I.—REPORT ON THE CONSTRUCTION AND WORK IN 1880 OF THE FISH COMMISSION STEAMER FISH-HAWK.

By LIEUTENANT Z. L. TANNER, U. S. N., Commanding.

The U. S. S. Speedwell was put out of commission at meridian October 24, 1879, and I received orders on the same day to report to Prof. S. F. Baird, United States Commissioner of Fish and Fisheries, for duty connected with the construction of the steamer Fish Hawk building at the establishment of the Pusey and Jones Company, Wilmington, Del. The vessel was designed by Charles W. Copeland, consulting engineer of the Light House Board, and constructed under the supervision of the board.

I arrived at Wilmington on the 29th and found the iron hull practically completed and a portion of the wooden sheathing on. The wood-work was well advanced above the main deck, and lumber for the joiner's work dressed and prepared for putting up.

The engines were approaching completion, the boiler well advanced, and at high water, December 13, the vessel was successfully launched. The trial trip took place February 19, 1880, with the following results:

Course—Down the Delaware River from mouth of Christiana Creek and return.

Duration of trial	6 hours.
Total distance	54. 9 knots.
Average speed per hour	9. 15 knots.
Pitch of screw	12 feet 3 inches.
Average revolutions per minute	89. 77.
Average revolutions per mile	574. 2.
Average slip, per cent	15. 6.
Average steam	28 pounds.
Average vacuum	21 inches.
Ship's draft forward	5 feet 9 inches.
Ship's draft aft	7 feet 2 inches.
Mean draft	6 feet 5½ inches.

The engines were not stopped nor the throttle-valve moved during the trial, everything working satisfactorily, and though the contract called for a sea trial of twelve hours, it was not considered necessary to extend it to that time.

Cadet Engineer William B. Boggs was ordered to special duty in connection with the construction of machinery about the middle of December, 1879, and has been on duty since that time.

The builders completed their contract February 23, 1880, and the ship was turned over to the commission, but remained at the works awaiting her outfit. This depended upon a deficiency appropriation not yet passed, and which did not, in fact, become available until June 2.

I received orders from the Navy Department to assume command of the vessel on the 12th of March, 1880, and reported to Professor Baird for that duty on the above date.

The months of June and July were occupied in procuring the vessel's outfit and in the construction of her fish-hatching machinery.

Mate James A. Smith was ordered to report as executive officer, and Assistant Engineer William B. Boggs in charge of engines, on the 4th of June. Passed Assistant Paymaster George H. Read was ordered to the ship June 12, and Dr. F. C. Van Vliet joined the vessel on June 14, as medical officer.

The general description of the vessel is as follows (see Plate):

	Feet.	In.
Length from rabbet to rabbet on 7 feet water-line	146	6
Length over all	156	6
Breadth of beam moulded	27	00
Depth of hold amidships	10	9
Shear forward	4	4
Shear aft	1	9

The vessel's rig is a fore-and-aft schooner with pole topmasts.

The hull below the main deck is of iron, built on Lloyd's rules for vessels of her class, and sheathed with yellow pine, from 2½ to 3 inches in thickness, calked and coppered. Above the main deck the structure is of wood. She has a promenade deck extending from stem to stern, and from side to side, covered with canvas, on which are located the pilot house, captain's quarters, and laboratory.

There are five iron bulk-heads: the collision bulk-head about 20 feet from the stem, No. 2 forward of the boiler, No. 3 between the boiler and engines, No. 4 abaft the engines, and No. 5 about 9 feet from the stern rabbet, all water-tight except No. 3.

In the hold forward of the collision bulk-head, on a platform raised about 5 feet above the keelson, is the boatswain's store-room. Abaft the bulk-head, extending aft about 10 feet, are the ice-houses, one on each side of a central passage 3 feet in width. The bulk-heads are double, with an air space of 4 inches, which is filled with sawdust, the whole interior lined with sheet tin soldered and well secured, and a lead drain-pipe in the after outboard corner of each. They have two entrances, one through a door in the central passage and another through a scuttle in the main deck.

The chain-lockers are under the ice-houses and extend across the hold, a bulk-head amidships separating the starboard from the port chain. They are entered through a scuttle in the central passage above mentioned.

Abaft the houses are six store-rooms, three on each side, on an extension of the floor platform, with a central passage 4 feet 3 inches in width. The laboratory store-rooms are forward, one on each side, 4 feet wide fore and aft, with shelves for the reception of specimens. Abaft this, on the port side, is the navigation and equipment store-room, 9 feet 4 inches fore and aft, and abaft this the sail-room, 4 feet wide. On the starboard side, abaft the laboratory store-room, is the paymaster's store-room, 9 feet 4 inches wide, and abaft this the bread-room, 4 feet in width, lined with sheet tin.

Next aft is the steerage, extending 15 feet fore and aft. There is a state-room in the after end, on each side, two bunks in the starboard and one in the port room; forward of the rooms are two open bunks on each side, a pantry on the starboard side forward, and a wash-stand on the port side.

The rooms are carpeted, and are furnished with bureaus, wash-stands, lamps, &c.; the steerage country has an oil cloth on the floor, a hanging lamp, extension table, chairs, steam heater, &c. The entrance is at the forward end, amidships, by a ladder from the main deck.

Fore hold.—Under the steerage and store-rooms, extending 32 feet 6 inches abaft the chain-lockers, is the fore hold. The water-tanks, having a capacity of 800 gallons, are located at the after end, immediately forward of bulk-head No. 2.

Engine department.—Abaft the bulk-head, extending about 45 feet to bulk-head No. 4, is the space occupied by the boiler, coal-bunkers, fire-room, and engines.

Lower cabin.—Abaft the bulk-head, extending 26 feet, is the lower cabin, having seven open bunks on a side. The dispensary, wash-stand, and a wardrobe are in the forward end, amidships. The floor is covered with an oil cloth, and the apartment is furnished with lamps, extension table, chairs, &c.

Linen-room and pantry.—Abaft the cabin, on the starboard side, is the linen-room; and on the port side a pantry and store-room, 6 feet 6 inches in width fore and aft, extending to bulk-head No. 5.

The entrance to the lower cabin is aft, amidships.

Store-room.—Abaft the bulk-head, in the stern of the vessel, is a cabin store-room about 9 feet fore and aft, entered through a scuttle on the main deck.

Forecastle.—On the main-deck forward, extending 31 feet from the stern, is the forecastle, having fourteen bunks arranged in two tiers on the sides and after end.

The paint-locker is in the forward end; and the forward force-pump, windlass, compressors, and riding-bitts are located there. In the deck are the scuttles leading to the boatswain's store-room, the ice-houses and chain-lockers. The apartment contains two sliding tables, camp-stools, a swinging lamp, steam heater, &c.

There are two entrances, one through a door on the after end to the main deck, another by a ladder and booby-hatch to the promenade deck.

Water-closets.—The water-closets are abaft the forecastle on each side of the fore hatch.

Main or hatching deck.—The main or hatching deck extends 47 feet aft from the forecastle. The fore hatch is on the forward part of this deck; the foremast 5 feet abaft the hatch; the steerage companion way about 2 feet abaft the mast, and the lamp-locker abaft the companion way. The boiler hatch extends about 17 feet forward from the after bulk-head, is about 9 inches above the deck, and on it are placed the donkey-pump, distributing-tanks, and, attached to the beams overhead, are the cam-shaft and attachments for working the hatching-beams.

There are three coal-scuttles through the main deck on each side of the boiler hatch. A gangway port on each side abreast of the foremast, 6 feet wide, extending from deck to deck, and four swinging ports on each side 4 feet by 3 feet 4 inches, which can be opened or closed at pleasure.

The hatching machinery is located on the main deck each side and forward of the boiler hatch.

Donkey-boiler room.—There is a sliding door in the starboard side of the after main deck bulk-head, communicating with the donkey-boiler room, which extends 13 feet aft from the main deck.

The donkey boiler stands on the starboard side forward; the steam chimney amidships, and the galley, 8 feet 6 inches by 7 feet 6 inches, on the port side. The galley door is in the after bulk-head; there is a window on the side, and another forward, in the main-deck bulk-head. The floor is of brick laid in cement.

There is a cooking-range, coal-bunker, fresh-water pump connecting with the tanks, a sink and ample lockers, shelves, &c.

The distiller stands on the starboard side of the boiler hatch between the steam chimney and main-deck bulk-head. There is a ventilator, through which ashes are hoisted, in each after corner of the boiler hatch, and the deck between them and the engine-room bulk-head is composed of an iron grating, giving light and air to the fire-room. There is a vertical iron step-ladder attached to the engine-room bulk-head leading from the donkey-boiler room to the fire-room.

Engine-room.—The engine-room extends aft 11 feet from the donkey-boiler room, is 12 feet in width, and occupies the central part of the deck. There are two doors in the forward end opening into the donkey-boiler room; a door on the starboard after end into the cabin, and a stairway on the port after end communicating with the lower engine-room. The engines are worked from the upper engine-room.

Machinist's room.—The machinist's room is on the starboard side abreast of the engine-room; has a door opening to the donkey-boiler room, a large window in the side, and two bunks. Abaft this is a room (opening into the cabin) used for members of the scientific corps; it has two bunks, also, and a window in the side.

Passage.—There is a passage 2 feet 6 inches in width on the port side of the engine-room leading from the donkey-boiler room to the cabin.

Cabin pantry.—The cabin pantry is on the port side of the above passage, 11 feet fore and aft, and about 5 feet wide; there are two large windows on the side; a door opening into the passage; shelves; lockers; racks, and other necessary appliances for a pantry on ship board.

Cabin.—The cabin is abaft the engine-room, 30 feet in length, has four rooms on a side with one bunk in each. Aft on the starboard side is the Commissioner's office. The lower cabin companion way is amidships, and a bath room and closet on the port side. Between the latter and lower cabin companion way is a passage 2 feet 4 inches in width, leading from the cabin to the bath-room and after deck.

After deck.—The after deck above mentioned is 14 feet in length and extends to the stern. The sides are open above the main rail. The spare tiller and relieving tackles are on this deck. The cabin storeroom scuttle is forward of the rudder; the entrance to the Commissioner's office on the starboard side; the lower cabin companion way amidships; the entrance to the cabin passage on the port side, and just abaft the rudder the after force-pump.

Promenade deck.—On the promenade deck, forward of the foremast, are the anchors, forward force-pump, windlass brakes, capstan, forecastle booby-hatch, fore hatch, hoisting and reeling engine, and the dredging boom, its heel attached to the foremast.

Abaft the mast is a booby-hatch covering the entrance to the main deck, and abaft that the pilot-house and captain's quarters.

Pilot-house—The pilot-house is 8 feet in length fore and aft, 10 feet in width, and has an elliptical front. The glass windows and venetian blinds are hung with weights, and all metal work about it, or used in its construction, is brass.

There is a liquid steering compass on the port side forward of the wheel; a sofa, signal-locker, and convenient receptacles for fire-works and flags on the after end. The floor is covered with lignum and ash gratings. The necessary bells, speaking and sounding tubes, and whistle-rope are in their appropriate places.

The pilot-house is raised 26 inches above the captain's quarters; has a door on each side, the upper portion set with glass. There are also windows in the after end, giving an unobstructed view fore and aft, and a door on the starboard side communicating with the captain's room.

Captain's room.—The captain's room is in the deck-house, abaft the pilot-house, 9 feet 10 inches in length, fore and aft, 12 feet in width, 7 feet high, and has a sky-light 2 feet 6 inches by 3 feet 3 inches. There is a door and window on each side; a door opening into the pilot-house in the forward end and one into the bath-room aft. There is a folding bed, a sofa, writing-desk, marble-topped bureau, and book-case of black walnut. There are also drawers for charts, clothing, &c.

Bath-room.—The captain's bath-room, 6 feet 10 inches long and 4 feet 10 inches wide, is on the starboard side of the deck-house, abaft the captain's room, and communicates with it. A door on the starboard side opens on the promenade deck. The room has two windows, one on the starboard side and one in the after end; a bath-tub, wash-stand, mirror, &c.

There is a state-room on the port side of the deck-house, abaft the captain's room, 6 feet 10 inches in length, 7 feet wide; the sky-light extending over it. A door communicates with the bath-room, and another, on the port side, with the promenade deck. There is a window on the port side and one aft; a folding bed, a secretary-bureau, wash-stand, lamp, mirror, steam heater, &c., in the room. The funnel is about 2 feet abaft the deck-house, the engine-room sky-light abaft the funnel.

The laboratory.—The laboratory, 10 feet 7 inches in length, 9 feet 11 inches wide, and 7 feet 3 inches high, is abaft the engine-room sky-light, and covers the entrance to the cabin. It has a book-case, work-table, specimen case, box for microscope, and the necessary shelves and drawers. There are two windows on each side, two in the forward end, and one aft. The door is in the after end.

Abaft the laboratory is the mainmast, cabin skylight, standard compass, rudder head, tiller, &c.

Steering gear.—The steering gear consists of an iron tiller, secured to the rudder head on the promenade deck, with chains extending through sheaves on each quarter. Iron wire wheel ropes are led over small rollers on each side of the promenade deck, the after ends secured to chains and the forward ends to the after block of the sliding purchase, which consists of two single blocks, the fall leading over the barrel ot the wheel in the pilot-house.

Spars.—The vessel is schooner rigged, the foremast 49 feet in length above deck and 17 inches in diameter; mainmast 46 feet, and 14 inches in diameter; the poles 15 feet in length, the masts and poles in one stick. The fore-gaff 23 feet, and main-gaff 18½ feet in length, diameter 5 inches, main-boom 38 feet long and 8 inches in diameter.

Sails.—There are three sails, fore stay-sail, foresail, and mainsail, all of cotton canvas; the stay-sail of No. 2, the foresail and mainsail of No. 3.

Anchors and chains.—There are three anchors, the largest weighing 1,525 pounds, including the stock; one 846 pounds, and one 307 pounds, stocks included. Two chain cables, one ninety fathoms 1⅛ inches, the other 75 fathoms $\frac{15}{16}$ inch in diameter.

Boats.—The vessel has four boats; 1st, a steam cutter built by the Herreshoff Manufacturing Company, Bristol, R. I., 24 feet in length, 6 feet 9 inches beam and 3 feet 6 inches depth; weight, 2,900 pounds; capacity of coal bunkers, 560 pounds, sufficient for 28 hours' steaming at 6 knots per hour; a fresh-water tank holding 40 gallons of water, enough for six days' steaming; she has a keel condenser which receives the discharge from the cylinder and escape valve.

Both hull and machinery are constructed of the best material. Steam is raised in a few minutes, and when under banked fires requires no attention. She is an excellent sea-boat and has been of great service to this ship.

2d. A ten-oared cutter 24 feet 6 inches in length.

3d. A gig 26 feet 5 inches in length.

4th. A dingy 17 feet 6 inches in length.

She has also several flat-bottomed boats 18 feet in length, used for spawn taking.

Awnings and stanchions.—The promenade deck is covered with awnings fore and aft, supported by turned wooden stanchions.

ENGINES AND MACHINERY.

General description.—There are two propelling-screws, right and left handed, one under each counter; each screw driven by one inverted cylinder surface-condensing engine, 22-inch diameter of cylinder, and 27-inch stroke of piston. The two engines are fitted on one bed-plate; the surface condenser, common to both, is located between the engines and forms a part of the framing for them.

The center of the cylinder is about 49½ feet forward of the stern-post; the distance between the shafts being about 8 feet 8 inches. The engines are inclined towards the center line of the vessel, the cylinders at the upper end being about 36 inches from center to center athwartships. There is one overhead return-flue boiler 8½ feet diameter of waist and 21½ feet in length, with steam chimney 6 feet 2 inches diameter outside and 10½ feet high.

The water of condensation is supplied by an independent steam pump.

The valve-chests are on the forward side of the cylinders, main valves working by a link motion, the cut-off valve working on a separate face within the main steam chest and operating by a link, one end of which is connected to an eccentric and the other to a concentric disk on the main shaft.

The air-pumps are trunk-plunger pumps, driven by cranks on forward end of main shafts; the feed-pumps are driven from the same motion. The bilge-pump is independent.

Cylinders are 22 inches diameter and 27 inches stroke of piston; steam openings 2 inches wide by 14 inches in length; exhaust openings 3½ inches wide by 14 inches in length. All necessary lugs, flanges, nozzles, and lower cylinder head are cast with the cylinder, and all flanges faced. The lower ends are fitted with a small bonnet, with stuffing box and gland, both bushed with composition; also a composition "water valve" seven-eighth inch diameter, which works either automatically or by hand. Cylinders and steam chests are fitted with the necessary pipes and valves for applying the indicator, and are cased with black walnut staves, secured by brass bands and screws.

Framing.—The main frame for carrying the cylinders is the surface condenser, which is strongly ribbed and bracketed for that purpose, the outboard sides of the cylinders being supported, each by two wrought-iron columns, 2¼ inches diameter, turned and finished. The ends of these columns are fitted to flanges of lower end of cylinders and to bed-plate, each end being fastened by two bolts 1⅛ inches diameter.

Steam chests are cast separate, fitted with faced joints and bolted to cylinders, covers planed, finished and fastened with finished bolts and case-hardened nuts. Set screws are fitted to break the joints. The cut-off valve operates in a separate chest, which is bolted to that of the main valve.

Pass-over valve.—To each cut-off chest is fitted a screw-valve for a pass-over valve, 2½ inches diameter. The valve, seat, and stem are of composition, and valve is worked by a hand-wheel in front of chest.

Relief valve.—A composition relief valve of seven-eighths inch diameter is attached to steam chests and to exhaust connection to condenser.

Slide valves.—The valves are of cast iron, of a different texture from that of the seats and scraped to a bearing surface. The main slide valves are of the ordinary D form; for steam openings 2 by 14 inches and for exhaust openings 3½ by 14 inches, and are worked by a "Stephenson" link motion. The link is case-hardened and link block composition. The link is worked by hand, by means of a pinion, quadrant and "tumbling" shaft.

Cut-off valves.—Cut-off valves are of cast iron, of the gridiron pattern, with two openings 1¼ by 13 inches. The valve is operated by a link, one end of which is worked by an eccentric and the other end held in position by a concentric disk on crank-shaft. Steam can be cut off at points from three-fourths to one-fourth the stroke of piston. Proper hand gear is fitted to alter the point of cut off and to hold the link in position.

Cylinder-heads.—Upper cylinder-heads are ribbed, turned, and finished. Inside of heads are recessed for nuts of piston-rods and for heads of follower-bolts. Wrought-iron eyebolts are fitted for lifting the heads and set-screws for breaking the joints; also a "traveler" for removing them.

Bed-plate.—The bed-plate or frame is of cast iron, in one piece, and extended forward to receive the pumps; is hollow, of the box form of section, 14½ inches in depth, and has all the necessary passage-ways for water, bosses and nozzles or flanges for pumps, pillow blocks, &c., and flanges or lugs for bolting in place. All surfaces for flanges, pumps, hand-hold plates, and pipes are planed.

Surface condenser.—The shell is of cast iron 1 inch thick, well ribbed, strongly bracketed, and serves as a frame for the engines. The necessary seating for cylinders and for cross-head slides are cast on. All joint surfaces are planed, and suitable bonnets are fitted for access to interior, to tubes, and to all valves. The condenser is fitted with horizontal yellow metal tubes ⅝ inch diameter, turned both inside and outside; cast-iron tube sheets 1¾ inches thick, planed, and tubes packed with "Allen's" wood packing. Condensing surface is 900 square feet. The tubes are arranged in three nests, and the condensing water passes three times through the tubes. A 3½-inch copper pipe is also fitted to convert this into a jet condenser, if necessary. There is a screw-valve 1½ inches diameter connecting the salt with the fresh water, as an additional feed; also a brass cock for introducing soda. A perforated cast-iron scattering plate is fitted above the tubes, upon which the injection water impinges.

Exhaust connections.—Exhaust connections from the cylinders to the condenser are so arranged as to be independent; one engine exhausting without interfering with the other.

Steam-pipe connections.—The main steam-pipe is a single copper pipe from the boiler, with slip joint and double poppet throttle-valve operated by a hand-lever. The pipe branches near the engines, and there is a throttle-valve for each engine, operated independently.

Air-pumps are horizontal trunk-plunger pumps, one for each engine, and driven by a crank upon the forward end of main shaft. Pumps are 11 inches diameter and 12 inches stroke; lined with composition; trunk, piston, valve-seats, stems, and guards of composition; valves of pure rubber; chests for receiving and delivery valves cast with the pumps and with convenient openings for access to valves. There is also a guide cast on for slipper side of trunk.

Hot well.—There is a suitable cast-iron hot well, common to both air-pumps, with vapor-pipe from top and overflow-pipe to outside of ship, with proper outboard valve. This pipe is of copper, 7 inches diameter, No. 10 wire gauge; composition valve 7½ inches diameter, with composition seat and stem.

Circulating pump is an independent steam-pump, direct acting, of the "Davidson" pattern, 13½ inches diameter and 13 inches stroke; lined with composition; piston, valve-seats, stems, and guards of same metal; steam cylinder same diameter as pump; pump-valves of rubber. Outboard delivery pipe is of copper, No. 12 wire gauge, and fitted with outboard valve of composition. To suction-pipe there is a branch leading to engine-room bilge, with a separate screw-valve and "check" valve to prevent flooding. Screw-valve has an attachment for locking.

Pistons are of cast iron, double shell, ribbed, with cast-iron follower fastened by wrought-iron bolts screwed into brass bushings; follower turned and scraped to rings and piston, and fitted with eye-bolts for lifting. Packing-rings of cast iron in two thicknesses, accurately turned and fitted and set out with steel springs.

Piston rods are of mild steel, 2⅝ inches in diameter, and fastened to piston with a nut.

Feed-pumps.—To each engine there is fitted a feed-pump, worked from the air-pump motion, 4 inches in diameter and 12 inches stroke; composition plunger, valves, and seats; also a by-pass valve and air-vessel.

Bilge-pump is an independent steam-pump of the Davidson pattern, valves of rubber, composition seats, guards, and stems, and copper air-chamber. This pump has connections through a "manifold" to the various water-tight compartments; also, in the event of breakage of the auxiliary pump, can be used in lieu of that pump, having the same connections.

Cross-heads are of wrought iron, finished and fastened to piston-rod by a nut secured by a "dowel." Journals are $2\frac{3}{8}$ inches diameter and $3\frac{1}{4}$ inches long. Cross-heads move upon composition slipper slides working in a cast-iron guide. The bottom slipper has a bearing surface of 80 square inches. Both top and bottom gibs can be readily removed.

Slide-valve stems are of mild steel; those for main valves are $1\frac{5}{8}$ inches diameter, and cut-off valves $1\frac{3}{8}$ inches diameter; stuffing boxes and glands are bushed with composition.

Eccentrics and rods.—There are two eccentrics for each main valve, with a "Stephenson" link of wrought iron connected by the proper rods. For each cut-off valve, there is one eccentric to one end of a link, and the opposite end of the link is held in position by a proper rod in connection with a concentric disk on the crank-shaft. This link is adjusted by a hand-lever working against an arc, which is marked for the different points of cut-off. The straps are of composition, ribbed and "babbitted." Eccentric rods are of wrought iron, and connected to links so as to be adjusted for wear. Links and pins are case-hardened and link-blocks are of composition.

Connecting-rods are of wrought iron, forked at the cross-head end and finished, 5 feet 11 inches long between centers; crank-end neck $2\frac{5}{8}$ inches diameter and fork-end $2\frac{3}{8}$ inches diameter. Boxes for cross-head and crank-pin journals are of composition and secured by wrought-iron straps with gibs and keys; keys secured by steel set-screws.

Main pillow-blocks are cast with the bed-plate, and the lower part of the box is of phosphor-bronze. After journal $6\frac{1}{2}$ inches by 9 inches in length, forward, 5 inches by 8 inches; pillow-block caps for after journals are $2\frac{1}{4}$ inches thick and $7\frac{1}{2}$ inches in width, and for forward journals $2\frac{1}{4}$ inches thick and $6\frac{1}{2}$ inches in width; each cap held by two bolts $2\frac{1}{8}$ inches diameter; caps made so as to lip over ends of blocks.

Crank-shafts are of wrought iron, forged in one piece; after journals $6\frac{1}{2}$ by 9 inches, forward 5 by 18 inches, crank-pin journals $4\frac{3}{4}$ inches diameter and $6\frac{1}{2}$ inches in length.

Line-shafts are of wrought iron in three lengths, smallest diameter $6\frac{1}{4}$ inches; covered with composition-sleeve the length of the stern-bearing. Line-shaft couplings are of cast iron, turned and fitted and fastened by six bolts $1\frac{1}{4}$ inches diameter and with a steel feather. Couplings of crank-shaft to line-shaft are a pair of cast-iron wheels, with wrought-iron driving pins fastened by a cross-key in forward wheel and working free on composition bearing-plates in after wheel. The wheels are 3 feet 4 inches diameter, with mortises on periphery for turning the engine with a pinch-bar. Thrust-bearing is on forward length of line shafting, and is a collar thrust.

Thrust pillow-blocks are of cast iron, with phosphor-bronze boxes and collar plates; with set-screws to adjust wear. There is also a fore-and-aft fastening to receive forward thrust.

Line-shaft-pillow blocks are of cast-iron, with cast-iron caps, and fitted with phosphor-bronze for lower half of journal.

Screw-propellers are of cast iron, four bladed, 6 feet 8 inches diameter, 12¼ feet mean pitch, and 20 inches in length fore and aft. They are keyed upon shafts by a feather key and cross-key; ends of shafts fitted with a water-tight composition cap and fastened with composition tap-bolts to after end of hub; also, composition caps over ends of cross-keys.

Shaft brackets supporting the after end of shafts are placed close to forward side of propellers and are of composition. Section of brackets 1¼ by 6½ inches; forward and after edges rounded off; feet of brackets 1¼ inches thick, each foot fastened by four composition bolts 1⅜ inches diameter, with countersunk heads and screwed up on plates on inside of ship. The eyes of the brackets are boxed to receive a phosphor-bronze bushing 7¼ inches diameter by 10½ inches in length, and bushing lined with lignum-vitæ, fastened to brackets with composition tap-bolts.

Stern bearing is of composition, 2 feet 8 inches in length. The outer end has a large warped flange, 1⅛ inches thick, to fit the counter of the vessel, and the inner end a loose flange riveted to hull of ship. The inner ends of the stem-bearings project inboard about 10 inches and are fitted with lignum-vitæ staves. The inboard stuffing-boxes are of composition, riveted to hull of vessel, with a packing space of 8½ inches, and a loose ring fitting in bottom of packing space; packing held in place by a gland also of composition.

Sea-valves are screw valves, with composition chambers, valves, stems, and glands. One valve for injection, 4½ inches diameter, one for circulating pumps, 6 inches diameter, and one for steam pump, 4 inches diameter. Chambers bolted to cast-iron forms, which are riveted to hull of vessel. All sea-valves are fitted with strainers.

Hoisting-engine. (Plates V and VI.)—There is a hoisting-engine with double cylinders and cranks at right angles to each other; cylinders, 9 inches diameter and 9 inches stroke of piston, placed forward on hurricane deck for "trawling" purposes. The central drum holds the steel wire rope and is independent of the engine proper, connection being made by means of a friction clutch. The load on the drum is held by a friction brake. With the central drum disconnected, the two smaller drums can be used for ordinary hoisting purposes. There is also fitted an automatic guide by means of which the wire rope is neatly coiled upon the drum. Steam from either the main or auxiliary boiler may be used, and the engine exhausts into the atmosphere through the escape pipe of the main safety-valve. There is a pan of sheet-lead fitted under the engine to receive all dripping oil or water.

Boiler is an overhead, return-flue boiler, 8½ feet front, 8½ feet diameter of waist, and 21½ feet in length, with water-leg furnaces; two furnaces, 6 feet 8 inches long, by 3½ feet wide; grate surface, 46.6 square feet; main flues, three of 11 inches diameter, one of 12 inches, and one of 15 inches for each furnace; return flues in two tiers, seven flues of 10½ inches diameter in each tier. The flues are welded and drawn. All outside seams, seams of steam chimney, and water-legs double riveted. Flat surfaces are braced with seven-eighth inch socket-bolts 7½ inches from center to center. Thickness of circular part of shell is five-sixteenths inch; water-legs three-eighths inch; steam chimney of mild steel five-sixteenths inch. Fire-box and crown-sheets are also of mild steel, three-eighths inch thick; heads of shell and flat surfaces three-eighths inch. There are the necessary man-holes and hand-holes and double furnace doors. The boiler has been tested by a hydrostatic pressure of 65 pounds per square inch. The legs of the furnace part of the boiler rest upon cast-iron chairs set outside of ash pans, and under the waist is a cast-iron saddle. The boiler is held in place by turnbuckle-bolts. Under the furnaces are cast-iron pans, made in one width, for each furnace; bottom of pans five-eighths inch and one-half inch thick for all flanges. Ash pans have a long, beveled front flange, projecting 15 inches from front of boiler to catch dropping fire and cinders. Grate-bars are of cast iron in two lengths, three-fourths inch thick on face and five-sixteenths inch at lower edge, with five-eighths inch air spaces. Boiler shell and steam chimney are covered with hair felt, and wool backing 1½ inches thick. Main and all other steam pipes are covered with hair felt 1 inch thick, with canvas backing, and painted.

Boiler attachments.—There are attached to the boiler, one steam stop-valve 7 inches diameter, one safety-valve 6 inches diameter, with connections to engine-room, and copper escape-pipe, 16 feet long; one bottom blow-valve 2½ inches, one surface blow-valve 2 inches, two check-valves 2½ inches, and one screw stop-valve, each for auxiliary and circulating pumps. All these valves are of composition, with composition glands and stems; also four brass gauge-cocks, glass water-gauge 15 inches long and salinometer.

Smoke-pipe and casing.—The smoke-pipe is 42 inches diameter and 24 feet high, in three lengths of 8 feet each; flush jointed, 2½-inch angle-iron at top, and band 2½ by ⅜ inches at bottom. Pipe is made of iron No. 14 wire gauge, and is fitted with a proper damper. There is a casing around lower part of pipe and top of steam-drum, extending above the hurricane deck 2½ feet, made of iron No. 12 wire gauge, and fastened to deck with angle-iron; casing covered by an umbrella. There are six stays to smoke pipe of wire rope nine-sixteenths inch in diameter, and secured to deck by eye bolts.

Auxiliary boiler is of the vertical fire tubular type, 48 inches diameter, and 7 feet 8 inches in height, with 106 brass tubes, 2¼ inches outside diameter, and 5 feet 2 inches long. Boiler rests on a cast-iron frame 14 inches in height. Upper end of boiler surrounded by a casing of iron No. 12 wire gauge, and secured to deck by 1¼-inch angle-iron, fastened with wood-screws. Smoke-pipe is 18 inches diameter and 18 feet in height.

The boiler was tested to 120 pounds hydrostatic pressure, and is fitted with all the necessary grate-bars, bearers, safety-valve, steam-gauge, gauge-cocks, blow-cocks, and "check-valves." This boiler can be supplied with water either by a Hancock "inspirator" or by the auxiliary pump, and has the same steam connections as the main boiler. It is situated on the main deck, immediately over the fire-room.

Steam-pump.—There is one fly-wheel steam-pump with water-cylinder, 5 inches diameter and 12 inches stroke, having all the necessary connections to be used as a fire-pump, as a feed to main or auxiliary boiler from either hot-well or the sea, as a bilge-pump, as a circulating pump for Baird's distiller, and to supply hatching tanks. There is a double exhaust connection to either condenser or atmosphere. In case of fire the flow of water can be increased by combining this pump with the independent bilge-pump. By means of the proper gearing, this pump works the hatching cylinders on outside of ship. The suction-pipe is connected with the overflow-pipe from hatching apparatus, so that the same water can be used repeatedly for hatching. There is a connection on the "manifold" for suction-hose of sufficient size to supply both auxiliary and bilge-pumps. All water-pipes are of copper; steam and exhaust pipes of iron.

Miscellaneous.—There is one ash-chute for discharging ashes over side of ship; eight cast-iron deck scuttles on main deck with close covers and gratings; two iron ventilators, 16 inches diameter, to fire-room, with revolving caps, and also used to hoist ashes. The fire-room is covered with rough cast-iron floor-plates one-half inch thick, and above fire-room is an open cast-iron grating for ventilation. There are steam-heaters in pilot-house, and all habitable portions of the ship are fitted with the proper steam and drain pipes and valves. All heaters drain into a "trap" in fire-room, and a vapor-pipe from top of "trap" leads to escape-pipe from main safety-valve. There are the proper tanks for oil, waste, and tallow. There is a steam-whistle 6 inches diameter of bell with valve where attached to boiler. In the engine-room there are three gongs, one of 12 inches diameter, and two of 8 inches diameter, with "jingle" bell; all arranged with proper wires and pulls to pilot-house; also shield and tube to return sound to pilot-house, and a speaking tube from engine-room to pilot-house.

In the engine-room there are two 6½-inch nickel-plated gauges, one for steam and the other for vacuum; two counters, one for each engine, and a marine clock. There are the proper oil-cups to all journals; also proper connections for applying water to journals when necessary. A "Baird's" distiller is in use, capable of distilling 1,500 gallons of tepid and 800 gallons of potable water per diem.

OUTFIT.

The contract for building the vessel covered only hull and machinery, the outfit being provided from a special appropriation.

Anchors, chains, hawsers, &c., were loaned by the Bureau of Equipment and Recruiting, Navy Department.

Boats—gig, cutter, and dingy—by the Bureau of Construction and Repair.

Compasses, flags, nautical instruments, books, and chronometer by the Bureau of Navigation.

Small-arms and ammunition by Bureau of Ordnance.

Charts and Atlantic Coast Pilot were furnished by the United States Coast and Geodetic Survey.

The various articles of outfit were procured by open purchase at reasonable prices and have given general satisfaction.

FISH-HATCHING MACHINERY.

The fish-hatching machinery was constructed by the Pusey & Jones Company under special contract, and consists of a Woodward steam-pump with water cylinder, 5 inches diameter and 12 inch stroke, capable of supplying 10,000 gallons of water per hour.

Two iron distributing tanks with a capacity of 500 gallons each are placed forward of the pump on the boiler hatch and raised 3 feet 4 inches above the deck. (Plate II.)

There is a water connection and proper valves between the pump and tanks, with overflow and drain pipes connecting with the general delivery for hatching machinery. There is also an arrangement of valves by which the water can be pumped back into the tanks and used as often as desired instead of discharging it overboard.

HATCHING CONES.

The number of hatching cones on board at present is thirty-six, capable of hatching 7,200,000 shad at a time, or 200,000 each when charged to their full capacity.

The number of cones can be increased about one-third in case of necessity. The material of which they are made is copper, tinned inside, and the mountings are of brass. Their arrangement on the port side of deck will be seen by reference to the Plate. They are in sets of 4 and 6 to each frame and are hung on gimbals which permit a free motion in every direction, maintaining a vertical position even when the vessel is in violent motion.

In artificial fish hatching it is necessary to maintain a constant and carefully graduated flow of fresh water through the vessels in which the eggs are placed for development. In the early days of this industry shad eggs were hatched in floating boxes with gauze bottoms anchored in a tide way or current which effected the necessary change of water, but they were subject to various accidents beyond the control of those having the operations in charge. A sudden squall might capsize them, a gale of wind break them from their moorings, or drift-wood carry them away, the entire charge of eggs being liable to loss or serious damage in either case.

Various other methods have been used with good results, but for service on shipboard, under all conditions of wind and weather, the cone is thus far the most perfect appliance for hatching non-adhesive eggs, with greater specific gravity than the water in which they are developed.

To prepare for shad hatching with cones, water is pumped into the distributing tanks, which have independent connections for each set of cone frames through which the water flows by gravity into the upper or feed-pipes, where, at proper intervals, small feed-valves are tapped in and connected to the base of the cones by a flexible hose. The feed-valves being opened, a stream of water is admitted at the bottom, rapidly filling them till near the top, where a fine wire gauze rim is encountered. Through this the water finds an outlet to the discharge connections, thence to the waste pipes at the bottom of the frames, and into the general delivery; thus establishing a steady and constant upward current.

From 100,000 to 200,000 impregnated eggs are placed in each cone and the current regulated by the feed-valves so as to give them a gentle movement, just sufficient to prevent "matting," or settling to the bottom in a mass, where they would soon become asphyxiated. The dead eggs being lighter soon accumulate at the surface, and are removed with a skimmer, sediment and other impurities being cleared from the gauze rims to allow an unobstructed flow of waste water to the discharge-pipes.

Development takes place rapidly, and the embryo is hatched in from two and a half to five days, according to the temperature of the water.

HATCHING CYLINDERS.

There are in addition to the cones eighteen hatching cylinders, which are suspended, nine on each side, from beams outside of the vessel and operated by a cam motion imparting a vertical movement of about 8 inches. (See Plate III.) They have wire-gauze bottoms, and both solid and wire-gauze covers, the former used when the cylinders are converted into transporting cans, the latter in stormy weather. The cylinders are made of heavy tin and the mountings are brass.

To prepare for shad hatching they are suspended from the beam, as shown in Plate III, in such a manner that the bottoms will be constantly submerged; from 250,000 to 300,000 impregnated eggs are placed in each cylinder and the cam motion put in operation, which gives them a very gentle ascent, occupying about three-quarters of the revolution; the descent, being accomplished during the remaining fourth of the revolution, is made more rapid, causing the eggs to rise from the bottom and circulate freely through the water at every downward movement.

The cylinders require but little attention during the hatching process, and, in moderately smooth weather, are undoubtedly equal, if not superior, to all other appliances for shad hatching. They can also be made available for the development of all non-adhesive eggs, no matter what their specific gravity, as the requisite motion can be attained by simply modifying the form of cam.

Plate IV shows some of the apparatus used by the United States Commission in fish hatching: the spawn pans of marbleized iron in which the eggs are placed for impregnation; the spawn pail in which the impregnated eggs are placed for transportation to the hatching establishment; the dipper in which all eggs are measured when received on board, and the hatching cone, with goose-neck unscrewed; the three kinds of cylinders used, the large one with the solid tin body, a smaller one with a combination body of copper and wire gauze, and a third with gauze body.

Between the cylinders stands a funnel, with fine wire-gauze bottom, used for siphoning water from hatching cones without removing eggs or young fish.

DREDGING MACHINERY.

The hoisting and reeling engine, the main features of which are given in the general description of machinery, stands on the promenade deck immediately forward of the foremast, as shown in the plates V and VI.

The drum, or reel, holding a thousand fathoms of steel-wire dredge rope, three-eighths inch in diameter, is carried on the main shaft of the engine and driven by friction gear. An automatic guide lays the rope fairly on the reel when heaving in. One man attends the engine, hoisting and lowering the trawl and dredge without the necessity of touching the rope by hand.

The dredging beam is 36 feet in length and 10 inches in diameter, the heel secured to the foremast by a strong goose-neck 5 feet above the deck. The forward end, when not in use, rests in a cradle on an iron frame in which the ship's bell is suspended.

There is an iron band at the boom end for fore-and-aft guys; the topping lift band is about 3 feet from the end, and has a strong link on the under side, to which is hooked the dredging block. The topping lift is composed of two 14-inch double blocks and a 4-inch manila rope. The upper block is shackled to an iron collar on the foremast 3 feet below the eyes of the rigging. There is a strong sheave in the boom inside of the lower topping-lift block, over which is rove the pendant of a tackle used for hoisting the bag of the trawl on board when the weight is too great to be managed by hand.

A composition sheave (Plate VI) is inserted in the heel of the boom, two revolutions of which are equal to one fathom of dredge rope, and attached to its shaft is a register which accurately records the amount of rope out at all times.

SAFETY-HOOKS.

The safety-hooks (Plate VII) are designed for the purpose of detaching the trawl when from any cause, such as fouling a rock, or wreck, the tension on the dredge rope reaches the limit of safety. It can be adjusted to detach at any point between 3,000 and 6,000 pounds by the nut on the end of the central rod. In practice we have set it to 4,000 pounds, the breaking strain of the dredge rope being 8,700 pounds. The spring and hooks being placed in the cylinder and the cap screwed on, it is ready for use.

The end of the dredge rope is spliced into the eye and the trawl shackled to the hooks, which are held in position by their shoulders pressing against the inner surface of the cylinder (Plate VIII.)

The spring is compressed as the tension increases till, the limit of safety being reached, the shoulders are released and the hooks open freely, allowing the shackle pin to slip through, detaching the trawl and relieving the rope from undue strain.

The accumulator (Plate VIII) is designed to prevent jerking strains on the dredge rope due to motion of the vessel in a sea-way, or working over a rough bottom. It is copied from that used on board the Coast-Survey steamer Blake, with slight modifications. It answers its purpose admirably and is an almost indispensable adjunct when steel-wire rope is used.

The side rods and central shaft are of steel, the ends of wrought iron. Twenty-six rubber buffers, with a brass washer between each, are placed on the central shaft under considerable pressure and secured by a nut on the upper end. A swivel link at the lower extremity carries a leading block.

The hubs of the brass washers are extended on each side, forming a collar over which the rubber buffers ride free from contact with the central shaft. This feature, introduced by Lieutenant-Commander Sigsbee, U. S. N., placed the present form of accumulator far ahead of all others for our purposes.

DREDGING BLOCKS.

The dredging block at the boom end and that seen hooked to the accumulator (Plate VIII) are all that are used. They, also, are copied from those of the Blake, except that the diameter of sheave is reduced from 18 inches to 12 inches, making the blocks much lighter.

STEEL-WIRE DREDGE ROPE.

This excellent rope was made by the John A. Roebling's Sons' Company, Trenton, N. J. It is one and one eighth inch in circumference, composed of six strands laid around a hemp heart, each strand composed of seven galvanized steel wires (No. 19 American gauge) having no hemp heart.

Sigsbee—"Deep-sea dredging and trawling"— gives the ultimate strength of the rope as 8,750 pounds, and the breaking strain, in kinks, 4,500 pounds; weight, 1.14 pounds per fathom in air, or about one pound in sea-water.

PREPARATION FOR DREDGING.

The rope being on the reel the end is passed between the rollers of the automatic guide (Plate V), carried aloft and rove through the block on the lower end of the accumulator (Plate IX), brought down again and rove under the registering sheave in the heal of the boom, thence through the dredging block at the boom end, and spliced into the eye of the safety-hooks.

The boom is then topped up and secured over the side port by strong fore-and-aft guys, the trawl shackled to the safety-hooks and swayed up clear of the rail, a man at each end to steady it, an engineer at the hoisting engine, and the officer in charge, as shown in Plate IX, ready at the order to lower away.

TRAWLS.

The beam trawl, shown in Plate IX, is used by the Commission, and, for moderate depths, has not been equaled by any other form. Three sizes are used, the smallest with 9 feet length of beam, the second with 11 feet, and the third 17 feet, the length of net from 15 feet to 40 feet. The trawl nets are invariably provided with pockets.

The Otter trawl has been used to advantage in shoal water, over smooth bottom, when the capture of fish was the special object.

It is necessary for the successful operation of the beam trawl that it should land right side up. A capsize in moderate depths is rare, but in deep water it may be considered as among the probabilities.

To avoid the vexatious delays attending accidents of this nature, Professor Agassiz and the officers of the Blake devised a double trawl which works equally well either side up and was subsequently used on board that vessel with excellent results. It has also been used experimentally by the vessels of the Commission, but they have not heretofore operated in sufficient depths to make it a necessity.

DREDGES.

The common form of deep-sea dredge is used by the Commission, with excellent results on sandy bottoms. The form designed by the officers of the Blake, and used successfully on board that vessel, is adapted for very soft bottoms usually encountered at great depths.

THE CHESTER RAKE DREDGE.

This arrangement of a double rake to be used in connection with a dredge of any form is shown in Plate X and is very useful in bringing to the surface mollusks and various other forms living a few inches under the mud or sand of the bottom.

The Blake dredge is usually preferred for use with the rake as it skims over the bottom lightly, picking up what has been turned up by the rake without overloading itself with mud.

THE TANGLE BAR.

The form of tangle bar used by the Commission was devised by Prof. A. E. Verrill in 1873, and consists of an iron bar supported at each end by a fixed wheel, or iron hoop. Six chains are attached to the bar at intervals of one foot, and they are about 12 feet in length. To these chains are secured deck-swabs or bundles of rope yarn at intervals of about 18 inches. The apparatus is shown in Plate X, partially suspended under the main boom. It is very useful on rocky bottoms where it will capture specimens when no other device could be made available.

THE TABLE SIEVE.

Plate XI shows the table sieve, as used by the Commission. The hopper, with its coarse wire-gauze bottom, is seen in the foreground, then the fine wire-gauze tray which rests beneath it, and finally the table itself with its canvas bottom and hose from which the waste-water is conducted to the scupper. This device is peculiar to the United States Fish Commission, and has probably contributed as much towards its success in deep-sea exploration as any single implement used. To prepare the table sieve for service, the tray is placed in position, then the hopper when it will assume the form shown in Plate XII. The contents of the trawl (a mixture of mud and various forms of marine life) being emptied into the latter, a stream of water is turned upon the mass and the work of collection and assortment commences. The larger forms are taken from the hopper, the smaller ones from the tray, while the more minute and delicate specimens are found on the canvas bottom.

THE CRADLE SIEVE.

The cradle sieve is designed to receive the contents of the dredge, as the table sieve does that of the trawl. It is semicircular in form, as shown in Plate XI; the bottom and sides being composed of a coarse wire-gauze, lined with the same material, but very fine; the tray or hopper has also a coarse gauze bottom.

To prepare the cradle sieve for use, the hopper is placed in position and the sieve hung over the side, abreast of the dredging port. The contents of the dredge being emptied into it, a stream of water, strong or light as desired, is turned on as with the table sieve, the collection and assortment being carried on in a similar manner.

DREDGING ARRANGEMENTS, MAIN DECK.

Plate XII shows a portion of the starboard side of the main deck as arranged for dredging. The table sieve is seen standing abaft the dredging port. On the swinging table which has been lowered from the beams overhead is a nest of hand sieves and various sizes of jars, bottles, and vials, used for preserving specimens. Deck tubs, buckets, &c., are at hand, and a tank of alcohol is secured on the boiler hatch. The side ports are closed in the view, but if more light or air is required they can be opened and secured by iron hooks suspended from the deck beams.

SOUNDINGS AND SERIAL TEMPERATURES.

The vessels of the Commission have heretofore used the ordinary deep-sea lead and line for soundings and serial temperatures, and in shoal water it answered their purpose, but in depths exceeding 100 fathoms it consumed much time and required nearly every man of the small crew to haul the lead back.

During the season of 1879 a wooden reel was improvised, on which the lead line was coiled and, by a simple attachment to the fly-wheel of the hoisting engine was hove up rapidly, requiring the services of but two men, one at the engine and one to attend the reel. This was a marked improvement over the old method, but as the work of the Fish Hawk was expected to take her into 300 fathoms or more, it was deemed advisable to substitute piano wire in place of hemp in order still further to facilitate the work of taking soundings and serial temperatures.

SOUNDING MACHINE.

The machine adopted is shown on a small scale in Plate X, where it is mounted at the stern in readiness for casting the lead. The reel is of cast brass 11.43 inches in diameter, and holds 600 fathoms of wire. A friction line, led through a groove common to all sounding reels, controls the motion. The cranks are thrown out of gear and hang vertically one on each side. The register is on the left of the reel. A small ratchet wheel and pawl hold the reel in place when desired.

On the extremity of the frame is a small grooved pulley of brass, working in guides and suspended by a coiled spring which allows several inches vertical play. A brass guard is fitted over the upper portion of the pulley to prevent the wire from flying off if suddenly slacked. The reel is moved by friction motion; a half turn of the right crank ahead brings them both into action, the reverse motion throwing them out, leaving the reel to revolve freely.

To prepare the machine for sounding, wind the wire on the reel, splice on two or three fathoms of stray line, reeve it over the pulley and bend on the lead and thermometer, the reel being held in position by the ratchet and pawl. Pass the friction line over the groove, reverse the pawl, attend the friction line, lowering the lead carefully to the water's edge, then set the register at zero and all will be ready for a cast. The total weight of the apparatus is 96 pounds. The ordinary leads from 12 to 20 pounds weight are used, and, if specimens of the bottom are required, they are armed in the usual manner. This, however, is a matter of little consequence, as the dredge or trawl invariably follows the lead, from which specimens can be taken.

The machine described was purely experimental as we had no practical knowledge of sounding machines or the use of piano wire. The results were eminently satisfactory, and the little machine continued to do its work well until finally we got into depths exceeding its capacity. We then decided to have a larger one made embodying such improvements as our experience suggested; the original being relegated to the stern, where, with Bassnett's patent atmospheric lead, it is still doing good service as a navigational sounding machine by which we can ascertain the depths to 25 or 30 fathoms while running at full speed.

The improved machine is shown on Plates XIII, XIV, and XV, and its location on Plates I and IX. It is constructed on the same general plan as the original machine. The standard which ships in the rail is of wrought iron screwed firmly into the base of the brass frame that carries the reel. The frame above mentioned is cast in one piece, is bored to receive the shaft, and has appropriate lugs for the pawl and register. The reel is of cast brass, and will hold 2,000 fathoms of sounding-wire, one fathom to a turn on the first layer, increasing as the score is filled. It has also the usual friction groove, Plate XIV. The cranks by which the reel is turned have friction surfaces, which are brought into action by moving the right one-half a revolution ahead, the left remaining clamped, as shown in Plate XIII; or it may be held firmly in the hand. The reverse motion releases the reel, and it revolves freely without moving the cranks.

On the left of the frame, between it and the crank, is a worm-wheel which operates the register, as shown in Plate XIII. The ratchet and pawl are on the right, between the frame and crank.

The arm supporting the guiding pulley is of flat bar-iron, its lower end riveted between lugs on the frame. The small metal block projecting from the arm is part of a tackle for suspending the reel when mounting and dismounting. The guiding pulley is the same as that used in the original machine, except that it carries a small arm near the upper end of its shaft or spindle, which works through a slot in the casting, as shown in Plate XIV. A small cord is attached to the arm and made fast to the free end of the friction rope, the standing part being hooked to a small metal eye in the frame over the reel.

By this arrangement the friction is intended to act automatically in the following manner: The machine being ready for a cast the small friction line is hauled taut before the lead is bent, and while the guiding pulley is up in its place. In this condition it requires a strong man to move the reel, but, the lead being bent and suspended, it compresses the spring and drags the pulley down sufficiently to slack the friction rope and allow the reel to move with comparative freedom; the instant the lead strikes the bottom, however, or the weight is removed from any cause, the pulley flies up, putting a strain on the friction rope which stops the reel at once. It acts also as a check in paying out, the friction being governed by the weight suspended on the guide pulley. The reel is kept in a tank of oil when not in use, to preserve the wire. By a most ingenious arrangement, for which we are indebted to Mr. Tippet, draughtsman at the ordnance department, Washington navy-yard, the reel is unshipped by simply unscrewing one nut, shown in Plate XIII, on the left crank, with a chain attached to prevent its loss by falling overboard. The nut being unscrewed releases the shaft, which is drawn out leaving the ratchet, worm-wheel, and left crank in position.

With the use of the tackle one man can easily ship and unship the reel.

The comparative sizes of the ordinary deep-sea lead-line, hand-line and sounding-wire are shown in Plate XIII.

Plate XIV shows the machine in position for heaving in.

Plate XV shows the machine in poition for sounding with the Bassnet atmospheric lead, used for navigational purposes, when the vessel is steaming ahead at her usual speed.

When the machine is in place it turns freely, the guide-pulley taking the direction of the wire if, from any cause, it trends out of the perpendicular. A set-screw is provided in the rail bearing for clamping the apparatus to steady it while heaving in. Total weight of the machine, 128 pounds.

PIANO-FORTE WIRE USED FOR SOUNDING.

The steel wire used for sounding and serial temperatures was purchased of the Washburn & Moen Manufacturing Company, Worcester, Mass. It is called No. 11, music, by the makers; is 0.028 of an inch in diameter, tensile strength about 200 pounds, weight .0145 of a pound to the fathom, or 14.5 pounds to the nautical mile.

The method of splicing is simple and effective. The ends of the wire, for about 2 feet, are thoroughly cleaned, and laid together with about eight turns; the ends and two or three intermediate points are wound with a few turns of very fine wire, and covered with solder, which is smoothed with a knife or piece of sand-paper. As this form of splice is smooth, flexible, and reliable, we have tried no other.

Slack-laid cod-line is used for stray-line, and is applied to the wire in the following manner: The end of the wire is stuck twice against the lay, about six inches from the end of the line, then passed with the lay for six inches, the end stuck twice against the lay and served over with seaming twine. The wire is then passed with the lay to the end of the line, the strands trimmed down and served over with twine; a seizing is also put on over the wire first stuck against the lay. This makes a smooth and secure splice, which passes readily over the guide-pulley without danger of catching under the guard.

DEEP-SEA THERMOMETERS.

The Miller-Casella and Negretti & Zambra deep-sea thermometers have been used by the vessels of the Commission. They are both excellent instruments, but the latter possessed some notable advantages for the peculiar service required of them in the prosecution of our work.

THE NEGRETTI & ZAMBRA DEEP-SEA THERMOMETER.

This thermometer is shown in Plate XVI; the tube removed from its case; the rubber guards taken off and laid beside it; the messenger between them. The metal case used by the Commission and the wooden frame furnished by the manufacturers are shown. The spring and slip hooks are removed from the former, and lie beside it.

The bulb containing the mercury is cylindrical; the neck much contracted, and the tube near it bent in a peculiar manner, with a catch reservoir at the bend. To take the temperature the bulb is held downward, when the column of mercury in the tube will be in contact with it. To register the temperature the instrument is capsized; the column breaking at the bend, falls to the bottom, and the scale is then read in the usual manner, it being marked from the opposite end toward the bulb.

The tube is completely inclosed in a glass shield, which protects it from pressure, eliminating any errors that might arise from that cause; and in order to avoid sluggishness, the portion surrounding the bulb is filled with mercury.

This thermometer, as mentioned above, registers by being capsized, or turned with the bulb up, at the point where the temperature is to be taken; and, to accomplish this, some device is necessary by which the requisite movement will take place with certainty at the proper time.

For this purpose the manufacturers use a wooden frame containing a charge of shot, which moves freely from end to end, and is of sufficient weight to leave the entire apparatus a slight buoyancy in sea water.

In using this instrument the end of the frame carrying the bulb is made fast to the sounding-line and is pulled down in the descent; the shot are at the lower end, and the buoyancy of the frame, added to the friction of the water, keeps it in position.

The ascent is commenced with a quick pull of the line, which, by changing its center of gravity, causes the thermometer to capsize, the weight of shot transferred to the lower end and friction of the water keeping it in position. The ascent should be continuous after it commences, for if the line is stopped or slacked from any cause the thermometer is liable to reverse, giving, of course, erroneous readings.

We experienced no trouble from this cause in smooth water, but in a sea-way, with the vessels moving rapidly, the results were unsatisfactory; in fact, totally unreliable. The frames soon became water-logged in depths of four or five hundred fathoms, which was another fruitful source of error.

The accuracy of the thermometer itself and its extreme sensitiveness made it particularly valuable to us where we required several temperatures in rapid succession at moderate depths, provided we could control its motions.

Several devices were tried, and finally a simple gas-pipe, seven-eighths of an inch inside diameter, was adopted. Several holes were drilled in the end inclosing the bulb, a slit cut in the side to expose the scale, and a pair of slip-hooks held in position by a small spring placed in the opposite end. The thermometer was then inserted; the rubber guards used to protect the shield in the wooden frame serving not only to hold it securely in place but to protect it from sudden jars, and a lanyard of cod-line, spliced into the end carrying the bulb, completed the arrangement.

THE MESSENGER.

The messenger used for capsizing the thermometer is of cast brass, cylindrical in form, with rounded ends. It is about two inches in length, one in diameter, and has a three-eighth-inch hole through its center, well rounded at the ends to prevent catching on splices. Its weight is from three to four ounces.

TO TAKE A DEEP-SEA TEMPERATURE.

Plate XIII shows both forms of the Negretti & Zambra thermometer arranged for descent. In the modified form it is held firmly in position by the slip-hooks through which the stray-line passes.

Having attained the proper depth, and sufficient time elapsed for the thermometer to indicate the temperature, the messenger, which has been resting in its cradle under the guide-pulley, is sent down the wire and capsizes the thermometer by striking the slip-hooks and forcing them open, when, having lost its support, the instrument promptly reverses, as shown in Plate XIV, where both forms are represented as on the ascent.

All buoyancy being destroyed by substituting a metal case, the thermometer is independent of the motions of the vessel either from rolling, pitching, or drifting. The line may be stopped on the ascent or lowered again without affecting the instrument in any way. We have taken hundreds of temperatures with the apparatus described, under varying conditions of wind and weather, with the most satisfactory results.

THE MILLER-CASELLA DEEP-SEA THERMOMETER.

Plate XVII shows this thermometer in its copper case used for deep-sea work; also partially dismounted, to show the form of construction. The magnet seen between the two instruments is used to adjust the indices.

The following description is from Sigsbee's "Deep-sea Sounding and Dredging:"

"A glass tube bent in the form of U is fastened to a vulcanite frame, and to the latter are screwed white glass slabs containing the graduated scales. Each limb of the tube terminates in a bulb. A column of mercury occupies the bend and a part of the capillary tube of each limb.

"The large bulb and its corresponding limb, above the mercury, are wholly filled with a mixture of creosote and water; the opposite limb, above the mercury, is partially filled with the same mixture, the remaining space therein being occupied by compressed air. In the mixture, on each side, is a steel index having a horse-hair tied around it near the upper extremity. The ends of the elastic horse-hair, being held in a pendent position by the inner walls of the tube, exert enough pressure to oppose a frictional resistance to a movement of the index in elevation or depression. As thus described, the instrument is a self-registering maximum and minimum thermometer for ordinary use. The indications are given by the expansion and contraction of the creosote and water mixture in the large, full bulb. The instrument is set by bringing the lower ends of the indices in contact with the mercury by means of a magnet provided for the purpose. Then, when the instrument is submitted to a higher temperature, the expansion of the mixture in the large bulb depresses the column of mercury on that side, and correspondingly elevates it on the other side. A decrease of temperature contracts the mixture in the large bulb, and by the elastic force of the compressed air in the smaller bulb a transference of the column of mercury takes place in precisely the reverse manner to that which occurs on a rising temperature. Thus the mercury rises in the left limb for a lower, and in the right limb for a higher, temperature.

"The greater the change of temperature, the higher the point reached in the respective limbs; hence, the scale on the left is graduated from the top downwards, and that on the right from the bottom upwards. The rising of the mercury in either limb carries with it the index of that limb, and on the retreat of the mercury the index remains at the highest point attained. The bottom of the index, being the part which has been in contact with the mercury, gives the point at which to take the reading."

The large bulb of these instruments is now protected from pressure by a glass shield, with which it is covered; the space between shield and bulb is nearly filled with alcohol, which acts as a transmitting medium for temperature, performing the same function as the mercury in the shield of the Negretti & Zambra thermometer. The shield above mentioned has added much to the value of the instrument, as it has practically eliminated errors arising from varying pressures.

This thermometer has been considered the standard for deep-sea work, and where several are to be sent down on the same line, particularly to great depths, it is unrivaled. It is not as sensitive as the Negretti

& Zambra, but, under the above conditions, a delay of a few minutes is not of great importance. The movable indices are a fruitful source of annoyance and vexatious delay. An index may, without any apparent cause, absolutely refuse to move in the tube; coaxing with the magnet is followed by lightly tapping the frame in the hand or swinging it rapidly about the head, and, if this fails, more vigorous tapping is apt to follow, with various active measures, none of which tend to improve the general condition of the instrument.

The indices are also liable to move if the instrument is subjected to rough treatment; this, however, is not of frequent occurrence with careful handling.

Most of the minor casualties to which the instrument is liable are apparent to the eye and are readily set right.

WATER DENSITIES.

Hilgard's ocean salinometer (Plate XVIII) is used by the Commission for observing the density of sea-water. We found it difficult at times to use this delicate instrument at sea, until we adopted the plan of setting it on a nicely adjusted swinging stand, which rendered it to a great extent independent of the movements of the vessel.

An excellent description of the apparatus is given by Professor J. E. Hilgard in the Coast Survey Report for 1874, and reproduced in Sigsbee's Deep-sea Sounding and Dredging, as follows:

The density of sea-water in different latitudes and at different depths is an element of so great importance in the study of ocean physics as to have caused a great deal of attention to be paid lately to its determination.

The instruments employed for the purpose have been, almost without exception, areometers of various forms. The differences of density as arising from saltness are so small that it is necessary to have a very sensitive instrument. As the density of ocean water at the temperature of 60° Fahr. only varies between the limits of 1.024 and 1.029, it is necessary, in order to determine differences to the hundredth part, that we should be able to observe accurately the half of a unit in the fourth decimal place. This gives a great extension to the scale and involves the use of a series of floats, if the scale starts from fresh-water, or else the instrument assumes dimensions which make it unfit for use on board ship.

With a view to the convenient adaptation to practical use, this apparatus has been devised for the Coast Survey by Assistant Hilgard.

The instrument consists of a single float about 9 inches in length. The scale extends from 1.020 to 1.031, in order to give sufficient range for the effect of temperature. Each unit in the third place, or thousandths of the density of fresh water, is represented by a length of 0.3 of an inch, which is subdivided into five parts, admitting of an accurate reading of a unit in the fourth place of decimals by estimation. The float is accompanied by a copper can, with a thermometer inserted within the cavity, which is glazed in front. In use the can is nearly filled with water, so as to overflow when the float is inserted, the reading being then taken with ease at the top of the liquid. For convenience and security two such floats and the can are packed together in a suitable case, and a supply of floats and thermometers, securely packed in sawdust, is kept on hand to replace the broken ones.

The following table has been derived from the observations of the expansibility of sea-water, made by Prof. J. S. Hubbard, U. S. N. Column II contains a table of reductions for temperature of salinometer readings to the standard of 60° Fahr. To facilitate the use of this table the following directions are given:

Record the actual observation of hydrometer and thermometer. From Column II (which is applicable to any degree of saltness within the given limits) take the number corresponding to the observed temperature, and multiply this number by the number of degrees and fractions of a degree that the observed temperature differs from 60°. Apply this product as a correction, with proper sign, to the reading of the salinometer, and the result will be the reading of the salinometer at the standard temperature of 60° Fahr.

EXAMPLE.—Actual reading of thermometer=80°.5; actual reading of salinometer=1.02425.

Opposite 80°.5 in column II is +0.0001585, which, multiplied by 20.5, gives as a product +0.003249. Add this to the observed reading of salinometer, and 1.02750 will result as the reading of the salinometer at the standard temperature.

Temperature.	Coefficients for reduction to 60°.	Temperature.	Coefficients for reduction to 60°.	Temperature.	Coefficients for reduction to 60°.	Temperature.	Coefficients for reduction to 60°.
°		°		°		°	
50	−0.000108	60	+0.000000	70	+0.000145	80	+0.000158
51	−0.000110	61	+0.000130	71	+0.000146	81	+0.000159
52	−0.000112	62	+0.000135	72	+0.000147	82	+0.000160
53	−0.000113	63	+0.000137	73	+0.000148	83	+0.000162
54	−0.000115	64	+0.000137	74	+0.000149	84	+0.000163
55	−0.000118	65	+0.000138	75	+0.000151	85	+0.000164
56	−0.000120	66	+0.000140	76	+0.000152	86	+0.000166
57	−0.000120	67	+0.000141	77	+0.008154	87	+0.000167
58	−0.000120	68	+0.000142	78	+0.000156	88	+0.000168
59	−0.000120	69	+0.000143	79	+0.000157	89	+0.000170

A method quite different in practice for determining the density of sea-water has been suggested by Prof. Wolcott Gibbs, of Harvard University. It depends upon the determination of the index of refraction by means of an angular instrument similar to the sextant. As all navigators are familiar with the use of the sextant, and as the observation can be made without hinderance from the motion of the ship, this form of the instrument may be found to possess certain advantages.

NOTE IN 1876.—When the table of reductions for temperature above given was constructed, the investigations relative to the same subject made by Thorpe and Rücker (Royal Society's Proceedings, January, 1876) were not known. The following comparison of the results of the experiments on the thermal dilation of sea-water, as taken from Professor Hubbard's tables, and as derived from the results of Thorpe and Rücker, shows the differences within the range of temperature covered by our table of corrections:

Temperature	Volume.	
	Hubbard.	Thorpe and Rücker.
°		
50	0.99895	0.99902
55	0.99943	0.99946
60	1.00000	1.00000
65	1.00067	1.00059
70	1.00142	1.00127
75	1.00221	1.00205
80	1.00309	1.00280
85	1.00402	1.00364

DEPARTURE OF THE VESSEL FROM WILMINGTON.

At 4 p. m. July 29, 1880, the Fish Hawk left the builder's yard for Newport, R. I., the headquarters of the Commission for the season.

The hatching machinery was not entirely complete, but the dredging apparatus was in place, and it was considered advisable to leave at once, returning for the remainder of her hatching outfit after completing her work of deep-sea exploration for the season.

The weather was clear and pleasant, with a gentle breeze from NW. The vessel attained a speed of 7 to 8 knots during the night, the engines working smoothly. Passed Cape Henlopen at 11.20 p. m., Absecon at 4.30, and Barnegat at 8.35 a. m. July 30. The position at noon was latitude 40° 06′ N., longitude 73° 09′ W., 177 miles from Wilmington, giving an average speed of 8.55 miles per hour.

At 5 p. m. passed Fire Island light-house, and between 5 and 6 observed azimuths of the sun on such courses as we would require during the trip for the purpose of ascertaining the deviation of our compasses. July 31, at 12.25 a. m., passed Montauk Point, at 3.30 Point Judith, at 4.15 Beaver Tail, and at 4.40 a. m. anchored in Dutch Island Harbor for the purpose of cleaning and painting ship.

Monday, August 2, got under way and steamed to Newport, the headquarters of Commission, and reported for duty in connection with deep-sea exploration.

The weather was unsettled and rainy during the 3d, 4th, and 5th, clearing during the night of the latter date, and on Friday, the 6th, we left the wharf at 8.35 a. m., with the naturalists on board, for our first dredging expedition of the season. It was an experimental trip for the purpose of testing the mechanical appliances, which were mostly new. Three hauls of the dredge and three of the trawl were taken in the channel to the westward of Canonicut Island, in from 8 to 12 fathoms of water, returning to port at 3.58 p. m.

Slight modifications were found necessary in the arrangement of leading blocks, accumulator, &c. The sounding apparatus was easily operated by one man, doing its work satisfactorily. In fact, the experience of the day satisfied us that with the modifications mentioned above, the apparatus would answer the purpose for which it was designed.

Six hauls of the dredge and trawl were taken on the 7th, in the channel between Fort Adams and the Dumplings, in from 17 to 27 fathoms of water. Great numbers of specimens were taken, sufficient to keep the scientific corps fully employed in the laboratory for several days.

On Friday, the 10th, the weather being favorable, the ship was swung under steam, and azimuths taken on every point to determine the deviation of compasses.

Thursday, August 12, took six hauls of the dredge and trawl in the sound, about three miles to the southward of Brenton's Reef light-ship, in from 16 to 19 fathoms. The trawl fouled a wreck during the day, detaining us several hours in vain efforts to clear it. Failing in this, we hove in all slack line and backed the engines till the dredge rope parted, losing the trawl and about 15 fathoms of rope.

Five hauls of the trawl and dredge were taken on the 13th, about 5 miles to the southward and eastward of the light-ship, in from 18 to 20 fathoms; and seven hauls on the 14th, in the vicinity of Point Judith, in from 18 to 19 fathoms. Four hauls were taken in various localities in Narragansett Bay on Monday, the 16th, and on the 17th, eight hauls on Brown's Ledge, from 8 to 12 miles SW. by W. of the Vineyard Sound light-ship, in from 11 to 22 fathoms.

Wednesday, August 18, took four hauls of dredge and trawl, about 20 miles S.SE. of Block Island, in from 27 to 29 fathoms of water. Thursday and Friday, the 19th and 20th, the naturalists were occupied in the examination and preservation of specimens. Saturday, the 21st, was foggy and rainy, the weather clearing during Sunday, and on Monday, the 23d, three hauls were taken between Narragansett Pier and Point Judith. A heavy swell prevailing in that locality, we ran into Narragansett Bay, where four hauls were taken in from 11 to 15 fathoms.

Thursday, the 24th, five hauls were taken from 1 to 3 miles to the eastward of Block Island, in from 13 to 22 fathoms, and on the following day one haul in the same vicinity, when, being overtaken by a heavy squall of wind and rain, we were forced to stop work and start for port. We had heavy rain and a dense fog all the way in, the weather clearing after we reached the harbor. We were detained in port the following day by a heavy swell in the sound, and, on the 27th, finding an uncomfortable sea outside, we ran into the Sakonnet River and took ten hauls of the dredge and trawl between its mouth and Gould Island.

The naturalists were employed in the laboratory on Saturday, and we were detained by unfavorable weather on Monday, but Tuesday, the 31st, was more favorable, and ten hauls of the trawl and dredge were taken in the channel between the Dumplings and Beaver Tail, and various localities in Narragansett Bay, in from 8 to 27 fathoms. On the following day, September 1, ten hauls were made between the Dumplings and Beaver Tail, in from 3 to 20 fathoms. The naturalists were occupied the following day in the laboratory, and on the 3d six hauls of the trawl and dredge were taken at the entrance to Vineyard Sound, from 3 to 4 miles to the southward of Cuttyhunk, in 17 fathoms.

At 3.30 p. m. we started for Wood's Holl, arriving at 4.30, when preliminary examinations of the harbor, &c., were made, with a view of stationing the ship at this place for codfish hatching during the coming winter.

At 5.15 p. m. left Wood's Holl, and started for latitude 40° 04′ N., longitude 70° 23′ W., the locality where the first tile fish (*Lopholatilus chamæleonticeps*) were reported to have been taken. We passed Gay Head at 7.05 p. m., and slowed down to about 3 knots between that point and No Man's Land, to allow surface towing by the naturalists, which resulted in the capture of some interesting specimens. The vessel was then put at a speed of 8 knots per hour for the night, in order to reach the desired position at daylight. The wind was light to moderate from SW., but there was quite a heavy cross swell from SE. to SW., increasing as we left the land, and, during the latter part of the night the vessel was rolling and pitching in a most lively manner.

At 4.50 a. m., September 4, stopped, latitude 40° 04′ N., longitude 70° 23′ W., cast the lead in 65 fathoms' sand, and lowered the trawl with most satisfactory results. Four miles south we found 192 fathoms; eight hauls were taken during the day between the depths above mentioned.

The results were remarkable, and the temptation to seek greater depths almost irresistible, but we had 300 fathoms of dredge rope only on the reel, and were obliged to confine ourselves within moderate depths.

The bottom and intermediate temperatures were unreliable owing to the use of the Negretti-Zambra deep-sea thermometer in a sea-way, the motion of the vessel being liable to capsize it at any time. It was the results of this day's work that led us to devise some plan by which this admirable thermometer could be used under all conditions of wind and weather.

The sounding and dredging apparatus which had heretofore been used in depths of but 30 fathoms or less, worked so well that we concluded to double their present capacity by adding to the length of rope and sounding wire.

At 1.40 p. m. we started for port, about 100 miles distant. The weather was clear at this time, but about 5 p. m. a heavy bank rose rapidly ahead, the wind veering to NW. At 7 p. m. the sky was entirely overcast with a light mist and drizzling rain, and at 10 p. m. a dense fog closed in. The speed was reduced and the fog-whistle sounded at short intervals.

At 3.30 a. m., September 5, stopped near Brenton's Reef light-ship to wait for daylight or the fog to lift; and, although frequently within a ship's length of the vessel, we could not see the lights. In fact, we saw the vessel herself for an instant only, after daylight, when we were less than a hundred feet from her. I mention this as an illustration of the density of coast fogs and the difficulties attending navigation during their prevalence.

After daylight we ran in by compass, catching an occasional glimpse of points as we passed up channel, and finally arrived at the wharf at 7.15 a. m.

We were employed Monday and Tuesday, the 6th and 7th, coaling ship; were detained by unsettled weather till the 12th, when, at 6.40 p. m., we left port for another off-shore trip.

While in port we doubled the length of our dredge rope by splicing 300 fathoms to that already on the reel, increased the length of wire on the sounding machine to something over 600 fathoms, and adopted a simple spring catch or detaching arrangement by which the Negretti & Zambra thermometer could be held firmly in position until the proper time to register the temperature by reversing it; this being accomplished (as explained in the description of the Negrette & Zambra thermometer as used by us at present) by sending a small weight or messenger down on the wire, detaching the spring catch by impact, and freeing the upper end, when, being inclosed in a metal case without bouyancy, it promptly reverses, thus registering the temperature.

At 5.35 a. m. on the 13th we cast the lead in 100 fathoms—latitude 40° 02′ N., longitude 70° 57′ W.—and sent the trawl down. Nine hauls were taken during the day in from 85 to 325 fathoms, within a radius of 7 or 8 miles, everything working satisfactorily in depths less than 200 fathoms; but our first attempt in deeper water resulted in numerous kinks in the rope and several turns around the trawl, which, of course, came up empty. A little caution in paying out the rope was all that was necessary, and we had no further trouble from those causes.

We had provided ourselves with a quantity of menhaden for bait, and, during the morning, set a trawl line in 126 fathoms—latitude 39° 57′ 07″ N., longitude 70° 56′ W.—for the purpose of catching tile-fish (*Lopholatilus chamæleonticeps*). The line was down 45 minutes, and on hauling it up three tile-fish were taken. Three more got off the hooks after coming to the surface and were lost. There were numerous skate and hake on the line, and the bait was gone from most of the hooks.

The line was set again in the afternoon in 250 fathoms—latitute 39°

48′ 30″ N., longitude 70° 54′ W.—without success, so far as tile-fish were concerned. There were, however, several hake and skate taken, showing that the line reached the bottom.

One of the tile-fish taken in the morning was boiled for dinner and served with egg sauce. The flesh was white and firm, bearing a strong resemblance to codfish in texture and flavor, though somewhat coarser.

Work was continued till 6 p. m., when the vessel was headed for port. It was evident, from a rapidly falling barometer and other indications, that a change of weather was impending. At nine o'clock the sky was overcast, threatening rain.

At 1 a. m. on the 14th the wind veered to northwest with thick rainy weather. We made Block Island light at 1.45, and at 2.40 were struck by a furious squall of wind and rain, with incessant thunder and lightning, followed by a dense fog. Between three and four o'clock, while passing several miles to the eastward of the island, a large pyramid of light was observed on shore, penetrating the dense fog and illuminating our surroundings, increasing the range of vision from a few yards to at least half a mile in every direction, and toward the island to a much greater extent. We could not detect a distinct flame or discover the source of light, but learned subsequently that it was caused by the burning of a hotel. The possibility of penetrating and illuminating a dense fog by the use of powerful lights was practically demonstrated by the occurrence above mentioned.

The wind veered to the northward and eastward, increasing rapidly, till at 7.15, upon our arrival in port, it was blowing a gale, which continued with greater or less violence till the 16th, detaining the vessel in port.

Friday, September 17, was clear and pleasant, with light winds.

At 10.17 a. m. we left the wharf with a number of gentlemen on board, and steamed up the bay, where hauls were made with the beam trawl, otter trawl, dredge, and rake dredge. Our system of sounding and taking serial temperatures, the preservation of specimens, &c., were explained to the guests, and at 4.15 p. m. we returned to port.

The 18th and 19th were occupied by the naturalists in preserving specimens, and we were detained on the 20th by fog.

At 9.15 a. m. on the 21st we left the wharf and steamed to the southward of Block Island, where we took five hauls of the trawl and dredge in from 11 to 19 fathoms water. A heavy southwest swell made it excessively uncomfortable on board, and, at times, almost impossible to carry on the work. We returned to our wharf at 7 p. m., the results of the day's work having been very satisfactory.

At 11 a. m. on the 22d we left for Wood's Holl with the Commissioner on board, arriving at 4.15 p. m. An inspection was made with the view of establishing an experimental station for codfish hatching during the coming winter.

We left Wood's Holl at 1.15 p. m. on the 23d, arriving in Newport at

5.30 p. m., when fires were hauled to clean the boiler, and this opportunity was taken to make some needed repairs to machinery, which were completed on the 25th.

Preparations were made for an off-shore trip on the 26th, but we were detained by unsettled weather, fogs, or strong winds till October 1, when at 4.30 p. m. we left the wharf and proceeded to sea.

The local deviation of our compasses was accurately obtained and tabulated upon our arrival at the station, but later in the season it became evident that it was changing, at least, on the north and south courses, and, to ascertain the actual error, azimuths were observed on the points between S. and SW. and N. by E. to NNW., the result showing a decrease of 2° to 3° on those points.

When the above observations were completed we steamed to the southward, and at 5.40 a. m. on the 2d cast the lead and put the trawl over, in latitude 39° 46′ N., longitude 71° 10′ W., in between 300 and 400 fathoms, bringing up a heavy load of soft mud with but few specimens. The depth was uncertain, as the sounding-wire parted at 310 fathoms before reaching bottom.

At 8.40 a. m. the trawl was cast again in latitude 39° 46′ N., longitude 71° 05′ W., in 487 fathoms, mud and small stones. A large number and great variety of specimens were brought up.

At 11.23 a. m. the trawl was cast again in 39° 52′ 20″ N., 70° 58′ W., 372 fathoms, bringing up mud, sand, and a few small stones.

Another haul was taken at 1.10 p. m.—latitude 39° 53′ N., longitude 70° 58′ 30″ W.—in 365 fathoms, sand and mud; and another at 3.17 p. m.—latitude 39° 56′ 30″ N., longitude 70° 59′ 45″ W.—in 238 fathoms, sand and mud. The hauls were all successful, but the last was the largest of the season, both in numbers and species. The weight in the net was so great that it required considerable time and great care to land it safely on deck. This being accomplished, we started at 5.25 p. m. for port, arriving at 5 a. m. on the morning of the 3d.

The 4th and 5th were occupied in coaling ship; the 6th in taking on board specimens of natural history, the result of the season's work, destined for New Haven and Washington, and making preparations for sea.

At 6.05 a. m., October 7th, we left Newport for New Haven, arriving at 3.50 p. m., and remained over night.

The articles consigned to Prof. A. E. Verrill were delivered, and, at 7.30 a. m., October 8th, we left for New York, arriving at the navy-yard at 2.30 p. m., where we took on board a supply of paymaster's stores, water, &c.

We left at 4.20 p. m. on the 12th for Wilmington, Del., to complete the hatching machinery left unfinished on our departure in July.

The weather was clear with a moderate gale blowing from NW. It was a fair wind, however, and by hugging the coast we had comparatively smooth water till we opened out Delaware Bay, where we encountered a heavy sea, which tested the strength and weatherly qualities of the vessel.

At 8 a. m. on the 13th we passed inside the capes, and at 4.30 p. m. arrived at the Pusey & Jones Company's works, Wilmington, Del.

Work was resumed at once on the hatching machinery. Some slight repairs were made about the engines, and such modifications as the season's experience suggested were adopted.

The work was completed on the 13th of November, and at 8.50 a. m. on the 14th we left for Washington, D. C.

The weather was unsettled, and finding cautionary signals flying at the cape we deemed it advisable to wait for a change. We anchored inside the breakwater at 4.30 p. m., remaining till 7.50 p. m. the following day, when, the weather having partially cleared, and the cautionary signals lowered, we got under way and proceeded to sea.

After clearing Cape Henlopen a course was laid which would carry the vessel off shore, intending to make a depth of from 100 to 200 fathoms water by daylight, when we proposed to try the dredge and trawl.

We encountered a heavy southerly swell during the night, but it moderated towards morning, and at 9.20 a. m.—latitude 37° 26′ north, longitude 74° 19′ west—cast the trawl in 56 fathoms, sand and shells. Six hauls were taken during the day, in from 300 fathoms down to 18, with most satisfactory results; several new species were added to the marine fauna of the coast, and some were found new to science.

The last haul in 18 fathoms was taken after dark for the purpose of ascertaining whether a greater number of fish would be taken than during daylight. We saw no perceptible difference, but a single haul would hardly be significant either way.

The trawl was up at 7.30 p. m., and the vessel headed for land, passing inside the capes of the Chesapeake at 12.55 a. m., the 17th. At 10.45 a. m. we anchored off Saint Jerome Creek, and sent a party in with the steam cutter to bring out a barge belonging to the Commission, which we were directed to tow to Washington. They found her lying in a bad position, pretty well filled with water, and the tide ebbing and flowing through the open seams in her sides and bottom.

The water was finally bailed out, the worst leaks temporarily stopped, and at high tide, about 2 a. m. on the 18th, an attempt was made to tow her out; but the channel had become filled with sand, making it narrow for her to pass.

She was taken back to her old station and anchored again, and, at low tide, all our available force was put to work with shovels to widen the channel. It was high tide again between two and three o'clock in the afternoon, when we succeeded in getting her out, reaching the ship at 5 p. m., having kedged off against a fresh northeast wind, and quite a heavy swell. As soon as the barge was fast astern the boats were hoisted and we got under way for the Potomac.

It was blowing a moderate gale from northeast by this time, with a drizzling rain, and the night was intensely dark; the sea was quite rough, causing the vessel to roll heavily, and soon filling the barge with water. We had two hawsers fast to her, but one parted when we were off Point

Lookout; the other held, however, and at 7.25 p. m. we anchored in Cornfield Harbor for the night. The wind had backed to northwest by this time, and was blowing a fresh gale, causing quite a swell, but we rode it out very comfortably. Working parties were kept bailing the water out of the barge during the night.

We got under way at 6.35 a. m. on the 19th, and, with the barge in tow, started for Washington.

At 8 a. m. the United States Fish Commission steamer Lookout steamed out of Saint Mary's River, and coming within hail informed us that she had a mail for the ship. It was still blowing fresh, with a heavy swell in our exposed position, so she was directed to follow us under the lee of Piney Point, where the mail was transferred, and she was directed to make the best of her way to Washington. We were obliged to run at about half speed, owing to the bad condition of the barge, and working parties were pumping and bailing during the day. At 5.20 p. m. we anchored off Indian Head for the night.

At 7.20 a. m. on the 20th we were under way again and arrived at the navy-yard, Washington, D. C., at 1.40 p. m.

The specimens of natural history and other articles consigned to the Smithsonian Institution were landed on the 22d. We coaled ship on the 26th and 27th.

Arrangements were made with the authorities at the navy-yard to caulk the main deck, and the crew were actively employed refitting ship until 9 a. m., December 4, when we left for the Lower Potomac on duty connected with the artificial propagation of oysters at Saint Jerome Creek.

At 7.15 p. m. anchored in Saint Mary's River for the night. At 8 p. m. the Lookout arrived and anchored near this vessel. The weather was thick and rainy, with a fresh breeze from the eastward.

On Sunday morning, December 5, the Lookout went into Smith's Creek, where she could find a more secure harbor, and this vessel followed her on the morning of the 6th, the weather still rainy and unsettled, with a heavy swell in the bay.

The object of the expedition was to dredge a quantity of oysters and plant them at the station in Saint Jerome Creek, for the purpose of investigation and artificial propagation during the following spring and summer; but unfavorable weather forced us to seek a harbor, and on the 7th the wind veered to northwest, blowing a fresh gale, with very cold weather, ice forming rapidly. On the 9th, when the gale moderated, the oyster-pond was frozen over, obliging us to abandon the attempt to carry out the object of the expedition at that time.

It was desirable to test the practical working of our dredging apparatus, and for that purpose we put it in operation on the banks between Smith's Creek and Point Lookout for about three hours, the result being 75 bushels of oysters, dead shells, &c., and 25 bushels of marketable oysters.

Having satisfied ourselves as to the working of our apparatus we started at 1 p. m. for Washington, anchoring at 9.20 p. m. off Nanjemoy Point for the night. The weather was clear and cold, ice making rapidly along the shores.

At daylight on the morning of the 10th we got under way and steamed up the river. At 9.30 spoke the Lookout off Quantico. They reported the river frozen above that place, and that they were unable to go any farther. We then steamed up to Stump Neck, but were obliged to return, the sharp young ice cutting the unprotected planking of the vessel's sides like a knife.

Having anchored off Quantico, the Lookout, which was short of coal, was taken alongside and a sufficient quantity transferred to her bunkers. I took the train for Washington to confer with the Commissioner as to the future movements of the vessels, and, returning at 12.30 p. m. the following day, both vessels were got under way for Norfolk, Va.

There was considerable floating ice about us at this time, and the river was frozen over both above and below. The ice was not more than 2 inches in thickness, and our engines would have forced us through it without the least difficulty, but, owing to the fact that our metal sheathing was below the water line, there was every probability that the vessel would sustain serious damage if we made the attempt.

Fortunately the Lady of the Lake, an iron steamer, was seen approaching, and following in her wake we finally reached clear water and arrived at our destination, the Norfolk navy-yard, at 7.50 a. m. on the 12th, with the Lookout in company. Both vessels were carefully examined on the 13th to ascertain the damage by ice. This vessel was repaired by the naval constructor at an expense of $285. The Lookout was repaired by our own mechanics without expense to the government.

The weather during the remainder of the month was unusually severe; navigation became very difficult in the Potomac, and considerable ice formed even in Norfolk.

We were actively employed, when the weather permitted, in painting and refitting both vessels, the work being in progress at the close of this report, December 31, 1880.

REMARKS BY MR. RICHARD RATHBUN ON THE SCIENTIFIC RESULTS OF THE SEASON'S EXPLORATIONS.

The explorations carried on in Narragansett Bay, and to the eastward and southward of Block Island, demonstrated the existence of a fauna similar to that previously discovered by the Fish Commission, in and about Vineyard Sound (1871 and 1875) and in Block Island Sound and the neighboring regions (1874), the species differing more or less, however, according to the depth and character of the bottom on which they lived. No new species of fish were found in these inshore dredgings, and most of the invertebrates obtained were identical with already known species. Sufficiently large collections of fish and invertebrates were made to properly illustrate the fauna of the region.

The three trips of the Fish Hawk to the inner edge of the Gulf Stream slope, on September 4 and 13 and October 2, resulted in the discovery of a new and exceedingly rich marine fauna, quite excelling anything hitherto encountered by the Fish Commission off the New England coast. In fact, the region opened up by these off-shore dredgings may be fairly regarded as the most interesting and prolific of any yet explored upon our northern coasts, both as regards the number of species found and the abundance of specimens. Several hundred species of both fish and invertebrates were taken by means of the dredge and beam trawl, the larger share being new additions to the fauna of Southern New England, and a considerable proportion entirely new to science. The bottom appeared to be nearly continuously covered with life, as the dredge and trawl seldom came to the surface without a load of interesting forms, demonstrating that the region was eminently well fitted as a feeding ground for fish, of which several edible species were taken by the Fish Hawk.

Attention was first called to this region in the winter of 1878–'79, by the discovery there of a new species of food-fish—the so-called tile fish (*Lopholatilus chamæleonticeps* Goode and Bean)—by a Gloucester fishing schooner, commanded by Captain Kirby. This fish, which is quite unlike any other species occurring on the New England coast, ranges in size very much like the cod, specimens having been taken weighing all the way from 3 to 60 pounds. Its flesh is white and firm in texture, and by many who have tried it is considered good eating. It can be salted and dried like the cod.

The main object of the Fish Hawk, in visiting this section of the Gulf Stream slope, was to ascertain the distribution and abundance of the tile fish, and the character of its feeding grounds, which, as stated above, were found to be very rich. A comparison of the various animals obtained from there with those brought in by the Gloucester fishermen from the great fishing banks off Nova Scotia and Newfoundland indicates that a close resemblance exists between these two regions, and very many of the species of animals are identical in both. As the tile fish cannot be taken in the dredges and beam trawls commonly used in exploring the sea bottom, an ordinary cod trawl-line, with several hundred hooks, baited with menhaden, was set for about an hour in 100 fathoms of water, on one of the trips, and three fine specimens secured, together with other species of bottom-feeding fish. Otherwise, the natural history investigations were conducted entirely by means of the dredge and beam trawl.

The bottom in the region explored, which, beyond the 75 to 100 fathom line, forms quite a rapid slope, differs considerably in character in different localities. In some places it has a smooth surface, formed of fine compact sand, with more or less mud and fragments of shells, and sometimes with small stones. In others it consists of softer mud and sand, or is covered with broken shells and great quantities of sponges, hydroids, and worm tubes. Both the sand and mud generally contain a large percentage of calcareous foraminifera, some of which are of unusually large size. The mud in some places also yields innumerable quantities of large sand-covered rhizopods, which vary greatly in form, some being irregularly branched or rudely stellate, and others simply rod-like, and measuring at times nearly an inch long.

An especial feature of several of the muddy localities was a large round worm tube, resembling a goose-quill both in texture and consistency. These tubes, which belong to a new species of the genus *Hyalinœcia*, often came up by the thousands, sometimes composing fully half the contents of the trawl. They frequently measure over a foot in length and are nearly straight, but somewhat larger at one end than at the other. They live free upon the bottom, probably, as a rule, lying flat upon the mud, the worms being able to drag them about. These tubes afford attachment to many species of invertebrates, belonging to the groups of hydroids, actinians, and sponges. Another common inhabitant of the muddy bottoms, giving shelter to numerous species of worms, actinians, and mollusks, was the beautiful gorgonian, or bush coral, *Acanella Normani*, previously known from the northern fishing banks. A large cup coral of rather fragile texture, the *Flabellum Goodei*, occurred abundantly on some of the muddy bottoms, and was taken in large quantities, though generally in a fragmentary condition.

The mollusca were the most prolific of all the groups, as regards the number of forms taken, 175 species having been secured on the three trips. Of these, 115 species were new to the fauna of Southern New England, and 48 species entirely undescribed. Among the mollusca were 8 species of cephalopods, including 3 genera new to the New England coast. One of the species was a large and curious form of *Octopus* (*Alloposus mollis*), with the arms joined together by a web. Many fragments and several nearly perfect specimens of the paper nautilus (*Argonauta argo*) were obtained from the deeper hauls. Some of the species of *Octopus* and squids were quite abundant.

The crustacean fauna of this region was very rich in the number of species and individuals. The majority of the forms obtained belonged to the decapoda or higher crustacea, the species of schizopoda, cumacea, and amphipoda being comparatively few in number. The echinoderms were represented by a large number of species, many of which were new to the region and to science. Several of the species of starfishes and ophiurans, and a species of crinoid (*Antedon Sarsii*) frequently occurred in such extreme abundance as to form a very conspicuous feature of the hauls. One new species of starfish, the *Archaster Americanus*, sometimes appeared by the thousands, and other new species, as well as several species previously known only from occasional specimens brought in from the fishing banks off Nova Scotia, were very common.

About 50 species of fish were taken in the beam trawl beyond the 100-

fathom line, the larger proportion being new additions to the fauna of Southern New England, and including at least 5 new genera and 18 new species. One interesting form was the pole flounder, common in the deeper parts of Massachusetts Bay and the Gulf of Maine, and of which both young and adult individuals were secured.

At each dredging station, collections were made with the towing net, which is designed to scoop in the free-swimming forms, living at the surface and at intermediate depths. It was used at the surface, at depths of 5 and 10 fathoms, and near the bottom, for the latter purpose having been attached to the dredge line a short distance above the dredge or trawl. The animals obtained by this means were mostly jelly fishes, pteropods, heteropods, salpæ worms, larval crustaceans of the higher orders, and copepods, the latter frequently occurring in countless numbers. They serve as food for the surface-swimming fish, such as the menhaden and mackerel.

Many of the species found in this new faunal region are arctic, or belong to the colder waters of the Atlantic coast of Europe, or to the Mediterranean. Others again are more tropical, being related to southern or West Indian forms. Some of the commoner forms of crustacea and echinoderms are identical with species described from off the Florida coast. The surface species belong mainly to the Gulf Stream fauna.

The mass of material taken on these three trips was very great, filling several hundred jars, and a greater number of small bottles and homœopathic vials, as well as many large tanks. The proper working up of this material requires the expenditure of much time and labor, and while several hundred species have already been recognized and described, large quantities of the smaller and more obscure forms still await elaboration.

The few dredgings made November 16, off the mouth of Chesapeake Bay, in depths of 18 to 300 fathoms, gave very interesting results, especially in the greater depths, where nearly all the species secured were identical with those from the more northern localities, the character of the bottom being also the same. A large amount of material was obtained for a single day's work. All the species have not yet been worked out, but the identifications, so far as they have been made, indicate that the several groups of invertebrates are represented by about the following number of species: The mollusca by 48 species, including three species of squids and two of *Octopus*; the echinoderms by 19 species; the polyps by 6 species; and the hydroids by two species. The singular tube-dwelling worm of the north, *Hyalinœcia artifex*, was also very abundant in this region, as were other associated species of worms.

Synopsis of the steam log of the United States Fish Commission steamer Fish Hawk, for the year ending December 31, 1880.

Stroke of piston in feet	$2\frac{1}{4}$
Number of condensing cylinders	2
Diameter of condensing cylinders in inches	22

Mean point of steam cut-off from commencement of stroke of piston in inches	10.89
Mean number of holes of "throttle" valve open	2.47
Mean vacuum in condenser, in inches of mercury	23.51
Mean steam pressure in boilers, while engines were in operation	26.25
Mean temperature of engine-room	88.8
Mean temperature on deck	58.4
Mean temperature of injection water	60.38
Mean temperature of discharge water	85.52
Mean temperature of feed water	86.7
Total time fires were lighted, in hours and minutes	2,333.45
Total time engines were in operation, in hours and minutes	437.04
Total time engines were in operation, in hours and minutes while dredging	100.15
Total number of revolutions, port engine	1,772,970
Total number of revolutions starboard engine	1,394,190
Mean number of revolutions per minute en route	84.15
Mean piston speed, in feed, per minute	378.68
Total number of knots run	2,825
Mean number of knots run per hour	6.56
Mean number of knots per hour en route	9.02
Tons of coal consumed for engineer department	$239\frac{175}{2240}$
Tons of coal consumed while engines were in operation	$125\frac{1000}{2240}$
Tons of coal consumed for galley	$8\frac{1730}{2240}$
Tons of refuse	$51\frac{1320}{2240}$
Mean number of pounds of coal consumed per hour while engines were in operation	657.95
Mean number of pounds consumed per square foot of grate	14.1
Total number of gallons of oil consumed	149.75
Total number of pounds of tallow consumed	121
Total number of pounds of wiping stuff consumed	117.75
Mean draught forward, in feet and inches	7′ 1¼″
Mean draught aft, in feet and inches	7′ 4″
Number of screws	2
Kind of	True.
Mean pitch, in feet and inches	12′ 3″
Diameter of screws, in feet and inches	6′ 8″
Length of screws, in feet and inches, parallel to axis	20″
Number of blades	4
Mean indicated horse-power	186.7
Maximum indicated horse-power	222.92
Mean number of pounds of coal per horse-power	3.32
Maximum number of pounds of coal per horse-power	3.9

Maximum number of pounds of coal consumed per square foot of grate	18
Maximum speed attained under steam alone, in knots per hour	10.52
Number of hours maintained	9½
State of sea	Smooth.
Maximum slip of screws in per cent	17.08
Maximum number of revolutions per minute	105
Mean slip of screws in per cent	12.1

Table of distances made under steam by the United States Fish Commission steamer Fish Hawk, for the year 1880.

Date.		Where bound.	Distance.
1880.			
July	29	From Wilmington, Del., to Newport, R. I	} 315
	30	..........do	}
	31	..........do	}
Aug.	2	Dutch Island Harbor to Newport, R. I	8½
	6	Dredging trip	20
	7	..........do	12
	10	Adjusting compasses	14
	12	Dredging trip	23
	13	..........do	30
	14	..........do	27
	16	..........do	83
	17	..........do	48
	18	..........do	80
	23	..........do	29
	24	..........do	45
	25	..........do	86
	27	..........do	48
	31	..........do	18
Sept.	1	..........do	14
	3	..........do	97
	4	..........do	130
	5	..........do	17
	6	Going to coal wharf	½
	8	Picking up moorings of this vessel	2
	12	Dredging trip	57
	13	..........do	105
	14	..........do	55
	17	..........do	25
	21	..........do	60
	22	Newport, R. I., to Wood's Holl	43
	23	Wood's Holl to Newport, R. I	43
Oct.	1	Dredging trip	69
	2	..........do	122
	3	..........do	47
	4	Going to coal wharf	½
	5	Trying port engine	2½
	7	Newport to New Haven	82
	8	New Haven to New York	53
	12	New York to Wilmington, Del	69.5
	13	..........do	148.5
Nov.	14	Wilmington, Del., to Washington, D. C	67
	15	Dredging trip	38
	16	..........do	181
	17	On the way to Washington, D. C	80
	18	..........do	8
	19	..........do	84
	20	..........do	22
	26	Navy-yard to Seventh street wharf	2
	27	Seventh street wharf to Navy-yard	2
Dec.	4	Washington, D. C., to Saint Jerome Creek	100
	6	Saint Mary's River to Smith's Creek	5
	9	Smith's Creek to Washington	61
	10	..........do	85
	11	Quantico to Norfolk, Va	97
	12	..........do	72
		Total distance run	2,825

Dredging and trawliug record of the United States Fish Commis

SEASON

Date.	Thermometer used.	No. of observation.	Locality.	Hour.	Tide.	Air.
1880.						
Aug. 6	N. Z. 40007 surf.; 42666 bottom,	770	Beaver Tail Light, SE. by S., ⅜ mile mag.	10 a. m.	Ebb	68
6	....do	771	Beaver Tail Light, SE. ¼ S., ¾ mile mag...	10.30 a. m.	..do	68
6	....do	772	Beaver Tail Light, S. by E., 1¼ mile mag.	11.35 a. m.	..do	72
6	....do	773	Beaver Tail Light, S. by E., 1⅝ mile mag.	11.45 a. m.	..do	72
6	....do	774	N. end Dutch Island, S., ⅛ mile mag......	1 p. m.	..do	72
6	....do	775	N. end Dutch Island, S., 1 mile mag......	1.35 p. m.	..do	79
7	....do	776	Fort Dumpling, NW. by W. ½ W., ⅝ mile mag.	9.45 a. m.	..do	72
7	....do	777	......do..............................	10.20 a. m.	..do	72
7	....do	778	Fort Dumpling, N. ¾ E., 800 yards........	10.40 a. m.	..do	76
7	....do	779	Fort Dumpling, NE., 1¼ miles	11.05 a. m.	..do	78
7	....do	780	Beaver Tail Light, W., 1 mile mag	11.30 a. m.	..do	70
7	....do	781	Beaver Tail Light, N. NW., 1 mile mag..	12 m...	..do	75
12	....do	782	Beaver Tail Light, W. ¾ N., 1¼ mile mag.	9.30 a. m.	Flood ...	68
12	....do	783	Brenton's Reef Light-Ship, N. by E., 1 mile mag.	10.15 a. m.	..do	70
13	....do	784	Point Judith, W. ⅛ S., 4¾ miles mag......	10.50 a. m.	..do	71.5
12	....do	785	Brenton's Reef Light-Ship, N. ⅛ W., 2½ miles mag.	11.30 a. m.	..do	72
12	....do	786	Brenton's Reef Light-Ship, N.W. ½ W., 4½ miles mag.	2.35 p. m.	H. W ...	74
12	....do	787	Brenton's Reef Light-Ship, N.NW. ⅛ W., 4 miles mag.	3 p. m.	Ebb	74
13	....do	788	Brenton's Reef Light-Ship, N.NW. ¾ W., 6 miles mag.	10.40 a. m.	Flood ...	70
13	....do	789	Brenton's Reef Light-Ship, N.NW. ¾ W., 5¼ miles mag.	11.05 a. m.	..do	70
13	....do	790	Point Judith, W. NW. ¾ W., 8⅛ miles mag	11.55 a. m.	..do	70
13	....do	791	Point Judith, W. NW., 12⅛ miles mag....	1.10 p. m.	H. W ...	72
13	....do	792	Point Judith, W. NW., 12 miles mag.....	1.50 p. m.	Ebb	72
14	....do	793	Point Judith, W. NW. ⅛ W., 6 miles mag	9 a. m.	....	71
14	....do	794	Point Judith, W. NW. ⅛ W., 5 miles mag	9.45 a. m.	....	70
14	....do	795	Point Judith, W. NW. ⅛ W., 4 miles mag	10.25 a. m.	....	71
14	....do	796	Point Judith, W. NW., 3½ miles mag	11 a. m.	....	70
14	....do	797	Point Judith, NW. by W. ¾ W., 2½ miles mag.	11.40 a. m.	....	70
14	....do	798	Point Judith, NW. by W. ¾ W., 1¼ miles mag.	12.10 p. m.	....	71
14	....do	799	Point Judith, W. ⅛ N., 1¾ miles mag	12.30 p. m.	....	70
16	....do	800	Poplar Point Light, N. NW. ⅝ W., 2¼ miles mag	11.35 a. m.	....	63
16	....do	801	Poplar Point Light, W. by N., 2¼ miles mag.	12.20 p. m.	....	65
16	....do	802	Half Way Rock, W., ¾ mile mag.........	2.15 p. m.	....	68
16	....do	803	Half Way Rock, N. by E. ¼ E., 2⅝ miles mag.	3.25 p. m.	....	67
17	....do	804	Cuttyhunk Light, NE. by E., 8¾ miles mag.	11.15 a. m.	....	68
17	....do	805	......do..............................	11.20 a. m.	....	68
17	....do	806	Cuttyhunk Light, E.NE., 7¾ miles mag ..	12 m.	....	69
17	....do	807	Cuttyhunk Light, NE. by E. ¾ E., 7¾ miles mag.	12.50 p. m.	....	70
17	....do	808	Cuttyhunk Light, NE. by E. ⅛ E., 8 miles mag.	1.20 p. m.	....	70
17	....do	809	Cuttyhunk Light, NE. by E., 12 miles mag.	1.55 p. m.	....	70
17	....do	810	Cuttyhunk Light, NE. by E., 12½ miles mag.	2.15 p. m.	....	70
17	....do	811	Cuttyhunk, NE. by E., 12½ miles mag....	2.20 p. m.	....	69
18	....do	812	Block Island Light, N. NW. ¼ W., 20 miles mag.	11.30 a. m.	....	70
18	....do	813	Block Island Light, N.NW. ¼ W., 20 miles mag.	11.55 a. m.	....	70
18	....do	814	Block Island Light, N.NW. ⅝ W., 18 miles mag.	1 p. m.	....	72
18	....do	815	Block Island, NW. by N., 17 miles mag..	2.15 p. m.	....	72
23	....do	816	Brenton's Reef Light-Ship, E. ¾ S., 2¾ miles mag.	10.25 a. m.	....	71
23	....do	817	Brenton's Reef Light-Ship, E. ⅛ N., 3 miles mag.	11 a. m.	....	72

sion steamer Fish Hawk, Lieut. Z. L. Tanner, commanding.

OF 1880.

Temperature of water, intermediate. Surface.	5 fathoms.	10 fathoms.	20 fathoms.	Bottom.	Fathoms, depth.	Character of bottom.	Wind.	Drift.	What used.
66.5	....	......	....	62.5	8½	Sand and shells	NE. 4	....	Dredge.
66.5	....	......	....	62.5	8½	....do	NE. 3	....	Trawl.
69.5	....	......	....	67	8	....do	NE. 2	....	Dredge.
69.5	....	......	....	67	8	....do	NE. 3	....	Trawl.
72	....	......	....	69	10½	Sand and mud	N. 2	....	Dredge.
72	....	......	....	68	12	Gravel, sand, and mud.	Calm	....	Trawl.
67½	....	......	....	58½	27½	Sand and shells	N. 1	....	Dredge.
67½	....	......	....	58½	27½	....do	N. 1	....	Trawl.
70	....	......	....	58½	26	....do	N. 1	....	Do.
68	....	......	....	57¼	22½	....do	SW. 1	....	Dredge.
69	....	......	....	57½	18	....do	SW. 1	....	Trawl.
69	....	......	....	57	16	Sand	SW. 1	....	Do.
70	....	......	....	60	10	Sand and shells	N. 1	....	Dredge.
70	....	......	....	55	17½	Sand	N. 2	....	Trawl.
71	....	......	....	53½	20	....do	NW. 2	....	Dredge.
71	....	......	....	54½	19½	....do	NW. 2	....	Trawl; trawl caught in wreck; parted rope.
71	....	......	....	53½	19	Mud	NW. 1	....	Dredge.
71	....	......	....	53½	19	Sand and mud	NW. 1	....	Trawl.
71	....	......	....	54	18	Sand	NW. 1	....	Dredge.
71	....	......	....	54	17½	....do	NW. 1	....	Otter trawl.
71	....	......	....	54½	16	....do	S. 1	....	Trawl.
71	....	......	....	60	20	....do	S. SW. 2	....	Dredge.
71	....	......	....	54	18	....do	SW. 2	....	Trawl.
69	....	......	....	63	19	....do	SW. 3	....	Dredge.
69	....	......	....	53	19	....do	SW. 4	....	Trawl.
69	....	......	....	53	19	....do	SW. 4	....	Dredge.
69	....	......	....	53	19	Mud	SW. 4	....	Trawl.
68½	....	......	....	55	16½	Sand	SW. 3	....	Dredge.
66	....	......	....	59	12½	Sand and shells	SW. 3	....	Do.
67	....	......	....	61	13	Black sand	SW. 3	....	Do.
70	....	......	....	69½	4	Sand	N. 3	....	Trawl.
71	....	......	....	68	4½	Mud	NE. 1	....	Do.
70½	....	......	....	62	12½	....do	NE. 1	....	Do.
69	....	......	....	60	20	Sand	S. SE. 2	....	Dredge.
66	....	......	....	59	11¼	....do	SW. 2	....	Do.
66	....	......	....	59	11¼	....do	SW. 2	....	Do.
67	....	......	....	56	14	....do	SW. 2	....	Trawl.
67	....	......	....	60	12¼	....do	SW. 2	....	Dredge.
67	....	......	....	60	18	....do	SW. 2	....	Do.
67	....	......	....	52	21¼	....do	SW. 2	....	Do.
67	....	......	....	52	21	....do	SW. 2	W. NW. ½ mile	Trawl; came up torn.
67	....	......	....	58	19½	....do	SW. 2	SW. ½ mile	Dredge.
66	....	......	....	46	28½	....do	SE. 2	NW. ½ mile	Do.
67	....	......	....	46	28½	....do	SE. 2	SE. ½ mile	Trawl.
72	71	57	49	46	27½	....do	SE. 2	SW. ½ mile	Do.
72	71	56	49	48	29	....do	S. 2	SW. ½ mile	Chester rake dredge.
69	....	......	....	66	8½	.. do	S. 2	SE. ½ mile	Dredge.
68	....	......	....	63	10	....do	S. 2	SE. ½ mile	Do.

Dredging and trawling record of the United States Fish Commission

SEASON

Date.	Thermometer used.	No. of observation.	Locality.	Hour.	Tide.	Air.
1880. Aug. 23	N. Z. 40007 surf.; 42666 bottom.	818	Brenton's Reef Light-Ship, E. ½ N., 8½ miles mag.	11.20 p. m.	....	72
23	....do	819	South End Hope Isle, SE. by E. ½ E., ½ mile mag.	1 p. m.	....	74
23	N. Z. 42666 surf.; N. Z. 40007 deep.	820	South End Hope Isle, N.NE., ¼ mile mag.	1.40 p. m.	....	76
23	....do	821	South End Hope Isle, N. by E., ½ mile mag.	2.15 p. m.	....	78
23	....do	822	South End Hope Isle, NE. ½ mile mag ...	3 p. m.	....	78
24	N. Z. 46400 surf.; N. Z. 40007 deep.	823	N. Light Block Island, W. ½ S., 1½ miles mag.	12.35 p. m.	....	74
24	....do	824	N. Light Block Island, SW. ¼ W., 1 mile mag.	12.50 p. m.	....	74
24	....do	825	N. Light Block Island W.SW. ¾ W., 1¼ miles mag.	1.30 p. m.	....	73
24	....do	826	North Light, Block Island, W.NW. ½ W., 2½ miles mag.	2.40 p. m.	....	73
24	....do	827	North Light, Block Island, W.NW. ½ W., 2½ miles mag.	3.05 p. m.	....	71
25	....do	828	North Light, Block Island, SW. by W. ¾ W., 2½ miles mag.	12.40 p. m	....	70
27	N. Z. 42666 surf.; 40007 deep.	829	Cormorant Rock, NW. by N., ¼ mile mag.	10.45 a. m.	....	63
27	....do	830	West Island, SE. by E. ½ E., ¾ mile mag..	11.15 a. m.	....	64
27	....do	831	North end Gould Island, SW. ¼ W., 350 yards mag.	12.30 p. m.	....	68
27	....do	832	North end Gould Island, W., 150 yards mag.	12.45 p. m.	....	70
27	....do	833	South end Gould Island, W., 100 yards mag.	1 p. m.	....	70
27	....do	834	McCurry's Point, W. SW., ¾ mile mag ..	1.30 p. m.	....	63
27	....do	835	McCurry's Point, N. ¼ E., 1¼ miles mag..	1.50 p. m.	....	68
27	....do	836	Black Point, W. ¼ N., ½ mile mag........	2.25 p. m.	....	66
27	....do	837	Black Point, NW. by W. ½ W., ½ mile mag.	2.45 p. m.	....	69
27	....do	838	Woods' Castle, W. by N., 1 mile mag	3.15 p. m.	....	66
31	....do	839	Dumplings, NW. ½ N., 300 yards mag....	9.50 a. m.	....	67
31	....do	840	Dumplings, N. by W. ½ W., 100 yards mag	10.03 a. m.	....	67
31	....do	841	Goat Isle Light, NE. by E. ¾ E., ⅝ mile mag.	10.45 a. m.	....	68
31	....do	842	Goat Isle Light, E. NE. ½ E., ½ mile mag.	11 a. m.	....	69
31	....do	843	North end Dyer's Island, NE. ½ E., ¾ miles mag.	12 m.	....	69
31	....do	844	North end Dyer's Island, SE. ½ E., ¼ mile mag.	12.30 p. m.	....	70
31	....do	845	Prudence Light, N. ½ W., ¾ mile mag....	1 p. m.	....	70
31	... do	846	Prudence Light, N. by E. ¾ E., 1½ miles mag.	1.35 p. m.	....	70
31	....do	847	Halfway Rock, N. ¼ W., 1 mile mag......	2.15 p. m.	....	70
31	....do	848	Bishop's Rock, E., ½ mile mag	3 p. m.	....	69
Sept. 1	....do	849	Fort Dumpling, W. NW. ½ W., ¼ mile mag.	9.20 a. m.	Ebb	67
1	....do	850	Fort Dumpling, E. NE. ½ E., ½ mile mag..	9.40 a. m.	..do	67
1	....do	851	Beaver Tail Light, SW. ¼ W., 1¾ miles mag.	10 a. m.	..do	66
1	....do	852	Beaver Tail Light, S. SW. ¾ W., 2½ miles mag.	10.35 a. m.	..do	67
1	....do	853	Beaver Tail Light, SW. by S., 2 miles mag.	10.50 a. m.	..do	68
1	....do	854	Beaver Tail Light SW. ¼ S., 1¾ miles mag.	11.10 a. m.	Ebb	69
1	....do	855	Beaver Tail Light SW. by S., 2 miles mag.	11.40 a. m.	Ebb	70
1	....do	856	Beaver Tail Light SW. ½ W., 1⅜ miles mag.	12.05 p. m.	..do	69
1	....do	857	Beaver Tail Light, W.SW. ¾ W., 1 $\frac{3}{16}$ miles mag.	12 35 p. m.	..do	69
1	....do	858	Beaver Tail Light, W. NW. ¼ W., ½ mile mag.	1.05 p. m.	Flood...	69
3	N. Z., 46400 surf.; 40007 deep.	859	Cuttyhunk Light, N. ½ W., 3 miles mag..	11.20 a. m.	....	68
3	....do	860	Cuttyhunk Light, N. ½ W., 3 miles mag..	11.55 a. m.	....	70
3	....do	861	Cuttyhunk Light, N. ¾ W., 3¾ miles mag.	12.20 p. m.	....	69

steamer Fish Hawk, Lieut. Z. L. Tanner, commanding—Continued.
OF 1880.

Temperature of water, intermediate. Surface.	5 fathoms.	10 fathoms.	20 fathoms.	Bottom.	Fathoms, depth.	Character of bottom.	Wind.	Drift.	What used.
68	....	......	....	65	9½	Sand	S. 2	SE. ¼ mile	Dredge.
73	....	......	....	70	6	Mud	S. SW. 3.	W. SW. ½ mile	Trawl; cracked thermometer No. 42666.
72	....	......	....	70	5½	....do	S. SW. 4.	W. by S. ¼ mile	Trawl.
72	....	......	....	70	5	....do	S. SW. 4.	SW. ¼ mile	Do.
71	....	......	....	70	4½	Sand	S. SW. 4.	W. ½ mile	Do.
65	63	63	....	60	15½	....do	W. 3	NW. ¼ mile	Dredge.
65	63	63	....	67	13	....do	W. 3	NW. ¼ mile	Trawl.
67	61	......	....	60	13	....do	W. SW. 4	NW. ¼ mile	Otter trawl.
67	66	......	....	57	22	Sand	S. 3	S. SW. ¼	Dredge.
67	66	......	....	57	20½	....do	S. 3	....	Blake trawl.
66	....	......	....	60	15	....do	N. NE. 6	E. NE. ½	Dredge.
66	....	......	....	65	9	Gravel	E. 2	S. by E. ¼	Do.
66	....	......	....	65	10½	Sand	E. 2	NE. ½ E. ¼	Do.
71	....	......	....	71	6	Black mud	SE. 1	S. ¼	Do.
71	....	......	....	71	9	....do	SE. 1	S. ¼	Do.
71	....	......	....	71	6½	Sand	SE. 1	S. ¼	Chester rake dredge.
73	....	......	....	71	11	....do	E. 2	N. by E. ¼	Do.
73	....	......	....	71	8½	Shells	SE. 2	N. ¼	Do.
71	....	......	....	71	5	Sand	S. SE. 2	S. SW. ¼	Do.
71	....	......	....	71	5	....do	S. SE. 2	S. by E. ¼	Trawl.
70	62	65	....	68	5½	....do	S. SE. 2	S. by E. ¼	Do.
67	65	65	....	61	27½	Gravel	N. NE. 2	SW. ¼	Dredge.
67	67	65	....	61	20½	....do	N. NE. 2	SW. ¾	Do.
67			....	60	21	....do	E. NE. 2	S. ¼	Do.
67	....	......	....	67	8	Sand	E. 2	....	Do.
69	67	......	....	63	14½	....do	E. 2	N. ¼	Trawl.
69	67	......	....	63	11½	....do	E. 2	W. SW. ¼	Do.
69	67	......	....	64	14½	Gravel	NE. 3	....	Do.
68	67	......	....	63	14½	....do	NE. 3	E. NE. ¼	Chester rake dredge.
68	68	......	....	62	12½	Mud	E. 3	N. NE. ¼	Trawl.
68	68	67	....	62	15½	....do	SE. 3	N. ¼	Do.
67	67	66	....	63	20	Sand	Var. 1	SW. ¼	Chester rake dredge.
67	67	66	....	63	14½	Shells	E. 2	S. SW. ¼	Do.
67	66	......	....	66	12½	Sand	SE. 2	S. ½ m.	Do.
66	....	......	....	66	2½	....do	E. 1	S. ¼ m.	Trawl.
76	....	......	....	67	4½	....do	E. 1	S. ¼ m.	Do.
67	....	......	....	67	6	Sand	SE. 1	S. ¼ mile	Trawl.
68	....	......	....	68	3½	....do	E. 1	S. ¼ mile	Do.
68	....	......	....	67	11	Gravel	E. 2	S. SE. ¼ mile	Chester rake dredge.
63	....	66.5	....	66	19	Sand	SE. 2	SE. ¼ mile	Do.
63	....	66.5	....	66	14	Shells	SE. 2	E. ¼ mile	Do.
66	65	......	....	63	17½	Sand	SW. 2	W. ¼ mile	Do.
66	65	......	....	64	17½	Mud	SW. 2	W. ¼ mile	Do.
66	65	65	....	61	17	Sand	SW. 2	S. ¼ mile	Trawl.

Dredging and trawling record of the United States Fish Commission

SEASON

Date.	Thermometer used.	No. of observation.	Locality.	Hour.	Tide.	Air.
1880. Sept. 3	N. Z., 46400 surf.; 40007 deep.	862	Cuttyhunk Light, N., 4 miles mag	12.55 p. m.	....	68
3	....do	863	Cuttyhunk Light, N. ⅛ E., 8¾ miles mag..	1.40 p. m.	Flood...	70
3	....do	864	Gay Head Light, S. SW. ⅜ W., 5 6/10 miles mag.	3.00 p. m.	Flood...	70
4	N. Z., 46400 surf.; 46401 deep.	865	Lat. 40° 05′ N., long. 70° 23′ W	5.40 a. m.	....	71
4	....do	866	Lat. 40° 05′ 18″ N., long. 70° 22′ 18″ W....	6.30 a. m.	....	73
4	....do	867	Lat. 40° 05′ 42″ N., long. 70° 22′ 6″ W	7.04 a. m.	....	75
4	....do	868	Lat. 40° 01′ 42″ N., long. 70° 22′ 30″ W...	8.23 a. m.	....	75
4	....do	869	Lat. 40° 02′ 18″ N., long. 70° 23′ 06″ W...	9.27 a. m.	....	80
4	....do	870	Lat. 40° 02′ 36″ N., long. 70° 22′ 58″ W ..	10.50 a. m.	....	80
4	....do	871	Lat. 40° 02′ 54″ N., long. 70° 23′ 40″ W ...	11.40 a. m.	....	84
4	....do	872	Lat. 40° 05′ 39″ N., long. 70° 23′ 52″ W ...	12.45 p. m.	....	81
13	N. Z., 46404 surf.; 46400 deep.	873	Lat. 40° 02′ N., long. 70° 57′ W...........	5.36 a. m.	....	68
18	....do	874	Lat. 40° N., long. 70° 57′ W..............	6.26 a. m.	....	70
18	....do	875	Lat. 39° 57′ N., long. 70° 57′ 30″ W.......	7.51 a. m.	....	70
13	....do	876	Lat. 39° 57′ N., long. 70° 56′ W...........	8.45 a. m.	....	68
13	....do	877	Lat. 39° 56′ N., long. 70° 54′ 18″ W........	9.40 a. m.	....	71
13	....do	878	Lat. 39° 55′ N., long. 70° 54′ 15″ W.......	11.00 a. m.	....	72
13	....do	879	Lat. 39° 49′ 30″ N., long. 70° 54′ W	1.20 p. m.	....	73
13	....do	880	Lat. 39° 48′ 30″ N., long. 70° 54′ W	3.12 p. m.	....	74
13	....do	881	Lat. 39° 46′ 30″ N., long. 70° 54′ W.......	5.00 p. m.	....	70
17	....do	882	Halfway Rock, N. NE. ½ E., 2⅜ miles mag	10.50 a. m.	....	68
17	....do	883	Halfway Rock, NE. by N., 2¼ miles mag	11.35 a. m.	....	70
17	....do	884	Hope Island, NE. ½ E., 20 yards mag	2.10 p. m.	....	72
17	....do	885	Gould Island, N. by E. ¾ E., ⅜ mile mag ..	3.15 p. m.	....	71
21	....do	886	South Light, Block Island, N. ¾ E., 5¾ miles mag.	12.46 p. m.	....	67
21	....do	887	South Light, Block Island, N. ½ W., 5¾ miles mag.	1.30 p. m.	....	67
21	....do	888	South Light, Block Island, N. by E., 6 miles.	2.00 p. m.	....	68
21	....do	889	South Light, Block Island, W. ¾ S., 5 miles mag.	3.50 p. m.	....	68
21	....do	890	South Light, Block Island, W. ½ S., 4¾ miles mag.	4.15 p. m.	....	68
Oct. 2	N. Z. 46403 surf.; 46404 deep.	891	Lat. 39° 46′ N., long. 71° 10′ W..........	6.00 a. m.	....	60
2	....do	892	Lat. 39° 46′ N., long. 71° 05′ W	8.46 a. m.	....	64
2	N. Z. 46403 surf.; Mil.-Casel. deep	893	Lat. 39° 52′ 20″ N., long. 70° 58′ W	11.23 a. m.	....	63
2	....do	894	Lat. 39° 53′ N., long. 70° 58′ 30″ W	1.10 p. m.	....	63
2	....do	895	Lat. 39° 56′ 30″ N., long. 70° 59′ 45″ W....	3.17 p. m.	....	62
Nov. 16	46405 surf.; 46403 deep.	896	Lat. 37° 26′ N., long. 74° 19′ W..........	9.20 a. m.	....	52
16	....do	897	Lat. 37° 25″ N., long. 74° 18′ W..........	10.10 a. m.	....	62
16	....do	898	Lat. 37° 24′ N., long. 74° 17′ W..........	11.25 a. m.	....	60
16	....do	899	Lat. 37° 22′ N., long. 74° 29′ W	1.55 p. m.	....	58
16	....do	900	Lat. 37° 19′ N., long. 74° 41′ W	4.00 p. m.	....	55
16	....do	901	Lat. 37° 10′ N., long. 75° 08′ W	7.15 p. m.	....	53
Dec. 9	N. Z. 46405 surf.; 46402 deep.	902	Point Lookout, SE. by E., 3½ miles	9.55 a. m.	....	30
9	....do	903	....do....................................	10.05 a. m.	....	30
9	....do	904	....do....................................	10.08 a. m.	....	30
9	....do	905	....do....................................	10.15 a. m.	....	30
9	....do	906	....do....................................	10.33 a. m.	....	32
9	....do	907	....do....................................	10.40 a. m.	....	33
9	....do	908	....do....................................	10.55 a. m.	....	36
9	....do	909	....do....................................	11.07 a. m.	....	34
Dec. 9	....do	910	....do....................................	11.20 a. m.	....	34
9	....do	911	....do....................................	11.44 a. m.	....	34
9	....do	912	....do....................................	11.54 a. m.	....	34
9	....do	913	....do....................................	11.08 p. m.	....	36
9	....do	914	....do....................................	12.23 p. m.	....	38
9	....do	915	....do....................................	12.38 p. m.	....	38
9	....do	916	....do....................................	12.47 p. m.	....	38

steamer Fish Hawk, Lieut. Z. L. Tanner, commanding—Continued.

OF 1880.

Temperature of water, intermediate.									
Surface.	5 fathoms.	10 fathoms.	20 fathoms.	Bottom.	Fathoms, depth.	Character of bottom.	Wind.	Drift.	What used.
66	65	......	....	64	17	Sand	SW. 2	S. ½ mile	Trawl.
67	65	65	....	65	18	Mud	SW. 2	S. ½ mile	Chester rake dredge.
67	66	......	....	65	18	Sand	SW. 2	S. ½ mile	Dredge.
73	75	......	....	68	65	Sand	Var. 2	E. NE. ¾ mile	Trawl.
73	74.5	......	....	68.5	65	....do	Var. 1	NE. by E. ½ mile.	Do.
73	75	......	....	53	64	....do	Calm	E. SE. ¾ mile	Chester rake dredge.
75	75	......	....	47	162	....do	Calm	NW. ¾ mile	Trawl.
76	75	......	....	50	192	....do	Calm	N. NE. ¾ mile	Do.
77	75	......	....	......	155	....do	Calm	W. by N. 1 mile	Do.
76.5	75	75	....	49	115	....do	Calm	N. NW. ¾ mile.	Do.
77	75	......	....	50.5	86	....do	S. 1	NW. by N. ½ mile.	Do.
69.5	70	70	....	51	100	Mud	SW. 3	NW. by N. ½ mile.	Do.
70	70	70	64	51	85	....do	SW. 2	NW. ½ mile	Do.
70	71	70	69	53	126	....do	SW. 2	NE. ½ mile	Do.
70	71	70	69	53	120	....do	SW. 2	N. ¾ mile	Do.
71	70	70	66	57	126	....do	SW. 2	N. NW. ¾ mile.	Do.
71	70	70	55	52	142½	....do	SW. 2	NW. ¾ mile	Do.
71.5	71	71	70	42	225	....do	SW. 3	N. by W. ¾ mile	Do.
71.5	74	72	....	43	252½	....do	SW. 3	W. by N. ¾ mile	Do.
71	71	71.5	....	42	825	....do	SW. 3	W. NW. ½ mile	Do.
65	....	......	....	67	12½	Mud	SW. 2	SW. ½ mile	Trawl.
65	....	......	....	63.5	13	....do	SW. 2	SW. ½ mile	Do.
65	....	......	....	63.5	5	....do	SW. 3	SW. ¾ mile	Chester rake dredge
69	64	......	....	65	16	....do	SW. 2	S. ¼ mile	Otter trawl.
64	62	......	....	62	19	Shells	W. 2	N. ½ mile	Dredge.
64	62	......	....	62	19	....do	W. 2	W. ¾ mile	Trawl.
64	62	......	....	62	19	....do	W. 3	W. 1½ miles	Do.
64	62	......	....	61.5	11	Rocky	W. 3	W. SW. ½ mile	Dredge.
64	62	......	....	61.5	11	....do	W. 3	W. SW. ½ mile	Do.
67	....	......	....	......	810	Mud	NE. 3	N. ½ mile	Trawl; sounding wire broke at 810 fathoms.
65	....	......	....	......	487	Mud; small stones.	NE. 3	N. NE. 2 miles	Trawl; lost lead and thermometer at surface of water.
64	....	......	....	40	872	....do	NE. 3	N. 1 mile	Trawl.
64	....	......	....	40	865	Sand	NE. 3	N. 2 miles	Do.
65	....	......	....	42	238	Mud	NE. 3	N. 1½ miles	Do.
62	....	......	....	55	56	Sand and shells.	NW. 2	W. NW. ½ mile	Do.
62	....	......	....	48	157½	Mud	SW. 2	W. 1 mile	Do.
62	....	......	....	44	800	....do	SW. 2	W. 1 mile	Do.
61	....	......	....	54	57½	Sand	SW. 2	SW. ½ mile	Do.
59	....	......	....	56	81	....do	SW. 2	W. ½ mile	Do.
60	....	......	....	......	18	....do	SW. 2	W. ½ mile	Do.
50	....	......	....	40	8	Oyster bank	NW. 2	NW. ½ mile	Oyster dredge.
50	....	......	....	40	4	....do	NW. 3	NW. ½ mile	Do.
45	....	......	....	40	4	....do	NW. 3	N. ½ mile	Do.
45	....	......	....	40	8½	....do	NW. 3	N. NW. ½ mile	Do.
45	....	......	....	39	8¼	....do	NW. 3	N. NW. ½ mile.	Do.
45	....	......	....	39	8	....do	NW. 3	N. NW. ½ mile.	Do.
45	....	......	....	39½	8	Oyster rock	NW. 2	NW. ½ mile	Do.
45	45	......	....	40	8	....do	NW. 2	W. ½ mile	Do.
....	45	......	....	39	8	....do	NW. 2	NW. ½ mile	Do.
....	45	......	....	40	8	....do	NW. 1	N. NW. ½ mile.	Do.
....	45	......	....	40	8	....do	NW. 2	N. ½ mile	Do.
....	45	......	....	40	8	....do	NW. 2	N. NW. ¾ mile.	Do.
....	45	......	....	40	8	....do	NW. 2	N. NW. ½ mile.	Do.
....	45	......	....	40	8	....do	NW. 2	N. NW. ¼ mile.	Do.
....		......	....	40	8	....do	NW. 2	N. NW. ½ mile.	Do.

LIST OF PLATES.

INDEX.