.08
Clover hay, best	16.5	7.0	15.3	22.2	35.8	3.2	10.7	37.6	2.1	4.0	0.88	1.39
Timothy hay	14.3	4.5	9.7	32.7	45.8	3.0	5.8	43.4	1.4	8.1	0.69	1.09
Hungarian hay	13.4	5.7	10.8	29.4	38.5	2.2	6.1	41.0	0.9	7.1	0.66	1.04
Rye straw	14.3	4.1	3.0	44.0	33.3	1.3	0.8	36.5	0.4	46.9	0.35	0.55
Oat straw	14.3	4.0	4.0	39.5	36.2	2.0	1.4	40.1	0.7	29.9	0.44	0.69
Rich pasture grass	78.2	2.2	4.5	4.0	10.1	1.0	3.4	10.9	0.6	3.6	0.27	0.42
Average meadow grass, fresh	70.0	2.1	3.4	10.1	13.4	1.0	1.9	14.2	0.5	8.1	0.22	.36
Green maize, German	85.0	1.0	1.2	4.7	7.6	0.5	0.7	7.4	0.2	11.3	.10	.16
Green maize, Mr. Webb, 1874	86.0	0.8	0.8	4.8	7.3	0.3	0.6	8.3	0.2	14.4	.11	.17
Cured maize fodder, Mr. Webb	27.3	4.2	4.4	25.0	37.9	1.3	3.2	43.4	1.0	14.4	.57	.91
Potatoes	75.0	0.9	2.1	1.1	20.7	0.2	2.1	21.8	0.2	10.6	.29	.46
Mangolds	88.0	0.8	1.1	0.9	9.1	0.1	1.1	10.0	0.1	9.3	.14	.22
Rutabagas	87.0	1.0	1.3	1.1	9.5	0.1	1.3	10.6	0.1	8.3	.15	.24
Sugar beets	81.5	0.7	1.0	1.3	15.4	0.1	1.0	16.7	0.1	17.0	.19	.30
Maize, German	14.4	1.5	10.0	5.5	62.1	6.5	8.4	60.6	4.8	8.6	1.10	1.73
Maize meal, American, II	12.9	1.2	8.7	1.8	71.9	3.5	7.3	68.3	2.6	10.2	1.04	1.69
Oats	14.3	2.7	12.0	9.3	55.7	6.0	9.0	13.5	4.7	6.1	.97	1.53
Malt sprouts	10.1	7.2	24.3	14.3	42.1	2.1	19.4	45.0	1.7	2.5	1.31	2.06
Wheat bran, coarse	12.9	6.6	15.0	10.1	52.2	3.2	12.6	42.6	2.6	3.9	1.04	1.63
Wheat bran, fine	13.1	5.4	14.0	8.7	55.0	3.8	11.8	14.3	3.0	4.4	1.03	1.62
Middlings	11.5	3.0	13.9	4.8	63.5	3.3	10.8	54.0	2.9	5.7	1.07	1.68
Cotton-seed cake decorticated	11.2	7.6	38.8	9.2	19.5	13.7	31.0	18.3	12.3	1.6	2.05	3.23
Fish-scrap, by Goodale's process	11.5	....	64.0	.....	.....	4.6	57.6	.....	4.1	0.2	2.67	4.17
Fish-scrap, dry ground	11.7	..	51.5	.....	.....	8.1	46.4	.....	6.2	0.3	2.28	3.56
Dried blood	12.0	4.1	80.8	.....	2.6	0.5	54.1	2.6	0.5	.....	2.39	3.76
Whey	92.6	0.7	1.0	.....	5.1	0.6	1.0	5.1	0.6	6.6	.11	.18
Milk	87.5	0.7	3.2	.....	5.0	3.6	3.2	5.0	3.6	4.4	.34	.53

*Except those in italics, which are American products analyzed under direction of Professor Johnson.

Comparing the poorer foods, such as straw, cornstalks, and inferior hay with a good standard food like the best hay or pasture grass, it appears that the great difference is that the former lack albuminoids, just what bran, oil cake, cottonseed cake, and especially fish, supply. One

* Fat and carbohydrates have, it is believed, similar nutritive functions, and it is assumed that 1 part of fat equals 2.4 of carbohydrates.

hundred pounds of the fish scrap made by Goodale's process added to 900 lbs. of the poorest hay would make a mixture equal in composition to 1,000 pounds of the best hay. Three hundred pounds of the same fish-food with 1,700 lbs. of oat straw would be equal to a ton of the best hay.

It is clear, then, that what our farming wants, to make stock-raising profitable, manure plenty and rich, and crops large and nutritious, is nitrogenous material for foods.

One of the cheapest, most useful, and best forms in which this can be furnished is in fish products. In proof of this we have the testimony of both extensive experience and accurate experimenting.

Experience in use of fish as food for stock.—Feeding cattle on fish in Massachusetts.

319. The earliest account which I have met of fish as food for domestic animals is the following extract from the Barnstable [Mass.] "Journal," of February 7, 1833:

"*Feeding cattle on fish.*—The cattle at Provincetown feed upon fish with apparently as good relish as upon the best kinds of fodder. It is said that some cows, kept there several years, will, when grain and fish are placed before them at the same time, prefer the later, eating the whole of the fish before they touch the grain. Like one of old, we were rather incredulous on this subject, till we had the evidence of ocular demonstration. We have seen the cows at that place boldly enter the surf, in pursuit of the offals thrown from the fish-boats on the shore, and when obtained, masticate and swallow every part except the hardest bones. A Provincetown cow will dissect the head of a cod with wonderful celerity. She places one foot upon a part of it, and with her teeth tears off the skin and gristly parts, and in a few moments nothing is left but the bones."

The inhabitants of Provincetown are not the only people who feed their cattle upon fish. The nations of the Coromandel coast, as well as in the other parts of the East, practice feeding their flocks and herds with fish. The celebrated traveler, Ibu Batuta, who visited Zafar, the most easterly city in Yemen, in the early part of the fourteenth century, says that the inhabitants of that city carried on a great trade in horses in India, and at that period fed their flocks and herds with fish, a practice which he says he had nowhere else observed.

Experiment of Mr. Lawes, in England, with fish as food for swine.

320. In 1853 Mr. J. B. Lawes, of Rothamshead, England, reported several extensive series of experiments "On the Feeding of Pigs," in which were tested the effects of bean, lentil, Indian corn, and barley meals, bran, and dried Newfoundland codfish as foods for fattening and making manure. In speaking of the series in which the fish was fed with maize, barley, and bran in different proportions, Mr. Lawes says:

"In the series * * * where we have * * * a comparatively

small amount of non-nitrogenous matter consumed, the food consisted in a large proportion of the highly nitrogenous codfish; and in both of these cases we had not only a very good proportion of increase to food consumed, but the pigs in these pens were very fat and well ripened; and hence a large proportion of their increase would be real dry substance. * * * This result is in itself interesting, and it may perhaps point to a comparatively greater efficiency in the already animalized proteine compounds supplied in the codfish than in those derived, as in the other cases, from the purely vegetable diets."*

Other European experience.

321. In 1856 Professor Stoeckhardt, of Tharand, Saxony, who was one of the first chemists to recognize the value of fish guano, and has done more than any other one in Europe to encourage its manufacture and use, received a sample from Norway, which, as he says, "looked so inviting that I tried it for fodder also." He fed it to a half-year-old pig, which "did exceptionally well on this northern food."

In the northern part of Norway, when during the long winters the supply of hay and straw gives out, cattle are fed upon dried fish. They do poorly on this diet alone, of course, but recover very quickly when the spring pasturage comes.†

Success of Maine farmers in feeding fish to sheep.

322. The value of fish as food for domestic animals has been attested by experience of intelligent farmers in our own country, as is illustrated by the following extracts from Boardman and Atkins' report, from which so many quotations have already been made:

"As early as 1864, if not in fact previous to that date, the attention of members of the board of agriculture [of Maine], and farmers generally, was called to the matter of the value of fish pomace or scrap as a feeding stuff for sheep, swine, and poultry. In a communication to the board‡ Mr. William D. Dana, of Perry, spoke in high terms of its value as a feed for domestic animals, in which he said: 'Fish pomace, or the residuum of herring after the oil is pressed out, is greedily eaten by sheep, swine, and fowl; and probably pogy chum would be eaten as well. Smoked alewives and frost fish also furnish a food palatable to cattle. Sheep thrive well, get fat, and yield heavier fleeces when fed on this pomace than when fed on anything else produced in this section of the State. Careful and observing farmers, who have fed it, assert that it is of equal value with good hay, ton per ton, and that its value for manure is in no degree diminished by passing it through the living mill, and thus reducing it to a much more convenient state for applying. It it could be sufficiently dried, without other substances, to prevent putre-

* Jour. Roy. Ag. Soc., 1st Ser. XIV, 1853, p. 527.
† Meinert. Travels in Norway. Chem. Ack., 1870, xi, p. 45.
‡ Agriculture of Maine, 1864, p. 43.

faction, it would form a valuable article of cattle-feed in regions from which it is now excluded by the expense of transportation and its own odoriferous nature.'

"In remarking upon this the secretary of the board said that if sheep would eat the scrap readily, much poor hay or straw could be used to good advantage, thus allowing the farmer to consume all his first-quality hay in keeping other stock. He thought the meat would not taste of the flavor imparted by the scrap, provided other food was substituted for a proper length of time before slaughtering.

"From time to time following this, the matter was discussed before the board, and formed the subject of many articles in the agricultural journals. In 1869, Mr. M. L. Wilder,* of Pembroke, then a member of the board, presented a brief paper embodying his experience in the use of scrap as a feed for sheep, in which he said he believed 'fish offal to be not only cheaper, but much superior to any other kind of provender he had ever used' for this purpose. An extract from his paper is given: 'I keep about one hundred sheep, and have fed fish offal to them for the past ten years. The offal is made from herring caught in weirs, salted the same as for smoking, cooked, and the oil pressed out, leaving a pomace for which the sheep are more eager than for grain. For the last three winters I have kept my sheep on threshed straw with one-half pound per day to each sheep of dried fish pomace, or one pound of green (as it shrinks one-half in drying), and they came out in the spring in much better condition than when fed on good English hay with corn. I consider the dry pomace worth as much as corn, pound for pound. When I have had enough to give them one-half pound per day, I have found that the weight of the fleece was increased one-quarter, and not only that but also the carcass in a like proportion; the weight of the fleeces per head averaging from five to seven pounds.'

"Similar statements to the above were made by Hon. Samuel Wasson† and other gentlemen, not only at public meetings of the board, but through the press, so that the subject has been kept alive and invested with some interest down to the present time.

Experiments of Professor Farrington on fish scrap vs. corn meal as food for sheep.

"323. Wishing to test the value of scrap as a feed with more care than had apparently attended any of the trials that had been reported, and also wishing to make a sort of competitive trial of it in connection with corn, a quantity was obtained for this purpose of Mr. M. L. Wilder, of Pembroke. It was herring scrap, salted before the oil was expressed, and packed in barrels directly from the press, each barrel containing about 220 pounds. Its cost in Augusta, including freight from Pembroke via Portland, was not far from $2 per barrel.

*Agriculture of Maine, 1869, p. 60.

†Agriculture of Maine, 1874-'75, p. 1.

"This scrap was placed in the hands of Mr. J. R. Farrington, the instructor in agriculture at the State College, Orono, with the request that he would feed it to sheep in connection with Indian corn in such way as would best serve the purpose of ascertaining its comparative value as a provender or feed. Few instructions were given him, and he being left to carry out the experiment in his own way—and public acknowledgment should here be made for his interest in undertaking the matter, and for the care and faithfulness with which the experiment was conducted. The report of Mr. Farrington follows:

"'The statement made by a prominent agriculturist that for feeding sheep fish chum was equal to corn, pound for pound, furnished the basis for the experiment which we conducted to ascertain the comparative value of corn and fish chum when fed to sheep. Ten lambs, dropped the previous spring, were selected; each one was designated by a number, the number being stamped on a metallic tag and attached by a copper wire to the ear of the lamb; Nos. 1, 2, 3, 4, and 5 constituted flock 1; Nos. 6, 7, 8, 9, and 10, flock 2. We began feeding January 15, 1875. Flock No. 1 was fed with corn; flock No. 2 was fed with fish. Each flock was given what good hay it would eat. The hay fed to each flock during the month (four weeks) beginning February 13 was weighed. Flock No. 1 ate, in four weeks, 335 pounds; flock No. 2 ate 338 pounds.

"'At commencement of feeding, January 15, 1875:

Flock No. 1 weighed as follows:

Sheep No. 1 weighed	46	lbs.
" 2 "	77	"
" 3 "	67	"
" 4 "	55	"
" 5 "	68	"
Weight of flock, Jan. 15	313	"

Flock No. 2 weighed as follows:

Sheep No. 6 weighed	49	lbs.
" 7 "	74	"
" 8 "	68½	"
" 9 "	67	"
" 10 "	58	"
Weight of flock, Jan. 15	316½	"

During four weeks ending February 13, 19½ pounds of corn were fed to flock No. 1. At this date—

Sheep No. 1 weighed	50	lbs., a gain of	4	lbs.
" 2 "	81½	"	4½	"
" 3 "	73	"	6	"
" 4 "	59	"	4	"
" 5 "	77	"	9	"
Weight, February 13	340½	"	27½	"

During four weeks ending February 13, 18¼ pounds of fish were fed to flock No. 2. At this date—

Sheep No. 6 weighed	52	lbs., a gain of	3	lbs.
" 7 "	81	"	7	"
" 8 "	72½	"	4	"
" 9 "	68	"	1	"
" 10 "	64½	"	6½	"
Weight, February 13	338	"	21½	"

During four weeks ending March 12, 20 pounds of corn and 335 pounds of hay were fed flock No. 1. At this date—

Sheep No. 1 weighed	50½	lbs., a gain of	½	lbs.
" 2 "	75½	lbs., a loss of	6	"
" 3 "	69	"	4	"
" 4 "	56½	"	2½	"
" 5 "	70	"	7	"
Weight of flock	321½	"	19	"

During four weeks ending March 12, 20 pounds of fish and 338 lbs. of hay were fed flock No. 2. At this date—

Sheep No. 6 weighed	55½	lbs., a gain of	3½	lbs.
" 7 "	79	lbs., a loss of	2	"
" 8 "	71½	"	1	"
" 9 "	67½	"	½	"
" 10 "	63	"	1½	"
Weight of flock	330½	"	1½	"

During the above four weeks the *corn-fed flock*, weighing 340½ pounds, ate 335 pounds of hay and lost 19 pounds in weight. The flock eating fish, weighing 338 pounds, ate 338 pounds hay and lost 1½ pounds.

During four weeks ending April 9, 19 pounds corn were fed flock No. 1. At this date—

Sheep No. 1 weighed	51	lbs., a gain of	½	lbs.
" 2 "	76½	"	1	"
" 3 "	75½	"	6½	"
" 4 "	64½	"	8	"
" 5 "	78½	"	8½	"
Weight of flock	346	"	24½	"

During four weeks ending April 9, 19 pounds of fish were fed flock No. 2. At this date—

Sheep No. 6 weighed	62	lbs., a gain of	6½	lbs.
" 7 "	84	"	5	"
" 8 "	75	"	3½	"
" 9 "	71	"	3½	"
" 10 "	65	"	2	"
Weight of flock	357	"	20½	"

During four weeks ending May 7, 15 pounds of corn were fed flock No. 1. At this date—

Sheep No. 1 weighed.....	55 lbs.,	a gain of 4	lbs.
" 2 "	79 "	2½	"
" 3 "	80 "	4½	"
" 4 "	65 "	½	"
" 5 "	82 "	3½	"
Weight of flock.....	361 "	15	"

During four weeks ending May 7, 15 pounds of fish were fed flock No. 2. At this date—

Sheep No. 6 weighed.....	62 lbs.,	a gain of 0	lbs.
" 7 "	87 "	3	"
" 8 "	75 "	0	"
" 9 "	73 "	2	"
" 10 "	67 "	2	"
Weight of flock.....	364 "	7	"

Recapitulation.—During the sixteen weeks of the experiment—

Sheep No. 1 gained.....	9 lbs.	Sheep No. 6 gained.....	13 lbs.
" 2 "	2 "	" 7 "	13 "
" 3 "	13 "	" 8 "	6½ "
" 4 "	10 "	" 9 "	6 "
" 5 "	14 "	" 10 "	6 "
Flock No. 1 gained.....	48 "	Flock No. 2 gained.....	47½ "
Fed with corn—weighing, January 15, 313 pounds. Gained 48 pounds, or 15½ per cent.		On fish—weighing, January 15, 316½ pounds. Gained 47½ pounds, or 15 1/19 per cent.	

That is to say, the corn-fed flock gained 48 pounds, and the fish-fed flock 47½ pounds during the sixteen weeks of the experiment.

Professor Farrington has courteously favored me with some further, but as yet unpublished, details of his experiments. The fish scrap from herring was unground and some of the fragments were rather coarse. It was hard to get the sheep to eat much of the fish, though they gradually learned to like it better. This accounts for the very small quantity consumed.

A second trial similar to the above was made the succeeding winter, and with like results, except that the sheep ate rather more of the fish. In one case a flock of four consumed 28 pounds in four weeks, which is equivalent to 4 ounces per head per day, while in the above series they averaged only about 2 ounces per head per day. The meal was regulated by the amount of fish consumed. The quantities of both were thus extremely small. It is to be noted, however, that the sheep had "all the good hay they would eat." The fish was distasteful, and they took very little. If they had received a fixed quantity of staw, cornstalks, or poor hay, instead of good hay *ad libitum*, they could doubtless have been got to eat more fish, and would probably have learned to like it.

Mr. Wilder, of Pembroke, whose statements were quoted above, and who furnished the scrap for Professor Farrington's experiments, "keeps about one hundred sheep * * * on threshed straw with one-half pound per day to each sheep of dried fish pomace * *, for which the sheep are more eager than they are for grain * * *, and they come out in the spring much better than when fed on good English hay with corn."

Professor Farrington agrees with me in the opinion, indeed the experience of farmers who have fed fish successfully leaves room for no other, and the European experimenters quoted below say the same thing, that sheep, swine, and probably neat cattle, can be taught to eat fish, and when once wonted to it will take it with excellent relish.

A dry, well-prepared, and finely-groupd product, such as may be made by the Goodale or other processes, would doubtless keep better, be more free from offensive odor and taste, and worth much more for feeding than the ordinary scrap.

European experiments on digestion and nutritive value of fish, meat-scrap, etc.

324. The need and value of nitrogenous foods for food mixtures, explained and attested by science and confirmed by experience in Europe, has led to diligent seeking, careful trial, and rational use of available foods from every source. Of late a great deal of attention has been paid to animal products. The flesh meal left from the preparation of "Liebig's Meat Extract" in South America, the dried blood of slaughter-houses, and fish guano have all been tested and found extremely valuable.

The scope of the present article precludes details of the experiments on the digestibility and nutritive value of animal foods for stock; I therefore reserve them for a future occasion, and note briefly here some of the main results.

The following are among the experiments of this sort reported in the years 1876 and 1877. The original accounts are in "Die landwirthschaftlichen Versuchs-Stationen," the "Journal für Landwirthschaft," and the "Landwirthschaftliche Jahrbücher" for those years:

Experimenters.	Experiment stations.	Animals.	Food.
I. Wolff, and associates	Hohenheim	Swine	South American flesh meal and potatoes.
II. Wolff, and associates	do	do	Flesh meal, pea meal, potatoes, and starch.
III. Wildt	Kuschen	Sheep	Blood meal, flesh meal, and barley straw.
IV. Wildt	do	Swine	Blood meal, pease, and potatoes.
V. Weiske, and associates	Proskau	Sheep	Fish guano.
VI. Kellner, and associates	Hohenheim	do	Fish guano, Lucern hay, and oatmeal.

The general plan of each of these experiments was to feed the animals during different periods of two or three weeks each with different foods and mixtures, and to note, by careful weighings and analyses of foods and excrements, the amounts digested. The most prominent of the questions has been the comparative digestibility and nutritive value of vegetable and animal albuminoids. As a general result the albuminoids and fats of meat, blood, and fish are found to be as digestible or more so than those of the most concentrated vegetable foods.

In I, Wolff found swine to digest from albuminoids 92 parts and fats 97 parts out of every 100 parts of each in the flesh meal, and concludes that flesh meal is an easily digested and intensely nutritious food.

In II, Wolff found that the albuminoids in pease and fleshmeal had essentially the same effect.

From III, Wildt found some difficulty in getting sheep to eat the blood and flesh. He says that potatoes and roots will help to make the flesh and blood palatable, and thinks that these may be used with profit to supply albuminoids to herbivorous animals.

From IV, Wildt concludes that animal albuminoids may serve just as well as vegetable for supplying nitrogen to foods poor in albuminoids.

From V and VI, Weiske and Kellner conclude that fish guano, like meat and blood, may be fed with profit to herbivorous animals. In Kellner's experiment two two-year old wethers were fed during the first period with Lucern hay. During the second part the hay was replaced by

oatmeal, and during the third Norwegian fish guano was added to the ration of the second period. At first the animals did not like the fish, but on mixing it well with the oatmeal they accepted it more readily. At the close of the experiment they had got to liking the guano so much as to eat it greedily with no admixture of other foods. They digested on average of two experiments 90 per cent. of the albuminoids and 76 per cent. of the fat of the guano. Concerning the nitrogenous matter of the bone, Kellner made the same observation as has been previously noted, namely, that it was quite rapidly digestible. It is particularly worthy of remark that the Norwegian fish guano which was used in this experiment had 9.44 per cent. nitrogen and no less than 15.77 per cent. phosphoric acid, and only 2.11 per cent. fat. That is, it had more bone than our fish guano. This is because it is made not of the whole fish, but of the refuse heads, entrails, and bones. The most of the fat had been removed by the steaming process used in preparation of the guano.

General conclusions concerning fish as food for domestic animals.

325. On the whole, then, these experiments bear unanimous and convincing testimony in favor of the easy digestibility and high nutritive value of animal foods in general and of fish guano in particular when fed to sheep and swine.

How far they could be made profitable for other herbivorous animals than sheep has not yet been tested. In the nature of the case there is no reason why they should not be as nutritious for neat cattle as for sheep. As Voit has justly observed, all mammals are at one period of their lives, when living upon milk, carnivorous. Late investigations have shown very clearly that even plants are positively nourished by animal foods. The very interesting experiments of Mr. Francis Darwin with the round-leaved sundew demonstrate conclusively that plants may thrive on a meat diet.

In short, we have every reason, from practical experience, from actual experiment, and from what we know of the nature of the case, to believe that the immense amount of animal waste produced in this country from our slaughter-houses, and especially from our fisheries, can be utilized with the greatest ease and profit to supply the most pressing need of a most important part of our agriculture, nitrogenous food for stock.

We have seen that farmers in New England and in Europe have found fish good for their stock, that occasionally one like Mr. Wilder has hit upon a rational way of using it to piece out and improve the poorer products of their farms, and that patient research has explained why it is useful and how it may be made more so. This is one of the countless cases where practical men have worked their way in the dark by the tortuous path of experience to the same results to which scientific investigation leads. But here as ever the results when found need the light of science to explain the facts and make it possible to apply them most profitably.

53. SUMMARY.

Fish as manure.

326. The following is a brief recapitulation of the main points urged in this article:

1. The value of fish as manure is due mainly to its nitrogen and phosphoric acid.

2. Taking into account composition, quality, and price, fish manures furnish these ingredients more cheaply than any other class of fertilizers in the market except Peruvian guanos.

3. The crops most benefited by fish manures are those which need considerable nitrogen and phosphoric acid, but are not especially helped by mineral manures alone. Such are grass, grain, and corn. The same is generally true of potatoes and garden vegetables, and sometimes of roots. Leguminous crops, like clover, beans, and pease, are more benefited by mineral manures, and get little good from the nitrogen of the fish.

4. Fish manures are quick and stimulating in their action. Their force is soon spent and they often leave the soil in worse condition than before they were applied. This is, however, no argument against their value. The remedy for such cases is to apply other materials, as ashes, lime, potash salts, dung, muck, etc., with them.

5. The proper soils for fish manures are those which are deficient in nitrogen and phosphoric acid, and in which the stimulating effect of the decomposition of fish may render other materials available for plant food. Soils that have been treated repeatedly with fish, guano, phosphates, and bone are often overstocked with these ingredients and deficient in potash. Many soils are originally poor in potash. To apply fish on such soils and omit the lacking elements is to lose both fertilizer and crop. The deficiencies of a given soil are best told by actual trial, with different manures and crops.

6. The general usefulness of fish manures will be increased by adding to them phosphoric acid, in the form of bone or superphosphates, and potash in German potash salts. Fine steamed bone, that can be bought for $32 to $45 per ton, or "plain" superphosphates, made from South Carolina or Canada phosphates, and sold at $30 to $32 per ton, are economical sources of phosphoric acid. The "50 per cent. muriate," sold at about $40 per ton, is one of the cheapest grades of potash salts. Of the "ammoniated" superphosphates, a very few of the best brands are sold at cheaper rates than it would cost the farmer to make them. But instead of buying medium and inferior articles, farmers will do better to buy the materials and mix them at home.

7. The best form of fish manures is the dry-ground fish guano freed from oil. The water and oil add weight and bulk without increasing value. The coarse fish-scrap cannot be thoroughly spread, is not easily diffused by the water in the soil, is reached by few roots, and becomes slowly

available to the roots that find it. But the fine dry fish is easily spread, is diffused by rain, is thus made accessible to a large number of roots, and can be absorbed by them when they reach it.

8. The ingredients of fish may be made more available for plant-food and their value for manure increased by—

a. Fermentation with urine.

b. Composting with muck, earth, ashes, lime, bone, potash salts, and farm-refuse of all sorts.

c. Feeding to stock, thus putting it through a process similar to that by which Peruvian guano has been formed. In this way it can be used to enrich the manure made on the farm, and thus made one of the best aids to successful farming.

Fish as food for stock.

9. The chief defect of our fodder materials as a whole is their lack of nitrogen. From poor manuring our crops are not only small in quantity, but poor in quality. They lack nitrogen. This is true of our forage crops in general, and of poor hay, straw, and corn-stalks in particular. What our farming most wants, to make stock-feeding profitable, manure plenty and rich, and crops large and nutritious, is nitrogen.

10. One of the cheapest, most useful, and best forms in which this can be furnished is in fish products. These have been found very profitable for feeding in Europe. Our fish guanos are better than the European for this purpose, because they have more flesh and less bone.

The loss to our agriculture from waste of fish.—The evil.

11. Millions of pounds of fish not fit for human food are allowed every year to escape from nets into the sea, which, if saved and rightly utilized, would be worth untold sums for fertilizers and feeding materials.

12. Of the fish saved and used for fertilizers, a large portion is ill-prepared.

13. A large part of that which is well made is exported to Europe, where its value is better understood, and its use is more rational and profitable.

14. A great deal of the fish manure that gets into farmers' hands, be it well or ill prepared, is wasted by wrong application, and by use where it does not fit the needs of crop and soil.

15. A still greater loss comes from the neglect to use fish as food for domestic animals.

16. The total loss to our agriculture from all these sources is not capable of accurate computation, but amounts certainly to hundreds of thousands, and doubtless millions of dollars annually.

The remedy.

17. As the main source of the evil is ignorance, the chief reliance for cure must be in better understanding of the facts and the ways to improve.

18. The needed knowledge can be gained from two sources. The results of European experience and experimenting will be one; experiments and investigations of our own products in our own laboratories, fields, and stables, another. The knowledge once obtained and set forth in detailed reports will, in the natural course of things, be condensed and diffused through the agricultural press, and applied by manufacturers and farmers, to the great benefit of all.

19. The compilation of results of foreign work can be made by reference to the numerous German, French, and English scientific and agricultural journals through which the original memoirs are scattered.

20. The investigations would be properly divided into those on fish as manure and those on fish as food for animals.

21. The experiments on fish as manures would probably be made—

1. In the laboratory, and consist of: *a*, analyses of fish products; *b*, investigations on their changes in composition and action in the soil.
2. In the field, and consist of rationally planned and carefully conducted trials with different fertilizing materials, including fish manures, on different soils and with different crops, in order to obtain specific answers to specific questions whose solution is important.

22. The experiments on fish as food for stock should be made—

1. On farms, by feeding out fish with ordinary foods in simple ways, as was done by Professor Farrington at the Maine State College.
2. In stables fitted up for trials with simultaneous laboratory work, on the plan of the European experiments, above described. The object of these trials would be to determine the digestibility and nutritive effect of the materials employed.

The urgent need of popular instruction.

327. Here is a case where men with the best intentions in the world, fishermen, manufacturers, and farmers, are suffering the waste of thousands, and even millions of dollars' worth of material, bitterly needed to supply the wants of worn-out soils and make bread and meat for hungry men. The first step toward stopping this must be the getting of information. In Europe, governments, agricultural schools, societies, and experiment stations would, in fact do, grapple the questions, and with the best talent, aided by the best appliances that ingenuity, enthusiasm, and money can procure, work at them until they are solved. But here, we shall not get the needed knowledge until some educational institution, experiment station, or other agency, takes hold of the work with a will and put it through.