the fishery, perhaps permitting boats to work in areas now unsuitable for shrimping because of adverse bottom conditions. In addition there is a very definite need for trawl experimentation. The primary reason is that present gear is not sufficient to explore and adequately sample some areas of reported or suspected commercial potential. Coral and shell on the north coast of Yucatan, soft mud in the newly discovered red shrimp beds, large numbers of loggerhead sponges on the Florida coast, and the mud lump areas off the Mississippi Delta have been main concerns to date, and all these present different problems in adapting or designing gear. If gear can be developed to overcome these obstacles, a major problem in the exploitation of a possible commercial discovery will be well on the way to being solved.

Attempts are being made to evaluate the various components of shrimp trawls, to learn how different cuts and shapes, hangings, and the materials of a trawl affect catch-rate and selectivity of species. Trawls have been constructed and tested with the bottom completely removed back to the funnel, as have trawls with extremely lengthened jibs and wing-tips and with new jib shapes. After each series of tests the trawls are examined for areas of particularly severe strain or apparent poor performance. Whenever a possible improvement is devised it is incorporated.

The gear development program of the OREGON thus seeks to supplement, rather than duplicate experimentation by fishermen, and to work in fields which the industry cannot conveniently carry out trials.

Oceanographic Instruments, Their Use and Application in Marine Biology

A. W. Anderson and John Lyman

U. S. Navy Hydrographic Office, Washington, D. C.

Introduction

Special problems in marine biological work may often require detailed data on only one or two of the major environmental oceanographic factors, while general marine biological problems usually require comprehensive data on all of the environmental conditions, i.e., salinity, temperature, oxygen, nutrients, transparency, currents, and bottom sediments. To obtain such data scientists have employed both biological and oceanographic instruments.

Many of the instruments used in marine work are suited to the requirements of both the marine biologist and the oceanographer. Since some of the present-day devices have been used successfully by both groups for years, it might be of value to call the attention of biologists to other recent developments in the field of oceanographic instrumentation.

Basic Oceanographic Instruments

Two basic oceanographic instruments, the Nansen bottle and bathythermograph, the conditions they evaluate, and their application to marine biology will first be described.

A Nansen water bottle or sampler, for collecting serial samples at sub-surface levels, is closed at any desired depth by sliding a messenger down the wire when the proper amount has been paid out. The trapped sample is not contaminated by water at higher levels nor lost by leakage after the bottle is brought on board. To enable temperatures and water samples to be taken at the same depths, the water-sampling bottles are fitted with frames in which two or more reversing thermometers are placed.

The bottles are closed automatically by a messenger, released from the deck. Each bottle in turn releases a messenger to close the bottle below it. The vessel must be stationary, and sufficient time must elapse for the thermometers to record the temperature. From such a cast the temperature can be read to the nearest 0.01 °C, and there is sufficient sample, 1250 ml., for nutrient determination and salinity and oxygen titrations. The possible depth of sampling is limited only by the length of wire available. Usually 5/32″ diameter aircraft control cable is used with Nansen bottles.

The bathythermograph, (or "BT"), is designed to obtain a record of the temperature in relation to depth. It can be operated while the ship is underway at speeds up to 18 knots. Best results, however, are obtained when the speed is not in excess of 12 knots.

As the BT is lowered in the water a trace is made on a smoked glass slide through the interaction of a pressure element with a thermal element, graphing the water temperature against depth. From a calibration grid, individually prepared for each instrument, the temperature can be read to the nearest 0.2°F. or 0.1 °C. Models are available which can measure temperatures in depth up to 300 meters. Others give more expanded temperature traces in depths up to 60 and 150 meters. The wire used with the BT is usually either 1/16″ or 3/32″ diameter, and a length of about twice the maximum sampling depth is required, to allow for a wire angle of about 60°.

This instrument is useful for quick location of water of a particular temperature at a given depth. When such areas are located, specialized salinity- temperature-depth determining instruments may be employed to explore the region further.

Dual-Purpose Sampler-Type Instruments

Three outstanding, dual purpose sampler instruments have been developed since World War II. They are the Spilhaus Sea Sampler, (Woods Hole, 1948), the Auxiliary Sea Sampler, (Woods Hole, 1949), and the Wohlenberg Water Sampler-Sediment Trap, (Wohlenberg, 1950).

Spilhaus Sea Sampler

The Spilhaus Sea Sampler is a modification of the standard bathythermograph, to permit the collection of water samples, while under way, at predetermined depths, while simultaneously making a BT trace. The instrument consists of a bathythermograph around which are arranged twelve small sample bottles. These bottles are closed automatically at predetermined depths by pressure, as the instrument is brought to the surface.

Tests with the sea sampler have indicated that there is a lag of about 2.5 meters when operating from a stationary vessel. When the vessel is underway the error is reduced by vibration to a very small fraction of this figure.

Auxiliary Sea Sampler

A specialized sea sampler of single-bottle design is attached to a BT and arranged to trap water at the lowest depth of the instrument's traverse when used from a stationary or moving vessel. This is accomplished by utilizing the deep dive attachment, a standard accessory for the BT.

The use of the instrument is limited, in that the depth at which the sample is to be taken is not closely predetermined, but is largely left to chance. Also, only a single sample can be obtained during a BT dive. These disadvantages are partially outweighed by the fact that only minor BT modifications are necessary to attach the auxiliary water bottle.

Wohlenberg Water Sampler-Sediment Trap

This is a horizontal water sampler, which serves a dual purpose: as a water sampler and as a sediment trap. The instrument is lowered to the bottom from an anchored ship, allowed to orient itself into the prevailing current and then vented by means of a messenger. A second messenger is used to close the sampler, and trap its contents.

The sample can be collected to within two centimeters of the bottom, and under such conditions produces a representative sample of the water immediately adjacent to the bottom. These samples can be analyzed for salinity, oxygen, bacterial content, plankton concentration, and sediment load.

These three dual purpose sampler-type instruments have obvious application in pollution problems of marine waters. In many cases it is extremely difficult to trace the horizontal and vertical distribution of a pollutant except by means of sampling. Such sampling is often cumbersome and slow, especially in delineating the boundaries or interfaces of pollutants. Both the Spilhaus and Auxiliary samplers provide quick means of obtaining representative samples over large areas. The Wohlenberg sampler is particularly useful in locating pollutants with a density greater than that of water.

Dual Purpose Electronic Instruments

In all sciences electronic instruments are replacing or supplementing the mechanical instruments of yesterday. Electronic instruments are popular because they reduce the amount of physical labor necessary to perform a task. Typical new developments in the field of oceanography in electronic devices are the Salinity-Temperature-Depth Recorder, (the "STD.") (Jacobson, 1948) and the Conductivity-Temperature-Depth instruments, (the "CTD,") (Chesapeake Bay Institute, 1951). The development of the STD and the CTD indicates the scientists' need for faster, more accurate instruments.

Salinity-Temperature-Depth Recorder

The Salinity-Temperature-Depth Recorder consists of a sub-surface head, a mechanical measuring circuit, and a computer. The sub-surface head contains three parts: a resistance thermometer constructed of small nickel wires drawn into a fine tube and sealed at both ends; a conductivity cell, formed by the insertion of three platinum-lined electrodes in a plastic tube protected by heavy bronze tubing; and a Bourdon depth element constructed of beryllium copper alloy. The free end of the depth element carries a contact that moves over a wire slide in the manner of a rheostat, thereby converting a position movement into electrical values which can be transmitted to the computing and recording mechanisms on the ship's deck.

The measuring and computing mechanisms are electro-mechanical servo systems. A Wheatstone bridge circuit is used to measure the resistance of the thermometer unit, while the readings of both the temperature unit and the conductivity unit are fed into a computing mechanism that converts the values to salinity. Depth in feet, Fahrenheit temperature, and salinity are recorded against time by pen traces on a paper tape.

In field test the extreme range of errors of the STD was from plus 0.18 to minus 0.30 parts per thousand salinity and from zero to 1.6°F. temperature. The depth range is from zero to 90 meters.

Conductivity-Temperature-Depth Instrument

A second combination salinity-temperature-depth instrument is now being developed for use in shallow waters; i.e., less than 300 feet. This instrument, the CDT, measures conductivity, temperature, and depth with a reaction time of less than 0.4 second. The bulk of the device is one-third that of the STD. Values are indicated directly on four-digit counters.

The submerged head, lowered by its electrical cable, indicates by an amplifier and dial system on deck the conductivity, temperature and depth of the water through which the head is passing. A permanent record of the conditions may be obtained by adding a mechanical recorder in conjunction with the amplifier, or by photographing the readings of the counters and a clock.

Field tests indicate that the temperature element is accurate to 0.05°C., while the conductivity element is sensitive enough to produce figures accurate to 0.5 milimhos. The depth element is still under development.

Either the STD or the CTD can be hull-mounted to give continuous, instantaneous readings of horizontal distribution of the temperature and salinity. They are extremely valuable in locating regions of salinity or temperature difference and can cover large areas in much less time than the older sampling techniques.

Bottom Sampling Instruments, Mechanical and Electronic

Bottom conditions often provide the best key to the location of suitable grounds for particular types of marine organisms. Shrimp of economic importance are most often located over and on mud bottoms. Generally, oyster propagation is most successful on shell bottoms. Various species of ground fish show a preference for a particular type of bottom, and the determination of bottom conditions provides an aid in locating new fishing grounds. In pollution studies bottom sediments may disclose the presence of a heavy contaminant several days after the initial introduction of the pollutant.

Types of bottom sediments may be determined several ways, depending upon the data required and the time allotted to make the survey. The superficial layer of bottom sediments may be examined by using the Underway Bottom Sampler (Emery and Champion, 1948) or the Soundfish (Lafond, Dietz and Knauss, 1949). In coring operations to determine the depth of sediments, the Kullenberg Piston Corer, (Scripps, 1950), works equally well in sand, mud, shell, and clay.

Underway Bottom Sampler

This instrument for collecting bottom samples was designed to be used on ships moving at speeds up to 10 knots. The sample taken shows only the superficial layers of the sediments.

A connector or swivel on the sampler is attached to a bathythermograph cable, or similar equipment. The fish is allowed to sink freely until it strikes the bottom. When this happens the retaining cup is driven back into the tube, releasing the spring-loaded lid. The scoopfish is then brought to the deck, the cup removed and the sample examined.

In skillful hands samples up to fifty grams can usually be obtained. When working over shell or rock bottoms, mechanical difficulty in the closure of the lid sometimes results in loss of the sample. A prospective solution to the problem of proper closure is the redesign of the lid and the addition of a sponge rubber seal between the lid and fish case.

Soundfish

To meet the requirements of rapid bottom sediment determination, Lafond, Dietz, and Knauss developed and tested a sonic sampler consisting of a Brush hydrophone encased in a water-tight metal cylinder. The metal case provides protection for the hydrophone and forms a sounding board as it is dragged along the bottom. Circular ridges on the outside of the case increase the frictional sound developed. As the case scrapes the bottom the sound is picked up by the hydrophone and transmitted up an electrical cable to listening equipment. Suitable equipment consists of a battery-powered audio amplifier and headphones. The amplifier should be operative in the 500 to 10,000 cycle band.

The sounds produced by gravel, mud, shell, and sand are each distinctly characteristic. Rock produces loud clangs, sand makes a heavy rasping noise, and mud produces a quiet swishing noise. In combination of fine and course material the sound of the coarse fraction dominates. Under good condition a trained observer can differentiate between the sounds made by fine and coarse sand. A similar device has been employed by Woods Hole Oceanographic Institution to differentiate between sand, gravel, and clams.

Such an instrument is especially useful in delineating the horizontal boundaries of various bottom types and reduces the amount of working time necessary when looking for a particular type of bottom. A permanent record of the sounds produced and the bottoms sampled may be obtained by using a pen recorder coupled with the audio amplifier.

Kullenberg Piston Corer

The Kullenberg Piston Corer, with modifications by various users, operates well in all types of bottom sediments. The latest modifications made by the Hydrographic Office are in the cutting head and piston size. By reducing the diameter of the piston and cutting head a plastic tube may be inserted into the twelve-foot barrel. Cores taken in the plastic tube may be stored with little difficulty for future analysis. For marine bacteriological studies the cores must be extruded within a few hours of coring operations to prevent marked changes in the flora of the core. The plastic inserts can be reused.

The instrument and release mechanism must be lowered from a stationary vessel. As the pilot weight touches bottom the corer is released to penetrate the sediments. The corer's free-fall distance is determined by adjusting the length of the pilot weight line. Normal free-fall distances are less than thirty feet.

Several lengths of tubing may be used, convenient ones being 20, 15, 12 and 6 feet. The use of any one section or combination of sections works equally well. Cores of thirty feet and greater have been made in soft sediments.

Current-Measuring Devices

Current meters of many designs have been used both by the biologist and the oceanographer to determine the current velocities in marine waters. Probably the best known, the Ekman and Price meters, have been used successfully by the biologist in bays and near-shore waters to determine the current flow in relation to fish migration and marine life dispersal. The mass transport of plankton and marine invertebrates to and from the bays and shelf waters is greatly influenced by the currents of the near-shore waters. Detailed knowledge of the currents is necessary to understand the transport of larval forms of oysters, crabs, etc., from the point of hatching to the point of attachment or residence.

Three other instruments for current measurements are relatively recent developments in oceanography. The Roberts Radio Current Meter, (Roberts, 1950), and the Schaufelrad (Paddle-wheel) Current Meter as reported on by Boehnecke (1948), are mechanical instruments for measuring currents. The Geomagnetic Electrokinetograph, (von Arx, 1950), presents a new electromagnetic method for measuring the velocities of ocean currents from a ship underway.

Roberts Radio Current Meter, Model II

The Roberts Radio Current Meter consists of three parts: the buoy, transmitter, and meter. A buoy, of ship-like design, anchored at a particular station, contains a battery-operated radio transmitter and antenna. Below it is streamed the Roberts Current Meter, at the desired depth, connected by an electric cable. The meter impeller reacts to the flow, actuating an interior contacting mechanism controlled in part by a magnetic compass. Contacts are made within the meter for current direction and velocity, telegraphed to the buoy and transmitted from the buoy as a radio signal. At a radio receiving station, either ashore or afloat, the signals are received, amplified and recorded by means of a chronograph. Observers tune the individual radio buoy frequencies, record the signals, scale the tape, and tabulate the values for each current station.

Accurate measurements are not possible in currents of less than 0.3 knots. The radio transmitting range is limited to ten miles. While little can be done about the first limitation, the second can be bettered by redesign of the radio transmitter.

Schaufelrad Current Meter

Another moored and buoyed current meter, the Schaufelrad (Paddle-wheel) Current Meter, is a self contained, continuous recording instrument. This device is moored into position with an anchor and held off the bottom with a buoy. The buoy also aids in the recovery of the instrument. The size of the instrument, 170 cm. long and 58 cm. wide, makes it impossible to use the instrument closer than 100 cm. to the bottom.

A paddle-wheel mounted in the top of the bomb-shaped shell is turned by the currents. An intermittent light source records on photographic film strip the turns of the paddle-wheel and the direction as indicated by a compass. After the desired period of operation, up to four weeks, the meter is raised, the film strip removed and developed. The traces of light are scaled to determine the water current direction and speed adjacent to the instrument during the period of immersion.

Geomagnetic Electrokinetograph

As far back as 1832, (von Arx, 1950), there was an attempt to measure an electric current flowing over a short range in response to water motions. Little was accomplished until 1918 when F. B. Young and his associates used both moored and drifting electrodes to measure electric currents generated by tidal motions.

The duplication of Young's experiments in the autumn of 1946 led to the development of the Geomagnetic Electrokinetograph or "GEK." The electromagnetic principle on which the GEK operates is simple: sea water, being a solution of electrolytes, is a good electrical conductor. The motion of this conductor through the earth's magnetic field produces an EMF detected by a pair of silver-silver chloride electrodes towed behind the ship. They are spaced 100 meters apart and are streamed astern away from the magnetic and electrical influences of the ship itself. The shipboard end of the cable is connected with an industrial recording potentiometer.

On any given ship's heading, the reading is proportional to the component of current perpendicular to the course. Through measurements of the potential differences on two courses at right angles, the component velocity components in these two directions are determined, and the vector sum or resultant of these velocities is the surface water current vector for that locality.

For shore stations the GEK may be adapted for use in a channel, pass, or open arm of any estuary where turbulence is slight and where upwelling and sinking is negligible. As the electrodes may be mounted on each side of the channel and connected by a cable the horizontal velocity of the water passing between the electrodes may be measured. Because it is awkward to reverse the electrodes to calibrate the instrument when making measurements at a fixed station, it is necessary to consider the measurements of potential recorded during times of zero tidal flow. The measurements of potential recorded during times of tidal flow are computed with the measurements made during slack water. This comparison is used to determine the water current flow through the channel.

The use of the instrument is limited to areas more distant than 20° latitude from the magnetic equator, as the vertical component of the earth's magnetic field is involved. Also, highly industrialized areas are to be avoided since stray grounds and intermittently operating electrical machinery may mask the signals from natural sources.

Biological Net

The last device to be discussed is one developed for problems concerned with the larger organisms in relatively deep oceanic waters. The Midwater Trawl or Tucker Net, (Scripps, 1951), was designed to operate in depths up to 1200 meters and has been found satisfactory in depths up to 3000 meters. The net is extremely productive of bathypelagic forms, but has not been tested in shallow water. The catches have been in good condition after 4-knot tows.

The net is towed from a ⅜ or ½-inch dredging cable. The towing cable is shackled into the main bridle of the net through a swivel. The mouth of the net is held open by a lower beam of "V" construction. A depressor serves not only to depress the net but spread the mouth as well.

The net is an asymmetrical pentagonal pyramid with five main hauling lines, running from the five points of attachment to the ring just forward of the cod end. Net construction is of 2½-inch stretched mesh. A ¼-inch stretched mesh liner is attached just forward of the cod end and extends the entire length of the cod end. The mouth opening of the net is ten feet across, and the overall length is about thirty-five feet.

As previously mentioned, the net has not been tested in shallow water, but judging from its efficiency in deep water it should serve well in the collection of free-swimming marine organisms normally found in waters of ten fathoms or greater. Field tests indicate that the Midwater Trawl meets the specifications of a net long needed to collect small fish normally inhabiting very deep waters.

Accessory Equipment

Along with the development of instruments there has been development of accessory gear. Such gear as the Automatic Time Release Device, (Scripps, 1949), the Semi Expendable Concrete Depressors, (Scripps, 1949), and High Drag-Ratio Depressor, (Scripps, 1950), play their parts in the operation of biological and oceanographic equipment.

Conclusion

Development and design of new equipment is a problem for both the biologist and oceanographer. The use of oceanographic equipment should not be limited to the science of oceanography for these instruments show promise in marine biology. The instrument's transposition from the field of oceanography to that of biology is, in cases, a problem of modification or redesign while in other cases it is only a problem of application. Newer and better instruments are needed in both fields and it is the responsibility of the men using the instruments to make their needs known or to modify and redesign existing instruments to their particular needs.

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Fish Culture Project in Haiti

S. Y. LIN, *Food and Agriculture Organization of the United Nations, Port au Prince, Haiti*

THE POSSIBILITY of developing fish culture as a source to supply protein food to the people in Haiti was first visualized by Professor Ernest F. Thompson of Yale University. In the 1948 Report of the United Nations Mission to Haiti Thompson observed, "Haiti possesses a very considerable area of lakes, rivers, irrigation canals and ditches, vast land capable of being flooded and a great variety of shallow lagoons, both salt and fresh; and these are at present unproductive or produce only at an extremely low level, and most of them have little or no agricultural potential. In addition there are considerable rice field areas the flooding of which is contemplated." Further, in connection with fish culture, the Mission recommended, "Before deciding on a program of pond culture development the service of a first class specialist familiar with successful practices in other countries should be secured for making an extended survey;