FISHERIES DEPARTMENT, WESTERN AUSTRALIA

MONTHLY SERVICE BULLETIN

Vol. VI. No. 2. February, 1957

STAFF NOTES

The Superintendent (Mr. A.J. Fraser) visited Albany and Denmark on fishing matters during the month. On February 1 he will leave for Kulikup to investigate requests for a close season for English perch in the upper Blackwood River and tributaries, including the Arthur and Balgarup Rivers.

The Supervising Inspector (Mr. J.E. Bramley) accompanied by acting Fauna Warden B.A. Carmichael, attended Court cases in Geraldton on January 18.

The appointment of Mr. R.M. Morton as Pearling Inspector, Broome, is being annulled as from February 1. Relieving Inspector A.K. Melsom is at present at Broome and will remain there until a permanent replacement is made. Applications for the vacant position will be called shortly.

Messrs B.R. Saville, H.B. Shugg and G.C. Ferguson of Head Office and Relieving Inspector A.K. Melsom and Technical Officer J.S. Simpson all resumed duty in January after annual leave.

We were relieved to hear that Mrs. Gallop, wife of Inspector J.L. Gallop, who underwent a serious operation during the month, is now out of hospital and convalescing satisfactorily.

OBITUARY

It is with profound regret that we record the passing in January of Mrs. A.E. Munro (mother of Senior Inspector J.E. Munro) and Mr. S.J. Bowler (father of Inspector S.W. Bowler). The Superintendent and all staff members join in extending their sincere sympathy to Messrs Munro and Bowler and their families.

MOVEMENT OF DEPARTMENTAL VESSELS

The research vessel "Lancelin", under the command of Captain H.C.W. Piesse, with Inspector C.R.C. Haynes as Mate and Assistant Inspector S. La-Roche as crew member, will leave for Shark Bay on February 21 to carry out prawn and scallop surveys.

The p.v. "Misty Isle", which was brought to Perth from Shark Bay just before Christmas, is being refitted at Fremantle, and will be used for inshore patrols in the Fremantle - Lancelin District.

The p.v.'s "Kooruldhoo" and "Garbo" remain at Lancelin and Geraldton respectively.

PERSONAL PARS

Dr. G.M. Dunnet, Principal Research Officer, Wildlife Survey Section, C.S.I.R.O., called at Head Office during a 10-day visit to this State. He demonstrated techniques of quokka markings at Rottnest to members of the Zoology Department of the University of W.A., who will in future carry out all aspects of the quokka research programme. Dr. Dunnet returned to Canberra by air on January 18.

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Two visiting German scientists, Drs. Robert Mertens and H.A. Felten, of the Frankfurt Zoological Museum, West Germany, called at Head Office during the month. They have been issued with licenses to allow them to study and collect reptiles and bats in Western Australia. Dr. D.L. Serventy, Officer-in-Charge, Wildlife Survey Section, W.A., will take them on a short collecting tour of the South-West from February 8 to 11. Drs. Mertens and Felten will later go on a joint study expedition to central Australia.

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Mr. W.B. Malcolm and Mr. D. Dunstan, of the Division of Fisheries and Oceanography, C.S.I.R.O., also called on the Superintendent during the month. Mr. Malcolm, who was on holiday, was accompanied by his wife and brother.

CO-OPERATIVE'S SUCCESSFUL YEAR

It was reported at the annual general meeting of the Geraldton Fishermen's Co-operative, that a record trading year had been enjoyed. More than 2,500,000 lb. of crayfish had been purchased from fishermen and sales showed an increase of £80,000 over the previous year. £48,500 was distributed to shareholders, representing a total payment of 2/4½d. per lb. for crayfish purchased. The increased value of sales was due to a rise in price on the American market, which was expected to remain firm.

COTTESLOE INDUSTRIAL SHOW

Cottesloe Municipal Council will conduct a "Pageant of W.A. Industry" at the Cottesloe Civic Centre from February 22 to March 2, as part of their Golden Jubilee Celebrations.

This Department will include a general exhibit as part of the display by Government Departments. Mr. A.J. Buchanan, of Head Office, will prepare the necessary material.

ROLE OF SCIENCE IN MARINE FISHERIES: Limitations and Potentialities *

R.E. Coker.

Dr. Coker is emeritus Kenan professor of zoology at the University of North Carolina, where he introduced courses in fresh-water and marine hydrobiology in 1923. Last year he was visiting professor of marine biology and consultant to the Institute of Marine Biology at the University of Puerto Rico. Dr. Coker has served at various times as director or acting director of several U.S. Fisheries Biological Laboratories, including those at Beaufort, North Carolina, Fairport, Iowa, and Woods Hole, Massachusetts. In addition, he has held the positions of chief of the Division of Scientific Inquiry in the U.S. Bureau of Fisheries, chairman of the North Carolina Survey of Marine Fisheries, organising director of the Institute of Fisheries Research of the University of North Carolina, and chairman of the Division of Biology and Agriculture of the National Research Council.

During the past fourscore years, applications of science in agriculture have effected a veritable revolution in farming practices. We can hardly imagine an American small farmer of the most "backwoods" area who is not directly or indirectly making application of modern agricultural science for better production. Clearly, scientific research is the mainstay of modern land farming. Yet, by far the greater part of the productive surface of the earth is sea, the field of the fishermen, to whom as yet the service of science has been relatively minor. Is this the fault of the scientists - or what? The question is sometimes put: Cannot science do for crops of the oceans something like what it has done and is doing for those of the land? Put in this way, the answer is a sure negative: except in localised and semi-enclosed areas, the betterment of basic productivity of the sea is now beyond the reach of the scientist and technician.

The Big Question

But the practical question regarding science and fisheries requires restatement. Can marine scientists,

* This article, which appeared in The Scientific Monthly, 82, 4 (April, 1956) is reprinted with the kind permission of the Editor, Mr. Graham DuShane.

disregarding substantially the ordinary procedures of agricultural scientists, give really valuable service to marine fisheries? The answer now becomes a clear affirmative, provided only that one does not demand immediate and spectacular results and also that there is an unclouded concept of practicable objectives and of means of attaining them through scientific research. The tasks confronting the fishery scientist are usually complex and baffling enough, as will appear from discussions in this article (1). Unfortunately, the fishery scientist is at a yet greater disadvantage because many of those whom he would aid, and others who control funds and facilities, demand impossibly quick returns. Apparently this attitude derives only from lack of a clear grasp of limitations and real possibilities. More widespread understanding and a greater degree of patience would promote more effective service at less expense. Needed service is hampered because some troublesome problem must be solved today and another tomorrow, while the facts are not available for proper solution of either problem.

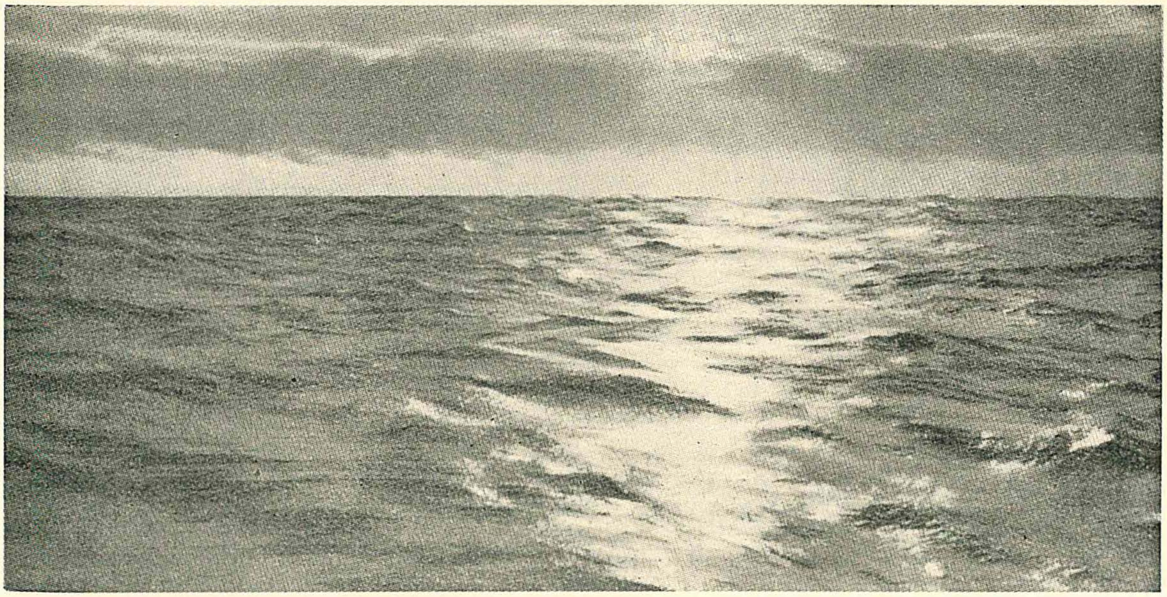
Cultivation crops from land and exploitation yields from sea offer entirely different stories of production and harvest. Without too detailed a comparison, let us note briefly some prominent contrasts between the conditions that face agricultural and fishery scientists. To marine biologists, some of the conditions may well seem too obvious to require discussion. Nevertheless, the conditions are not always fully grasped by those who would support scientific research in aid of fisheries, and their statement in brief is requisite background for consideration of potentialities and limitations.

Fertility, texture, and water content of soil call to the agriculturalist for study and action. Corresponding conditions in the sea demand no direct action from the marine scientist, even though the marine scientist most assuredly needs to know where the fertile areas are and when and why some areas are more fertile than others. Sea water, generally, is extremely infertile as compared with good farm soils. Plants in the ocean must make the best of a comparatively poor situation with regard to fertility (and, of course, without the aid of chemical science). This they can do, being microscopic in size, having a high ratio of exposed surface to volume, and being capable also of extremely rapid multiplication.

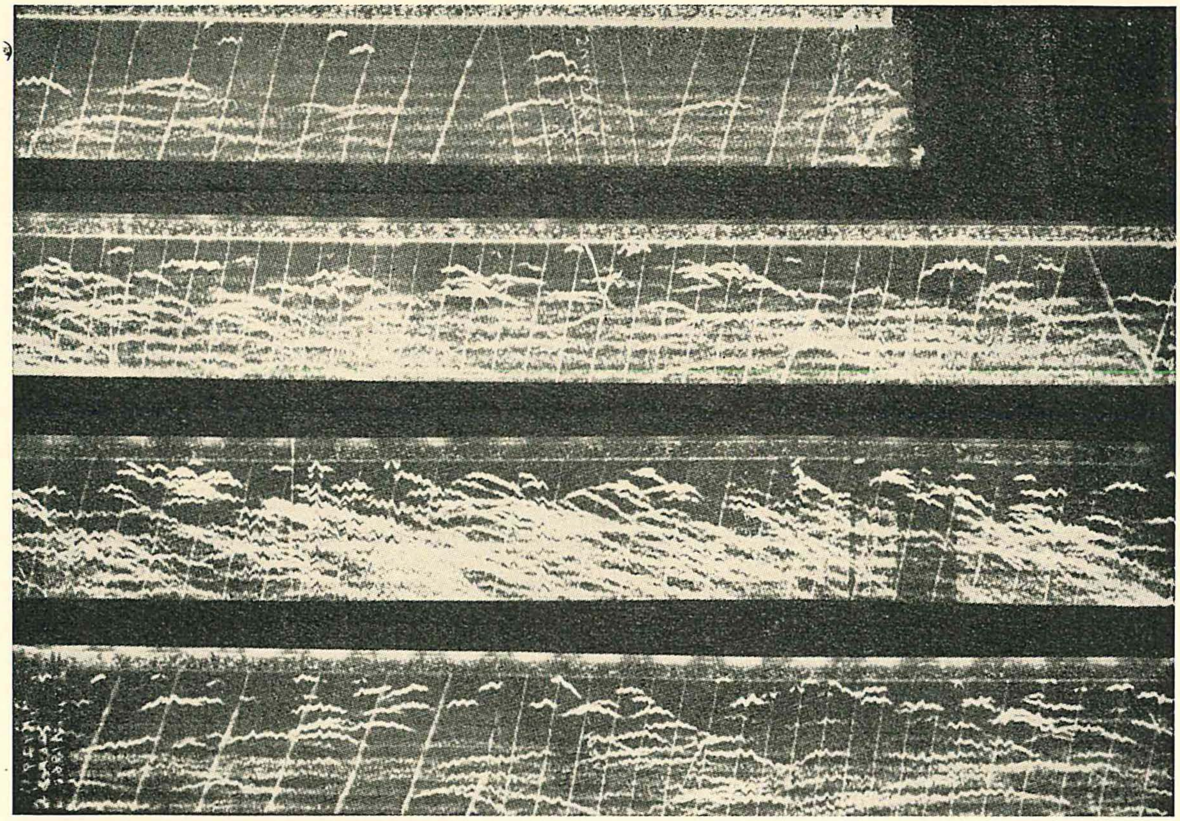
Light is an essential basis of productivity. About 70 percent of the solar radiation that reaches the surface of the earth comes to the sea, but much of it is reflected away and lost to plants within the sea; only radiation that actually enters the water can serve in marine production. On the other hand, some of the light reflected from solid earth is still available to plants of the land. Most of the radiation that enters sea water is soon absorbed, some wavelengths more quickly than others; thus, with depth, the light changes in character as well as in intensity. At the best, plants in the sea live in a dimmer light than most plants on land. Apparently, it must be said, most of them "prefer" a measure of dimness; necessity may be the mother of preference. Only the upper 50 to 200 meters of sea water, depending on the location, have enough light for photosynthesis or basic organic production. Again, marine algae find compensation in smallness, in all-round exposure to what light there is, and in lack of need to produce the elaborate supporting and water-transporting structures that are so essential to most land plants.

A very significant difference between production by land and production by sea is in the chain or web from fertility to harvestable crop. From fertility to grain suitable for the market is a chain of one link; fertility-to-grass and grass-to-beef (or milk) add only one link to the chain. Contrast the sea! The chain simile is no longer adequate. The multitudes of minute plants produced from fertility and sunlight are not directly useful to man, nor, generally, are the tiny vegetarian animals that consume the plants; one animal eats another and is devoured by something larger in an extremely complicated fashion. Hence, instead of a simple chain, we have an almost unravelable web leading from basic fertility to the larger fish that will grace the table.

The point of real concern is that, at each link of a food chain, or at every knot of the food web, there must occur great loss with respect to the proportion of the original production that goes to make the final substance that is to be harvested. At each



The marine fishery scientist is concerned with invisible crops and an immensity of water that is inches to miles in depth, unconfined, and restless from top to bottom. [Courtesy Jan Hahn, Woods Hole Oceanographic Institution.]



Echo-sounder traces made with a new recording system, the sounder lowered beneath the ship's hull. The traces on successive panels, from the top down, indicate diurnal migrations of individuals or groups in a vertical direction. Greatest concentration of traces is in the third panel from the top, which was made at sunset. [Courtesy Woods Hole Oceanographic Institution.]

step, so much goes to sustain internal (metabolic) energies; so much is lost as heat; so much is left as indigestible material; so much is taken to support the activities of just running about in search of food. It takes several pounds of algae (the minute plants, the pasturage of the sea) to make a pound of copepod, several pounds of copepod to make a pound of tiny fish or shrimp, and so on. In the end, perhaps thousands of pounds of algae were produced to make a pound of bluefish or cod for the table. Actual estimates now vary widely.

At best, close comparisons between respective efficiencies of production of meat on the farm from animals that are supplied in large measure with prepared or cultivated foods,and production of meat from the sea from fish that grew in the wild, foraged "on their own", and really worked for a living are wide open to dangerous fallacies. Indeed, a very notable contrast between production from land and production from sea is that, although in both cases human energy is required for the harvest, it is only for crops of the land that the energies of man play so great a part in so many ways in making something to be harvested.

Grouping of livestock is essential to profitable exploitation. The farmer brings his livestock together, keeps them together, and cares for them; he harvests if he pleases and when he pleases; rates of growth and quality of stock are prime considerations for which he depends on science - either that of his own practice or that of the experiment stations. The fisherman accepts nature's own standards of quality and rates of growth; he depends on nature to bring his "cattle" together in an accessible place; he harvests when he can, if he can, and if there is a reasonable prospect of disposing of the catch at a profit. The big if's in the equation have more significance than first meets the eye.

The farmer's field has only two dimensions, length and width; generally, too, it is enclosed; his stock is in easy view; then can be counted and weighed before harvest. The fisherman's field has three dimensions, length, width, and depth; the unconfined stock wander through all three. Since the fisherman cannot confine his stock, he would be greatly helped if he could be told where, in the regions available to him, the fish are to be found in practicable quantity at any given time. For meeting so practical a need, he calls on the scientist to tell him how fish react to external conditions, how the physical, chemical, and biological conditions change from time to time, and thus how, with reasonable assurance of accuracy, the movements and abundance of fishes can be predicted for any particular place and time.

For a service of the nature just described, the biologist alone is not fully adequate; for understanding of the environment that governs the movement of fishes, the physicist and chemist should work with the biologist. Furthermore, since populations of fishes in the sea are not subject to close scrutiny and easy counting, resort for knowledge of numbers and sizes can be gained only by methods of sampling and approximations as to numbers of each size; because samplings and the computations based on them are full of pitfalls, the biologist must often solicit the help of the qualified statistician.

By way of general qualification, it may be said that, in the few cases where exploiters of estuaries can be true "farmers" in effect, as in cultivation of the oyster, they do manage bounded areas and exercise a measure of control over sedentary populations and quality of stock. They then have some of the same problems as those of the land farmer, along with, it must be emphasised, a lot of special difficulties of their own.

To conclude this cursory account of contrasts, we may ask: Debarred as he is from giving aid in basic production, and from so many other offices of the agricultural scientist, what can the student of marine fisheries do? An answer by any one person to so broad a question can be only suggestive. In any event, the answer is somewhat different, according to whether we consider partially enclosed estuarial waters or the open sea beyond the outer coast line.

Science for Estuarine Fisheries

Restricted areas offer special problems. In coastal states, estuaries are important areas of fishery. Estuaries are limited in extent and highly variable in salinity and temperature, both from place to place and from time to time. They may have resident populations, but, much more significantly, they harbour migratory fishes that move in and out for spawning, for breeding, or in response to changes in the character of the water. Avenues of movement are narrow. In some cases, the objects of capture are either immobile (as the settled oyster), of slight mobility (clams), more or less lively migrants (mullet, shrimp and blue crabs), or fleeting passengers (salmon and shad) on their way to spawning grounds far upstream in rivers or lakes. Most of these are habituated to aggregate in limited areas. Their capacities to escape capture, and thus to perpetuate the species to best advantage, are relatively small. In consequence, the populations are readily susceptible to excessive depletion through injudicious exploitation.

The danger is not that a species will be exterminated. Theoretically, it might be possible to remove the last oyster from Long Island waters, from Chesapeake Bay, or from the North Carolina sounds, or to reduce the populations of oysters to such a degree that effective meeting of eggs and sperm would fail and the last oysters would fade out, as have some animals of the land. There is little or no danger of this. Even if, for any reason, one wanted to exterminate the oyster, the tremendous expense involved in searching out the last few potential breeders would make this impossible. The real danger is, or we should say, was (since the damage to oysters has been done), that populations will be reduced below the level of most profitable exploitation.

We know beyond peradventure that certain estuarial species - the oyster is a prime example - have been greatly depleted concomitantly with the pursuit of active exploitation. It must be said that we do not know whether other factors than the fishery may not also have played a part, perhaps sometimes the chief part, in population declines. Such other possible causes of depletion are changes in tributary rivers, alteration of the nature of bottoms and of sea inlets (worked by nature or by man), industrial and agricultural development, pollution, and even possibly innate biological cycles. Careful study and appraisal of all these external and internal conditions are tasks for the scientist and are equal in importance to the consideration of fishery practices. Nevertheless, it is quite obvious that no fish that must ascend a river to spawn can survive if passage to its natural spawning ground is completely blocked, whether by nets, dams, or pollution. It is equally certain that the oyster, which is dependent on solid bases of attachment (cultch) cannot retain its original density of population if the "rocks" (a common term for bottoms yielding oysters) are all scraped away and no new cultch is provided for the attachment of young oysters.

It seems clear, then, that for estuarial resources the maintenance of adequately productive populations depends in great part on human wisdom manifested in one way or another. Up to now, man's efforts, sensible or otherwise, toward the desired end have taken several forms. For fishes that must ascend rivers to spawn (anadromous fishes), resort to hatcheries has been general but of highly doubtful service, except for salmon whose ascent is blocked by dams that are not equipped with adequate fishways. For all estuarial fishes and shell-fishes, dependence to a great extent has rested on restrictive legislation that regulates mesh size, length of nets, number of nets, periods of operation - seasonal, weekly, or hourly - sizes of boats and trawls or dredges, the use of power, and other hampering measures. Some of these restrictive regulations are doubtless necessary. It cannot be denied, however, that they are commonly based on quite inadequate knowledge of the resources it is desired to protect, of the probabilities of effectiveness of the measures adopted, or of the cost in inefficiency of operations. Admittedly they often reflect mere compromises between the demands of pressure groups influenced by competitive interests. I will consider the general principles of regulation in a later section.

Another form of effort for the maintenance of estuarial populations is cultivation as a public undertaking or as a field of private enterprise. Cultivation must be clearly distinguished from hatching. The eastern oyster is the best example of an estuarial resource on which great effort has been devoted in cultivation, or "farming". Let us consider it more particularly, remembering, of course, that on the West Coast concern is not only with the transplanted eastern oyster, but also with the "native" or western oyster and the imported "giant" Japanese oyster.

The oyster still calls for research. It has been remarked by others that the oyster has been the subject of more research than any other object of fishery; yet it is plain enough that more is needed.

The hatching of oysters, or their artificial propagation by deliberate mingling of eggs and sperm, has frequently been attempted experimentally; but it has not proved generally practicable for purposes of production, nor does it seem to be needed in most eastern estuarial waters. As a scientific venture, it may provide possibilities for obtaining useful information about natural propagation or for opening possibilities in selection or hybridising. In the eastern states, all practical endeavours in the cultivation of oysters presuppose adequate propagation by nature somewhere. This is true whether one plants what is called "seed" (not fertilised eggs, but actual young oysters that have hatched and have grown to a fair size in nature) or lays down cultch (shells or other solid objects for the "setting" of free-swimming larval oysters).

Natural beds have been depleted almost everywhere they occur; but, long ago, it was found that oysters lend themselves well to cultivation. Oyster farming has been a profitable business when it has been established under proper conditions, as in Connecticut, New York, New Jersey, Virginia, Louisiana, and on the West Coast. In some states with waters that are fully capable of significant yield of oysters (such as Maryland and North Carolina), oyster farming has been practiced in only a small way, in comparison with seeming potentialities, yet enough to show its practicability there, too.

Because peculiar jealousy exists respecting private control of estuarial bottoms, there have been repeated efforts in certain states to bring about restoration of natural rocks by public planting. Nowhere as yet has state planting (which is not really oyster farming) yielded really notable results. Nevertheless, it may be desirable, or at least politically necessary, to continue the attempt long enough in the present and the future to ascertain whether, under proper guidance and management, and as only a second-best resort, state planting may yield results adequate to justify the cost. Advocates of state planting have generally overlooked the fact, which is readily obvious to land farmers, that little should be expected of planting that is not followed by care or cultivation. Demonstration planting, with cultivation, seems to be a more worthy undertaking.

The common oyster of the eastern states, starting life as an egg discharged from the female oyster and fertilised by sperm in the outside water, develops quickly into a larva with microscopic paddles. By the active use of the paddles, it keeps in slow movement while it is carried to and fro by currents. Great numbers are devoured by predators. At a certain stage of development, survivors settle and set by cementing themselves to some solid object that is sufficiently clean, provided that such an object is present where they settle.

Still of microscopic size, the infant oyster at this stage cannot, to any extent, seek out a proper object of attachment. It may "land" in the mud, only to be smothered and lost. Even hereafter, the lucky settlers face dangers from parasites, competitors, smotherers, predators, pollution, and human exploiters. Is it surprising that a mature female oyster, or one that has attained the female condition - for they change in sex - must extrude millions of eggs during one season?

For maintenance of a stable stock, only two of the millions of eggs from one oyster need come to full maturity. For even this small return, conditions must be right with respect to temperature, salinity, currents, food, parasites, associates, and predators. All of these conditions pose problems for biological and hydrographic research, which must also be concerned with questions of market value.

The value of the oyster depends on many things, including rate of growth, size, form, colour, flavour, sanitary quality, and handling from rock to table. There are tasks for the biologist, the chemist, and the bacteriologist, as well as for the research economist who has to deal with costs, processing practices, and marketing. The biologist should be further concerned about potentialities in selected strains or races, and hybridisation.

Other estuarine resources and problems. Something of what has been said concerning the oyster is also applicable to clams, except that commercial clams are not fixed in position, being always capable of slow movement. The artificial cultivation of either soft clams (Mya) or hard clams (Venus in the East, Saxidomus, principally, in the West) (2) has never become established as a commercial enterprise. Nevertheless, indications of practicability are sufficient to justify appropriate studies and experiments. Other clams need consideration - notably, in the West, the pismo clams (Tivela) and razor clams (Ensis and Siliqua). In very recent years, another clam fishery has developed off the Atlantic coast from Rhode Island to Maryland. This is for the so-called "surf-clam", Spisula (Mactra) solidissima, which is fished by special gear in water up to 100 feet in depth. What problems may arise are not yet apparent. Knowledge of the lives of all shellfish subject to exploitation is desirable.

The bay scallop in estuarine waters, because of its migratory habit and unpredictable occurrence, does not lend itself to cultivation. Once an important shellfish, it virtually vanished with the disappearance, from disease, of eelgrass, which harboured particularly the young scallops. There are, doubtless, possibilities in encouragement of its return.

Blue crabs, which are prominent in the market as recently molted "soft crabs" or as picked crab meat, are found only occasionally in the open sea; they prefer shallow bays, sounds, and river estuaries, where they thrive in waters ranging from ocean-salty to brackish or even fresh. Because of a sexual difference in migratory habit, populations of males and females may be apart from each other except at mating season; the young, too, may remain more or less segregated. Being of such pronounced migratory habits, the crab does not lend itself to farming operations or to more than brief retention in confinement.

Studies of the blue crab have been made principally in the Chesapeake Bay area. For other waters, information concerning densities of populations and migrations is still woefully inadequate. In some regions, utilisation of blue crabs may not now be at a desirable maximum. Much remains to be learned about the natural history, migratory habits, abundance, and distribution of crabs wherever they occur as well as about possible improved modes of capture and the processing and marketing of a resource that yields relatively high prices.

On eastern, western, and southern coasts there are other kinds of edible crabs whose habits and potentialities have been little explored. The large Dungeness crab of the Pacific Coast is important. The massive-clawed stone crab of southern waters is a shellfish of peculiarly high quality, but is perhaps too limited in abundance to offer significant opportunities for development. The northern lobster and the marine crayfishes (or spiny lobsters) of Florida, the West Indies, and other areas have received much attention; as it appears now, they must be left chiefly to their own devices in propagation and growth, although they may require protection.

High among fishery products in public esteem and in commercial value are the shrimps, of which several species are harvested - for an eager market - from the coastal waters of the Atlantic Ocean and the Gulf of Mexico, while others are taken from Pacific waters. Although the eastern shrimp are generally truly marine in life and in propagation, yet for some species at least, the estuaries are favoured nurseries of the young. Different species, some of which are not distinguishable to the average consumer, have diverse habits and distribution in place and season. Much too little is known about them; yet something of what in recent years has been learned about them through long-continued and painfully meticulous studies has already paid substantial dividends in dollar returns to fishermen.

The diamondback terrapin, now unimportant as an object of fishery, demands a place in the estuarial picture for its historical interest and the peculiar economic pattern of its fishery. Highly esteemed by epicures, it was at one time the most valuable fishery product per pound in large city markets. A single terrapin of no great weight - say one with an 8-inch undershell - might bring a retail price of $5 or sometimes as much as $10. While exhaustively fished, they were not prodigal in reproduction and were slow in growth, requiring maybe 20 years to attain maximum size. Depletion of populations occurred first in northern waters, then in the Delaware and Chesapeake bays, and later in North Carolina and southward. Prices in the city markets soared, particularly for terrapin presumed to have been reared in more northern waters. Incidentally, this led in some cases to the peculiar practice of shipping terrapin northward by stages, from South Carolina to North Carolina and from North Carolina to Maryland, so that they might arrive in the market as "true" Chesapeake terrapin.

In these circumstances, experiments in propagation and farming of terrapin were inaugurated by the Federal Government and the state of North Carolina. Considerable success was attained at Beaufort, N.C., and nearly a quarter of a million young terrapin were distributed widely. Private farms came into existence and seemed definitely promising of success. Unfortunately for the profitableness of these ventures, World War I and the era of "prohibition" that accompanied and followed it led to great reduction in the demand for so high-priced a market article as the diamondback. One large private farm closed quickly, but the public venture in propagation continued for nearly 30 years. On the basis of local reports and some personal observation - but without statistical check -it seems that the number of wild terrapin shows a notable increase in recent years. Nevertheless, the most noteworthy result of the hatching operations, despite more terrapin in the water, has been, not more terrapin on the market, but, rather, the accumulation of a considerable body of information about the natural history and propagation of terrapin.

In estuarial regions, there is also the possibility of "farming" of finfishes in bayous or creeks that offer practicabilities of enclosure and management, including the application of supplemental fertilising materials. The mullet (Mugil) particularly, has been the subject of successful farming in some places, but not apparently on this side of the Atlantic. The mullet is an exceptional fish that seems to be at home in salt to but slightly brackish or even fresh water. It can be reared in salt or fresh ponds under conditions of artificially increased fertility, and this has long been done in other countries. Whether or not this would be profitable under our conditions has not yet been determined. The mullet has an almost unique qualification as an object of cultivation in ponds. It feeds near the base of the food chain, possessing in its mouth a fine filtering apparatus that enables it to separate from the mud and water the small algae, animals and organic detritus. The food chain from raw chemicals to table meat is nearly as short as it is for the pig.

The seaweeds are not to be ignored. Many of the useful ones, notably the kelps, are more strictly marine; yet estuaries in their more saline parts have rich natural gardens of red seaweeds, some of which are utilised for preparation of merchantable products valuable to science and industry.

Significant in most estuarial waters are fishes that live the greater part of their lives in the sea but, when time for reproduction arrives, must find their way through estuaries and up the rivers. Familiar among such anadromous fishes are shad, alewives, striped bass ("rock") , some smelts and sturgeons, and most of all marine fishes. As they appear seasonally and in great numbers, the narrowing passageways offer inevitable bottlenecks where their capture is easy. They may meet actual barriers, such as dams or impassable zones of pollution with excessive depletion of free oxygen, if not with toxins or gill-lacerating fibers. The behaviours and susceptibilities of the fishes present practical problems to the scientists as well as to administrators and industrialists.

The catadromous eel (_Anguilla_) matures upstream in the rivers and creeks (females) or in the estuaries, but, in the end, must go far out in the sea to start a new generation. Since it is only the very small elvers that come in from the sea to distribute themselves in inside waters, the eels in passage are less vulnerable than the larger anadromous fishes. Yet their passage upstream may be blocked by dams and brood stock may be excessively depleted through fishing or pollution. Eel farming by trapping of the immigrating elvers and retention in ponds for growth to market size has long been practiced in Europe.

Basic hydrographic studies essential. Finally, for estuaries, let it be strongly emphasised that there is need for long-continued (and not inexpensive) surveys of hydrographic and bottom conditions and their special relationships to fishery resources. We require much more understanding than we now have of how estuaries are affected by runoff from land and by conditions in the sea outside. We need more knowledge of what goes through the several inlets outward or inward. Interchanges through inlets, bay openings, and river mouths include not only fish, shrimp, scallops, and crabs, but also volumes of water that transport dissolved salts and other chemicals, which are the basic food for plants, as well as populations of minute floating plants and animals, the basic food supply of fish and shellfish.

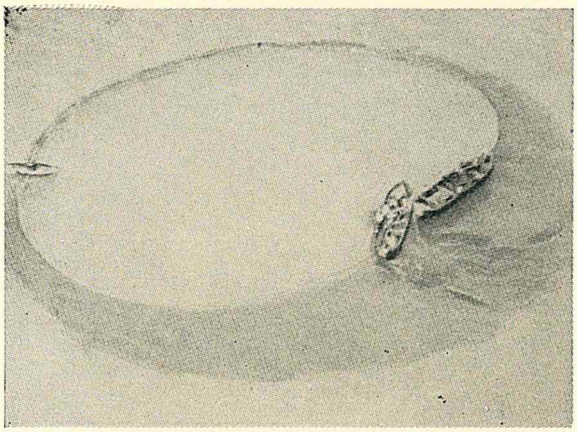
Studies of this nature are clearly of indirect value; yet it is only foolish to deny their practical use. They are basic to understanding, to economical and profitable pursuit of the fisheries, and to determination of need, if any, for regulation of the fisheries. Manifestly, one ought to be able to appraise the effects for which nature rather than man is responsible. Argument ought not to be required on the question whether understanding or ignorance is the better guide in regulation and development.

Science and Sea Fisheries

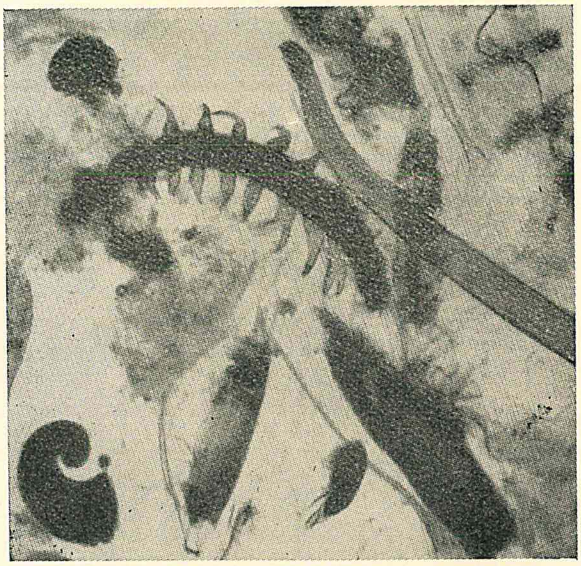
Nature does the farming (hatching and rearing). We are as definitely estopped from cultivation of strictly open-sea resources as we are from fertilisation of the briny "soil" that supports them. Just a few decades ago, when knowledge of the sea and its resources was of the crudest sort, it was assumed, perhaps naturally, that what worked on land would work in the sea. If one wants more cotton, corn, trees, or chickens, one plants more seed or hatches more eggs. The fisherman wants more fish; hence, 75 years ago, as well as more recently, it was generally assumed that artificial fertilising and hatching of eggs of marine fishes and planting of fry would make larger populations, or at least compensate for depletion of populations by man's fishery.

Fortunately, even from the beginning, the main objective of marine laboratories and oceanographic cruises was to gain more knowledge of fishes and other marine animals and of the conditions under which they live, grow, and multiply. If there were needed a special argument for biological and oceanographic studies, a cogent one might be found in the fact that research in these fields has effectively undermined the bland assumptions that once supported demands for more and more marine fish hatcheries. Unfortunately, it may be added that, if argument were required in support of a programme of popular education in the results of scientific research, it might rest on the fact that, notwithstanding the seemingly clear indications of science and common sense, at least one marine hatchery still operates at taxpayers' expense, apparently in response to the demand of ill-informed voters and the misinformation or helplessness of administrators and legislators. The defense that "hatcheries cost little and keep fishermen happy" may be profitable political psychology, but it is not a happy one - insofar as the practice merely regales ignorance.

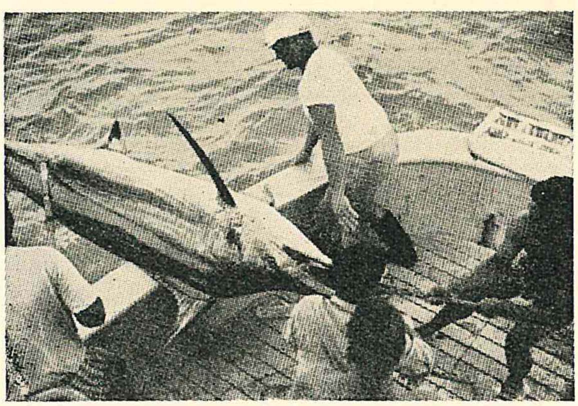
In these circumstances, it is advisable to mention briefly certain elementary facts that merit wider understanding. A previously noted difference between agriculture and fisheries should be recalled. Agriculture is concerned primarily with production, secondarily with harvest. Open-sea fishery is concerned only with the harvest of a crop of natural production. Now, it is well-known that nature is not economical in production of progeny of most commercial fishes. There are reputable estimates that a cod that has lived to market size is, on the average, but one survivor of something more than 10 million eggs produced by its maternal parent! A thousand cod in the market may represent billions that started life as fertilised eggs. The taking of spawn from captured codfish and the distribution of a few million fertilised eggs, adding them to those produced in nature with a prodigality that would require astronomical figures to give even a rough estimate, is plainly waste of time and effort. If the human fish propagator were no more successful than a parental codfish, and he is probably much less so, he would have to fertilise and plant 10 million eggs to produce one adult codfish. Would that fish ever come to market? The chances seem to be against it. Presumably we capture only a small proportion of codfishes in the sea, although it is now thought that, in particular areas of intensive fishery, a substantial part of the population at that place is



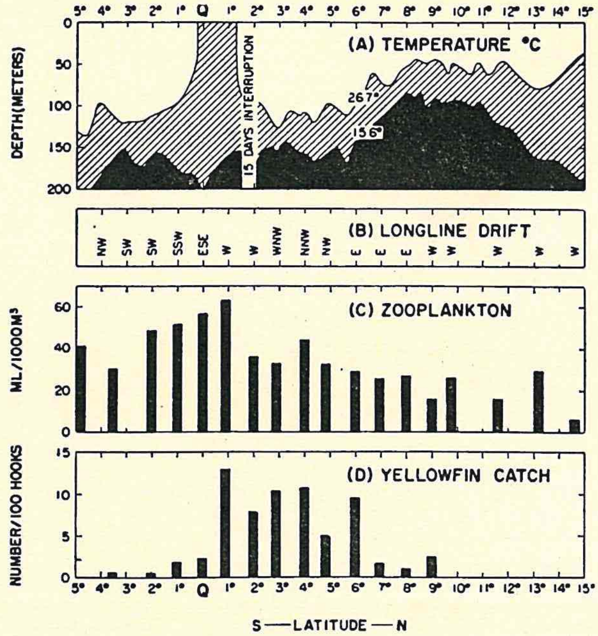
Purse seine encircling a school of menhaden in waters off northern Florida. [Courtesy Jan Hahn, Woods Hole Oceanographic Institution.]



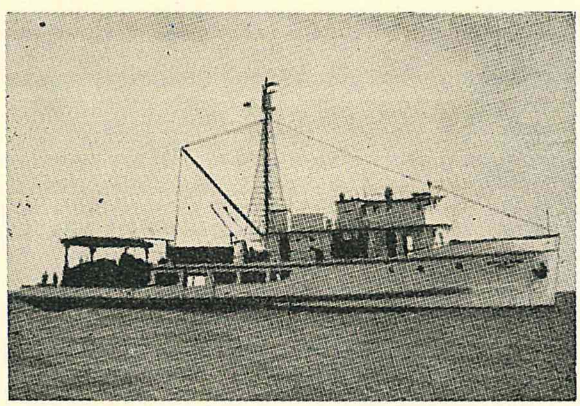
Plankton. [Courtesy U.S. Fish and Wildlife Service.]



A white marlin landed from longline gear over the stern of the *Hugh M. Smith*. [Courtesy Pacific Oceanic Investigations, U.S. Fish and Wildlife Service.]



Some results of an oceanographic-fishery survey cruise in the central equatorial Pacific Ocean. Under the influences of the south-east trade winds and the rotation of the earth, the surface waters diverge near the equator and are replaced from below by cooler and more fertile waters. *(A)* The upwelling of cool water, which is indicated by cross-hatching. *(C)* Increased production of drifting organisms (the plankton) in the upwelled water, which is rich in nutrients. *(D)* The resulting concentration of yellowfin tuna, which are displaced northward as the basic food supply is carried with the surface waters in a northerly direction. [Courtesy Pacific Oceanic Fishery Investigations, U.S. Fish and Wildlife Service.]



The *Hugh M. Smith,* a 128-foot U.S. Fish and Wildlife Service research vessel that is used for exploring fishery potentials in the central equatorial Pacific Ocean. [Courtesy Pacific Oceanic Fishery Investigations, U.S. Fish and Wildlife Service.]

removed. Until it can be shown that the numbers of spawners and eggs produced by them play a major part in the reproductive efficiency of a marine species, there is not adequate justification for great expenditure in artificial hatching of marine fishes.

In this connection, it may be noted that in some European countries there have been practical undertakings in which small fish (plaice, a small flounder) were trawled from coastal waters, where the population was dense and the growth of fish quite slow, and transplanted to other bottoms that have fewer fish and more food. It is reported that the fish thus transplanted from crowded nurseries to good fishing grounds grew faster and attained larger sizes (3). Doubtless this sort of expensive fish husbandry in the sea can be profitable only under unusual circumstances.

Because we must depend solely on nature to produce the crop, it follows that to gain more profit from our labours as harvesters we must rely on more efficient exploitation or wiser conservation. Conservation is sometimes a fight-provoking word; let us then deal first with this avenue of supposed hope.

Idea of conservation. As is well known, when argument prevails, the basic disagreement may be not so much in objectives as in understanding of the terms used. Like so many other words, conservation has been a much-abused term. It should never be assumed that it is merely synonymous with preservation and opposed to utilisation. Even in the limited number of cases where natural areas are set aside as national monuments or where songbirds or bright flowers are protected, the basic objective is not mere inviolate preservation but rather the maintenance of educational or esthetic values instead of other less generally esteemed uses; the choice is between two modes of utilisation.

I would define conservation, as applied to self-reproducing resources, as the effort to preserve a continuing stock in the interest of more effective, economical, enduring, and profitable utilisation. I see it, when properly applied, as intended to serve industrial and other modes of utilisation by insuring indefinite continuance at the highest possible level of continuing profit. (For general application, the word profit, it should be said, might require definition, but not in relation to the resources of the sea with which we are now concerned.)

There may be yet some who would adhere to the old policy of unrestrained exploitation: trusting to the unfailing operation of the law of supply and demand, let all premiums be put on the energies, daring, and resourcefulness of the exploiters. Curiously enough, in past times, when supplies of timber, minerals, soils, and water seemed (mistakenly, we now know) to be inexhaustible, this basic philosophy played a part in the development of this country. We have to give our ancestors credit for the effective courage, ingenuity, and drive that brought about an unprecedented accumulation of wealth in the form of bank credits, if, as we now think, with regrettable reduction of basic wealth in resources.

The philosophy of unrestrained exploitation of resources of the land no longer holds commonly. Large-scale exploiters of forests for timber and pulpwood now give thought to judicious restraint, restoration, and forest management. The efficient farmer is an out-and-out conservationist with respect to field crops, livestock, forests, game, soils, and water: he sees water conservation as linked with soil conservation and soil conservation as linked with profits. In these and many other cases, the change is not in service of self-interest, so much as in conception of a more enlightened self-interest, with recognition more and more of a high degree of linkage of interests.

With respect to conservation, the principles are the same, whether the effort is made by individuals or corporations to conserve the resources of "personally" controlled areas, or by a community or state to conserve resources of areas for which the public has retained responsibility.

With regard to fishery resources, legislators and administrators are perhaps fortunate in not having to face the proponents of esthetic values - unless the voyagers in glass-bottom boats or the wearers if aqua-lungs should yet be heard from. Their formidable constituents are those who take fish for market or for sport. Nevertheless, those responsible for formulation or enforcement of measures of conservation of fishery resources can never entirely escape consideration of the conflicts of group interests, each of which must be put in the balance as fairly and intelligently as may be possible. Hardly any measure of conservation can fail to cut across the immediate interests of some group of utilisers. The seiners, the pound-netters, the drift-netters, the oystermen, the shrimpers, the sportsmen, or any other group, can easily see their own special interests as paramount.

There is no debate about the desirability of maintaining perpetuity of values at the highest possible levels: the affirmative vote is unanimous. The practical question that comes to mind here is whether it is better to base exploitation and its restriction on vague guesses and general ignorance of all the complex conditions that govern the abundance and movements of fishes or on the fullest possible knowledge of the relevant facts - biological, physical, chemical, and economic. The farmer or the timber grower does not scorn the counsel and aid of trained scientists and economists; neither should the fisherman. Incidentally, it may be remarked that the landowner does not try to conserve his timber merely by requiring inefficiency of his lumberjacks; the state often does just that with respect to its fishermen.

Now, what is the general situation with respect to conservation of marine resources?

Conservation of sea fishes. It is not at all the purpose of the present discussion to propose restrictive measures in the interest of fisheries or to oppose the proposals of others. The intent here is only to emphasise the generally unrecognised complexity of the situations in which calls for regulation arise and to urge every responsible effort to break through the background of ignorance that makes for confusion and defeat. I believe that scientists should be able to help in this case as they do in others.

No one can question the fact that populations of fish and shellfish in largely enclosed sounds and river estuaries are limited in numbers of individuals and are vulnerable. If a fish of a particular kind must enter a sound or ascend a river at one or another stage of its life, it is theoretically possible to stop the last representative of the species. The qualification, theoretically, is necessary because the practicabilities will never permit so exhaustive an operation. Where areas and populations are limited, where possibilities of escape are slight for immobile or relatively inactive species (oyster, clam), where bottlenecks for active species (shad and salmon) occur here and there, restrictions of some sort become necessary.

Ideally, the objectives in restrictive regulation should be simplicity in statement, ease in enforcement, economy in harvesting the crop, and greatest public profit. For attainment of the ideal, regulation would necessarily be based on adequate scientific knowledge concerning the natural history of the fish, all the environmental conditions, and the relations between fish and environment, and on competent analysis of the actual results of the modes of capture that are to be regulated. The economics of the fishery also need consideration.

The ideal seems now to be quite unattainable, not only because of the lack of requisite knowledge, but also because, in a democratic community, the conflicting interests of particular groups are not ignored - indeed, we may say, cannot be entirely ignored - even though accepted compromise may sometimes involve actual sacrifice of the greatest good to the greatest number. This admission offers no condonement for knowing sacrifice of principle. What is meant is that, in the imperfection of exact knowledge in some situations, the administrative agency may find no reasonable alternative to governance by majority opinion of those who are inadequately informed.

Nevertheless, the ideal should always be in mind; approximation to it should constantly be advocated and striven for. The requisite stores of knowledge - biological, oceanographic, technologic, and economic - should be built up, with all vigor possible. If the situation with respect to regulation cannot be made perfect, certainly it is possible to make progress away from the present requirements of inefficiency in fishery.

How is it with fish of the open sea? Do we deal there with limited populations that necessitate in some cases restrictions of some sort? It matters little how many fish are in the sea with its wide extent of surface and its great depth; marine fish are of value to the commercial fisherman (or to the sports fisherman) only as they come together in such numbers and in such accessible locations that he can profitably capture them. Hence, despite the great area and immense volume of the sea, the important fisheries are localised. In general, they are not far from the coast and are on the continental shelves, where the water is not relatively deep. The more important fisheries are usually where relatively low temperatures prevail. The Grand Banks off Newfoundland, Georges Bank, the North Sea, and the halibut grounds of the northwestern states and British Columbia are well known examples.

In a preceding section it is mentioned that nutrient substance everywhere drains downward from upper to deeper waters. So it is that, wherever conditions lead to the rise of deeper, cooler and more fertile waters to the surface or where special conditions promote active turnover of organic matter in the upper, illuminated water, there occurs high production of food of fishes and, in consequence, large populations of feeders. Regions of "upwelling" off the coasts of California, Peru, and Africa are noteworthy for fish populations; so is a great region of the Antarctic south of the Antarctic Convergence, where great whale fisheries are followed; so, also, are some waters of the tropical Pacific, far from continental shores, where tuna fisheries have developed in recent years. Other more or less favourable situations are found, particularly near coasts and in estuaries.

Quite likely, all regions of potential fishery have not yet been discovered: new techniques or demands will lead to exploitation of populations and areas other than those now fished. Nevertheless, the oceans are not uniformly productive of either the food of fishes or of fishes themselves. Areas of commercial fishery are comparatively small spots in the sea as a whole.

Some investigators are led to a conclusion - supported by field studies, statistical analyses, and consideration of the economics of the fisheries - that stocks of many favoured sea fishes are subject to depletion and that, throughout great areas, excessive fishery has resulted in the reduction of populations below the level of most profitable exploitation. Depletion of particular populations need not be reflected in decreased market stocks: equivalent or even increased yield may be maintained by introduction of improved methods of capture and preservation, by the use of larger vessels or trawls, or by finding new grounds, usually at greater distances and at higher cost of harvest.

From such facts and ideas, there was developed a theory or principle of the "optimum catch". The thought is that the take of a properly moderated fishery, plus natural losses, should remove only as many pounds of fish as are added each year by new arrivals and new growth. By restriction of the fishery through voluntary action, by law, or, when necessary, through international agreement, fish populations in particular areas of fishery, such as the North Sea, Georges Bank, or the halibut grounds of the North Pacific, will be reasonably stabilised for fish of the kinds, ages, and sizes favoured by the market. The populations may thus be perpetually self-sustaining at the level of most profitable exploitation, subject only to the inevitable fluctuations that result from natural causes. Increased efficiency in capture and handling would result in economy of operation and either less effort or greater profit from a fairly constant catch, or, perhaps, lower prices and increased demand - in any case, it is assumed, with advantage in profit. The theory of the optimum catch is not applicable to all species or places. The herring, for example, which is connected by only a short link to the basic food supply, is seemingly not subject to depletion.

Interest in the question of optimum catch will vary with states and regions, according to whether the harvest is taken from resident or semi-resident populations of fish in areas of limited extent or from populations in passage (migratory schools) that can be tapped only when they are temporarily within reach. The extensive literature dealing with the theory of the optimum catch has been carefully analysed by G.L. Kesteven (4).

There are very real difficulties in any general application of the assumed principle of optimum catch. Many marine and anadromous fish pay no respect to state or national boundaries. Of desirable market fishes, there are a multiplicity of kinds, almost unlimited diversity of habits and ranges, and further complexities arising from year-to-year variations in ranges for particular species. In most cases, the optimum catch would have to be distributed by agreement among states or nations. At least the idea may stimulate more interstate co-operation in research to ascertain the facts.

The theory of the optimum catch and its potentialities in maintaining desirable fishery conditions, while commanding respect among many fishery biologists, is not universally accepted. There are those who seem to place paramount emphasis on natural cycles such as those that are well known to occur (independently of man's action) with terrestrial and marine animals. For any particular fish, and regardless of fishing, a series of years of successively large populations up to a certain maximum may be followed by a series of years of decreasing population. No one questions the likelihood of such cycles of natural occurrence, whether cycles of abundance are inherent in the fish or whether they are only the reflection of cyclical changes in the environment. Differences of opinion prevail only over the question whether or not major reliance can be placed on the cyclical concept to explain all variations in supply of particular fishes.

Taylor has recently presented arguments that if accepted would dispose of need for measures of conservation of marine fishes (5). Concluding that fishermen readily shift from species to species, he points out that "There do not appear to have been in the historical record any great general biological scarcities of fish... The curve of total quantity of food fish produced year by year follows that of the index of industrial production which is typical of the business cycle... Both the quantity and value of fish produced are determined solely by the economic factor of demand." For these data and discussion, reference must be made to the volume cited.

Whether or not one goes all the way in reliance solely on economic conditions, the emphasis on demand has importance; nothing is gained by capturing or attempting to market more fish or shellfish of any kind than consumers will buy.

On the other hand, it is hardly enough to say that the general market will always be satisfied, regardless of depletion of particular fishes of particular areas - that there are fish somewhere awaiting capture by someone with initiative and equipment. The administrator of fisheries still has to face those who may not be content that market demand is met through replacement of their own accustomed catches by other harvests. Especially is this true when the substituted fish are harvested from remote areas by those who can afford larger vessels, more expensive equipment, and more costly voyages.

Suffice it to say that no pat or generally applicable solution of the problems of actual or seeming depletion is now found in the theory of optimum catch, in the idea of cycles, or in the unfailing operation of the law of supply and demand. Some of the complexities that arise from environmental conditions or from the predator-prey relationship are suggested in the next section.

Discussion of this topic may be concluded with a quotation from Lionel A. Walford (6). "It is now realised that for most marine populations there is no final fixed maximum yield; that varies depending on the interactions with predation and prey populations - and with changes in environment affecting all populations. There is thus a shift of interest, in some quarters, to the study of marine "communities" (say all the fish populations along the Atlantic coast) and the effect of both the fishery and the environment - oceanographic and meteorological conditions - upon them. Naive acceptance of the idea of a single "optimum catch" for all marine fisheries may well lead to disappointment in the majority of cases."

Some of the complexities - an open question. As I mentioned in a preceding section, no particular types of regulatory measures are here proposed or opposed. It is intended, rather, to point to some lines along which researches are directed or needed. It cannot be too strongly emphasised that the situation with respect to populations of marine and estuarial fishes and their interrelationships is often highly complex. Some of the complexities arise from the fact that almost all commercial fishes are predators. Each predator lives at the expense of its neighbours: at the very least it feeds with them from a common table. Insofar as a particular fish is protected, others are left unprotected from it as predator or as competitor. One winces at the destruction of young sea trout (squeteague) in the shrimp fishery. If this is restrained, what is to protect the shrimp and the small fish from destruction by the voracious and growing sea trout? If one protects the bluefish, "perhaps the most ferocious and bloodthirsty fish in the sea", one withdraws by so much protection of mackerel, sea trout, and butterfish from the rapacity of the bluefish. The mackerel, in turn, feeds in part on herring and young mackerel.

As indication that fishermen themselves have long suspected the complexity of interrelationships, I may mention (but definitely without accepting its soundness) a contention of fishermen, 80 years ago, that the invasion of bluefish into New England waters in the middle of the last century led to a fourfold increase in the population of lobsters, because the bluefish drove away mackerel, which they considered to be the greatest enemy of young lobsters (7). Since the mackerel is not generally a bottom feeder, we may doubt the validity of the contention. At least, however, the fishermen of an older time sensed a valid principle, whether the application in this case was right or wrong.

The existence of complicating interrelationships, which are widespread among food fishes, does not require that we be indifferent to the preventable destruction of young fish or that we regard no protection of any fish as desirable. It does mean that complex interrelationships of species come into the picture and that particular actions in restriction of a fishery may have effects that were neither contemplated nor desired. It means, above all, that sound opinions regarding protection measures should not be arrived at by offhand glances at just one part of the picture, however vivid that part may seem to be. Snap judgments for or against protection are equally unreliable.

What is needed is more accurate and broader knowledge of the interrelationships of species. An objective is more intelligent appraisal of what may be called the "biological cost" of giving or withholding protection in particular cases. Surely we want also more deliberate and precise analyses of the economic cost to fishermen that is involved in either alternative. Perhaps in some cases we may never arrive at completely satisfactory answers. Nevertheless, costly errors of judgment are fewer when understanding is improved.

Service of Science

By what has been said, we are led to the inescapable conclusion that fishery science for the open sea, in contrast to agricultural science for the land, can do nothing about the crop with respect to fertility or propagation. Unless we can do something about survival, we are effectively hedged in insofar as production of the harvestable crop is concerned. Wherein, then, is the potential service of fishery science? In attempting at least a partial answer to a question that strikes at the very foundation of fisheries laboratories, we may list a few more-or-less-obvious lines of service.

In the first place, the cited limitations on human contribution to production of the crop do not, as we have seen, apply to some important shellfish of the estuarial waters. Seeding and cultivation of oysters of several species, considering east and west coasts, for increased production can yield results (with or without resort to artificial hatching). Clams of various kinds seem also to offer presently unrealised possibilities.

Anadromous fishes, such as salmons, shad, and striped bass, present special problems and, it is to be expected, fair opportunities for promoting by proper restraints greater stability of populations and harvest. A diversity of scientific studies is needed to determine causes of fluctuations in yield. To what extent are fluctuations attributable to excessive or improper fishery? to variations in market demand? to barriers, complete or partial, caused by dams or by pollution? to innate biological cycles of reproduction and growth? to varying conditions of precipitation and discharge of streams the fish must ascend for spawning, hatching, and early growth? or even to changing conditions of circulation, nutrition, competition, or predation in the sea where the fish must grow to maturity? Requisite for a proper interpretation of apparent trends is a lot of precise biological and hydrographic knowledge gained over periods of years - and a good measure of sound judgment.

With respect to marine fishes, it should always be in mind that it is not alone production in the sea that determines the harvestable crop but rather, and primarily, the availability of what has been produced naturally for the harvester. It does not matter how many fish are produced naturally if we do not know where, when, and how to get them. Insurance of availability offers fairly wide scope for human efforts in the fields of biology and oceanography to puzzle out the conditions that cause movements and aggregations. It is equally a problem of fishery engineering, where practical fisherman, biologist, oceanographer, and physical and chemical technicians must work hand in hand to devise ways of attracting fish into the nets and of keeping them in the best possible condition after they are caught.

In the line of exploration by the biologist and the oceanographer, there are possibilities in the discovery of new fishery grounds on the bottom or of new areas of fishery in the open sea.

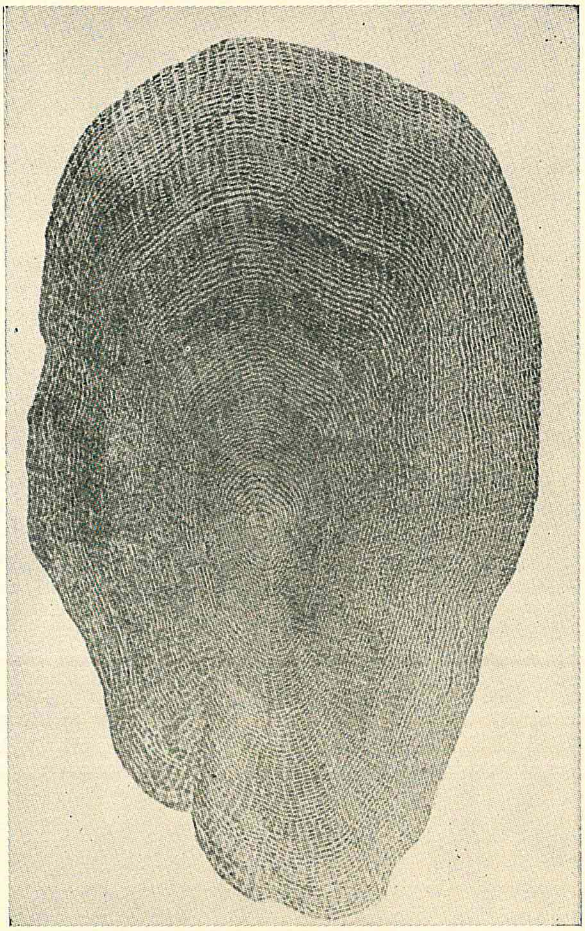
In the realm of opportunities and techniques of capture and handling, there is constant challenge to the inventive mind reinforced with experience in fishery operations. The farmer with modern equipment scorns much of what his predecessors used a century ago. The fishermen of today are content with much of the old apparatus and many of the old techniques of capture. There have been improvements but all too few. Processing and marketing now give greater evidence of modernisation. In general, resistance to change has characterised fishermen at least as much as it has any other group that works close to the bases of national economy.

The field of forecasting offers definite possibilities for reduction of wasted effort and expense in the fisheries. Long-continued studies of fishes, the food of fishes, the drifting microorganisms, temperatures, currents, and drifts do sometimes provide a basis of knowledge that permits forecasting with respect both to the movements of fishes and to good fishing years. The bane of most fisheries is the unpredictability of catch. If both farming and fishing may be described as gambling operations, a chief aim of science in these fields is to better the odds in favour of the operator.

By examination of the rings on scales or in earbones, a population of fish is sorted into year-classes. A year-class embraces all the individuals that, by proper interpretation of markings on the scales, are found to have started life in a particular year. It becomes evident that a given year was, or was not, good for hatching and survival. After lapse of the number of years required for fish of that kind to reach marketable size, a good year-class may be expected to appear in relative abundance in a succession of years while individual fish grow from year to year in size. Knowing, then, about the composition of the catch this year with respect to year-classes, one may forecast, with some assurance, not only which year-classes will make up the population of the next year but also whether these classes promise large catches.

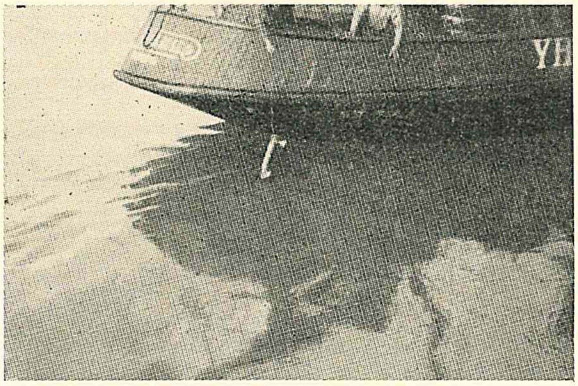
Just as one illustration of possibilities, a recent report of the Pacific Biological Station at Nanaimo, British Columbia, may be quoted. As a feature of their intensive and protracted studies of the herring, they say: "Predictions of fishing success are attempted each year after consideration of all pertinent data on each population. They make available to the fishery industry information of possible value in the efficient utilisation of the resources.... Predictions of year-class strength, population abundance, and the relative size of fish in the various fisheries have generally been correct."

One sort of forecasting derives from prolonged studies of the physical and chemical qualities of the water and of the drifting microorganisms (the plankton). Sometimes it may be determined (on the basis of sufficient experience in a given area) approximately how far north or south, east or west, schools of migratory fish will come in a given season.



Scale of haddock six years old. [Courtesy U.S. Fish and Wildlife Service.]

Underwater view of a sea scallop bed on Georges Bank off Cape Cod. A 2-mile strip of ocean bottom was photographed in an effort to make a census of the sea scallop beds. [Courtesy J. Artur Posgay, Woods Hole Oceanographic Institution.]



The Hardy plankton indicator. [Courtesy A. C. Hardy, Oxford University.]

There are also modes of short-range, hour-to-hour forecasting - for example, by the "plankton indicator", the thermometer, or the echo sounder. The idea that minute drifting organisms may be indicators of the presence of prey is not new. Whalers, observing the colour or the "soupiness" of surface waters, have long recognised "whale feed" (copepods, mollusks, small shrimp) and have been guided by its presence or absence. But feed and fish are not necessarily at the surface. The originality in the plankton indicator is in the design by the British scientist A.C. Hardy of a simple apparatus that is easily manipulated to reveal conditions at depths that are not visible to the observer on a vessel. A vast amount of highly technical biological and oceanographic study was necessary to accumulate the foundation of knowledge that paved the way for a simple appliance having potentialities for practical use.

A tube 3 inches in diameter and 1 foot long carries a fine-meshed silk disk as a filtering screen. Attached to a line held on the vessel and provided with vanes that assures its "diving" to a proper depth, the instrument can be repeatedly thrown from a moving vessel to sample microscopic life at a depth of several fathoms. When the plankton indicator is pulled back aboard, the screen tells the story; the fisherman needs no fancy microscope or special biological knowledge. A clean disk means little food for fish and little likelihood of herring; a brown or green disk may signify abundance of minute plants that are not generally favoured by herring; a reddish disk indicates copepods - "herring feed" - and suggests that nets be shot. Obviously insofar as the indicator is reliable, it can effect savings in labour, time, and expense.

When one is dealing with nature, particularly in the sea, complications are to be expected. As Hardy recognises, there are limitations on the reliability of the indicator. If a large school of herring moves into a rich feeding ground and substantially depletes the population of copepods, the sampler might give an unfavourable indication while herring were still abundant. Again, at certain times, the movement of the fish might be guided, not by conditions of food supply, but by conditions requisite for spawning. Fishermen who rely on the indicator cannot expect 100-percent reliability. At least, the instrument can tell them of conditions, otherwise undetectable, that are quite unfavourable to fishing operations (8).

This device is an example. What others may come in the future?

An understanding of the temperature relations of particular fishes, derived from extensive scientific studies, has led finally to relatively simple procedures in "fishing with thermometer." Studies of termperatures, salinity, and dissolved oxygen afford means of identifying masses of water, their origins, and their relations to the distribution of fishes. A striking illustration of the potential value to fisheries of long-term studies of hydrobiology and meteorology is afforded by the fact that the yield of mackerel for May and June in the great sound of Denmark, the Kattegat, can, it is said, be predicted from the knowledge of the frequencies of eastern and western winds during the preceding months of January to April as well as from studies of salinities in the preceding months (9).

Less simple than the plankton indicator is the fathometer, or echo sounder, which reveals the actual presence of fish at considerable depths. It is a triumph of physical and oceanographic sciences that is invaluable to fishermen. Hardy remarks (8), with reference to Scottish and English fisheries : "few drifter shippers now shoot their nets without first getting an indication of fish on their echometer."

The camera, sometimes with television, has become useful to oceanographers in exploration of deep waters, to biologists in observation of fishes in their habitats, and to fishery technologists in examination of subsurface fishing operations. As everyone knows, direct observation of fishes in coastal waters is attainable through the increasingly widespread use of self-contained diving equipment. Who knows what better understanding of the behaviour of fishes may accrue?

Meteorology has been alluded to. That the weather forecaster is the fisherman's best friend requires no emphasis. However, allusion should be made to the new speciality of forecasting wave heights, both for beaches and for offshore waters, a service that offers real possibilities for economy in fishery operations.

In much of what has been said about forecasting, it is assumed that we have some knowledge of the migrations of fishes and how the movements are related to temperatures, plankton, and other conditions of the environment. This presupposes a lot of basic study of the natural history of fishes, gained in part by extensive tagging of individual fishes, and recovery of tagged fishes. It assumes, too, a great amount of prior study of environmental conditions and of the correlation of the movements of fishes of different kinds with the environment - biological, physical, and chemical. On this, as on many fronts, the scientist cannot work alone; the cooperation of fishermen is of high importance.

Availability of fishes depends, not only on numbers and localisation, but also on the behaviour of fishes and their reactions with respect to modes of capture. Here, biology, physics, chemistry, and engineering come together. In some regions, lights are used extensively to attract fish to the net. This may be only a beginning. There seem to be possibilities in determining the more effective wavelengths of light. Here and there electric currents are being experimented with to direct the movements of fish or to shock them into numbness and readiness for capture. There is undoubted practical need for basic studies of the reaction of fishes to visual, electric and chemical stimuli.

Certainly there is occasion to explore the possibilities of new products from the sea. During the recent world wars, there was substantial scientific and commercial activity in the extraction of a vitamin from the otherwise useless horse mussel. If the sea holds in solution the basic elements of every biological need, what may be the possibilities of extracting from the drifting microscopic plants and animals valuable food and drug products, both biotic and antibiotic?

Barring the leasing of oyster beds, there is no private ownership; fish in public waters are common property, to be taken by anyone who will pay the requisite small tax. Too often the fisheries are not conducted with the consideration for the economy of effort that must control the use of land resources, such as forests, where private holdings and control prevail. There is, and probably will always be, demand for state regulation of fishery apparatus and methods, particularly in estuarial waters; but there should be more thought of the waste in effort that is required by some of the restrictions.

It has been remarked by others that the fishery is probably the only basic industry that is repeatedly required by law to operate inefficiently and uneconomically. Perhaps some of this is practically necessary in order to spread the operations among a larger number of people. Where resources are communally owned or communally exploited, the administrator may find it hard to resist entirely the demands for rationing the rights of exploitation among the vocal groups. In any event, more serious thought should be given to the waste of effort that is required by many of the restrictions. In general, however, as has been mentioned before, the restrictions are almost universally based on paucity of knowledge, both of the fish it is desired to protect and of the economic cost of the restriction. In these conditions, it is a primary responsibility of science to ascertain and publicise the real facts of natural history and economics and thus to promote wiser regulation and greater profit. Perhaps, in some cases, scientist and economist together should design experimental regulation, competently observed and controlled.

Considering the inevitability of demands for regulation, the need to promote more economical exploitation of nature's freely produced crops, there is call for statisticians, economists, biologists, and oceanographers to work cooperatively. Biologists and oceanographers can accumulate background data on the behaviour of particular fishes and shellfishes and of the physical conditions surrounding them; the objective is better understanding of the interrelationships of fish and environment. Without knowledge and understanding, the fluctuations of sizes of populations of desired fishes - or their total absence - in this place or that, at this time or another, remain impenetrable mysteries and substance for wild guesses: Regulation runs amuck, and exploitation is more haphazard and less economical than need be.

Whether or not it looks "practical", what is really called for is a lot of basic biological and hydrographic study, such as has long been in progress around the British Isles, such as is being done in the California Cooperative Oceanic Fisheries Investigations, and such as is now carried on in a few other American offshore areas. Oceanographic study, it must be recognised, is not inexpensive. A vessel must be operated; the skills of men of talent and training are required; it takes time; often, however, expense is distributed through cooperative effort among agencies of diverse specialities. Thought of long-continuing costs for ultimate economic return tends to discourage the appropriation of public funds. Yet one must emphasise the inescapable fact that investigation of almost any immediately practical problem of the fisheries is stalled sooner or later by the want of basic oceanographic knowledge that can be gained only through long-term research.

Market studies are of high importance. Better products and a broader market for them are needed. It is not enough to find good fish in the sea. Curiously enough, it is too generally the case that the fish most readily obtainable in the markets are not the fish of best natural flavour. Practices employed in capture, handling, transportation, and storage need always to keep pace with the more and more exacting requirements of the consuming public concerning appearance, grading, packing, and dependability. In actual food value, the better products of the sea rank second to no other item of food. Yet the consumption of fish in this country is quite low compared with that of other countries. In some parts of the United States, it is extremely low. What is wrong with our tastes - or with the fish we can buy? More concretely, what is wrong with the mechanism of getting from sea to table inexpensively harvested food of highest quality? Spotting a glaring deficiency in utilisation of fishery resources avails little in itself. Marketing and buying practices are not easily changed. A paramount need now is for marketing research that is pursued systematically and competently by specialists in the field of economics, with the sympathies and aid of fishermen and dealers. Marketing research has paid off for agriculture; it may well do so for fisheries.

Balanced Approach

But let us for a moment be what is often called "practical-minded". A public institution for fisheries research may seem to face an impossible dilemma.

It can be one of two or three things. It can become a mere political agency, playing handy man to one or another special interest of the fisheries or leaping from one piece of "research" to another as may be required to grease the wheel with loudest squeak; it accomplishes little of enduring value. With rather more stamina, it can restrict activities to "immediately practical problems", in the solution of which it runs too generally into blind alleys; the pathways are blocked by barriers of ignorance of the real facts essential to progress in solution. Assuming support, it can concentrate on basic science, leaving all hope of monetary return to some future time. Meanwhile, it needs funds: on the one hand, personnel want pay, as do equipment dealers; on the other hand, taxpayers, offered only vague suggestion of possible future repayment, are not free with credit.

Actually, with understanding leadership, the dilemmas so crudely stated need not be encountered. It is more than a matter of maintaining the golden mean. The alternatives are not mutually exclusive. The squeaks of the wheel should be heard; sometimes they point to vital problems. Immediately practical problems may be interesting and informative; they may give leads to the scientist in basic research. On the other hand, the need for basic research is not imcomprehensible to the intelligent fisherman and taxpayer any more than it is to the farmer. The fishery scientist may never be able to show the spectacular economic returns of the agricultural scientist; but fisherman, as well as farmer, seeing his bread-and-butter requirements faced sympathetically and as competently as conditions permit, may well learn where the true obstacles lie, come to see his own problems in proper perspective, recognise the practical necessity of expanding the bounds of knowledge of fish and environment, and acquire a proprietary interest in the scientific endeavour. On the other hand, the scientist in a fisheries research programme, if he is privileged to do more basic work, need not feel too wildly free. He is employed in a particular sort of cooperative undertaking having recognised and understanding objectives. The problem for leader and staff is to see the whole picture and to formulate a well-designed and defensible attack with diverse lines of approaches. When motives are clear, there is no more impracticality or incongruity for a fisheries laboratory than there is for an agricultural laboratory giving a <u>fair emphasis</u> to basic science.

In conclusion, it may not be quick and spectacular increases in fishery yield that can be expected but rather gradual and substantial improvement, based on scientific and economic studies to support and supplement individual initiative and enterprise, which must always be a chief reliance. Increasing profit to fishermen and to states and wiser regulation of fishery practices with fewer useless and costly restrictions are to be striven for. It is a virtual certainty that gratifying results will follow from continued and energetic cooperation between administrators, scientists, statisticians, economists, and, most important, fishery operators and fishermen.

References and Notes

1. Paper from the Department of Zoology and the Institute of Fisheries Research, University of North Carolina; completed in the Institute of Marine Biology, University of Puerto Rico. I have gotten ideas relating to this subject where I could. Acknowledgements could be innumerable, but special mention should be made of the critical and helpful comments on earlier drafts of the manuscript that were generously given by M.R. Carriker, A.F. Chestnut, J.L. McHugh, and L.A. Walford, who, however, share no responsibility for errors and limitations that remain. Should this presentation elicit more and better thoughts from others, a major part of its purpose will have been served.

2. The hard clam, thick-shelled clam, littleneck clam, cherrystone clam, or quahog is of the genus Venus; the soft clam, thin-shelled clam, long neck clam, or just "clam" of northern waters is of the genus Mya. On the West Coast, soft clams are Mya, hard clams are mostly Saxidomus.

3. E.S. Russell, The Overfishing Problem (Cambridge Univ. Press, Cambridge, 1942), pp. 70 and 110.

4. G.L. Kesteven, "An examination of certain aspects of the methodology and theory of fisheries biology," mimeographed at the Bingham Oceanographic Laboratory, Yale University. (Revised from the mimeographed edition issued from Cronulla, N.S.W., in 1946.)

5. H.F. Taylor, Survey of Marine Fisheries of North Carolina (Univ. of North Carolina Press, Chapel Hill, 1951), pp. 320, 420, 421.

6. L.A. Walford, personal communication.

7. S.F. Baird, Rept. of the Commissioner of Fish and Fisheries for 1871 (1873), p. 245.

8. Discussion of the plankton indicator is based in part on a personal communication (1955) from its designer, A.C. Hardy, professor of zoology, Oxford University.

9. G.L. Kesteven, referring to the effects of movements of water on abundance of mackerel in the work cited (4), quotes Jensen (1950) as follows: "Thus the yield of the fishery during May - June may be predicted (i) from the frequency of eastern and western winds during January - April, (ii) from the surface salinity in the Kattegat during February - April, (iii) from the bottom salinity in the Kattegat during April." Similarly, forecasts of the occurrence of mackerel in the sound in autumn are made from the meteorological-hydrographic factors of the preceding months.

INSPECTORS' ANNUAL LEAVE - 1957

Some alteration to the following programme to suit an officer's personal convenience may be permitted provided departmental requirements are satisfied.

Name of Officer	Commencing Date of Leave
Senior Ins. J.E. Munro	April 10.
Inspector H.J. Murray	March 18.
" S.W. Bowler	When convenient.
" A.K. Melsom	August 26.
Fauna Warden G.C. Jeffery	December 16.
Inspector J.L. Gallop	March 25.
" A.J. Bateman	When convenient.
" A.V. Green	September 23.
Ass. Ins. R.J. Baird	November 18.
Inspector N.E. McLaughlan	April 29.
Ass. Ins. T.B. Baines	March 4.
Ass. Ins. G.H. Lyon	September 2.
Inspector B.A. Carmichael	When convenient.
Ass. Ins. M.J. Simpson	March 25.
Cadet Ins. D. Wright	September 23.
Inspector R.M. Crawford	October 21.
Cadet Ins. R. McKay	September 23.
" " S. LaRoche	When convenient.

C.S.I.R.O. AND FISHERIES RESEARCH

C.S.I.R.O. is discontinuing fisheries research in this State.

A statement to this effect, attributed to Professor N.S. Bayliss, Chairman of the W.A. State Committee of C.S.I.R.O., appeared in a recent issue of a Perth weekly.

The statement went on to say that research on W.A. herring, salmon, tuna, mullet and prawns would stop this year. Oceanographic research on W.A. ocean currents would also cease. Whaling research only would be carried on by C.S.I.R.O. in this State, it was stated.

Professor Bayliss is reported to have said that the discontinuance of research was part of the new programme of the headquarters of the Division of Fisheries and Oceanography in Sydney.

He said the purpose of C.S.I.R.O. research in any State was to help form a basis for industry. The W.A. branch of the division had to date helped form this basis, and personnel were now being recalled for a reshuffle in the Commonwealth programme.

Professor Bayliss concluded his remarks by saying that C.S.I.R.O.'s 1956-7 programme allowed for more expenditure in some fields and less in others.

The Minister for Fisheries (Mr. Kelly) has commented on the statement in the press release he has made on the subject. The following is the full text of the release -

> Commenting on a recently-published statement that nearly all C.S.I.R.O. fisheries research in this State will be discontinued, the Minister for Fisheries stated that although C.S.I.R.O. research personnel were gradually being withdrawn, not only from Western Australia, but from other States as well, it had not been finally decided whether all research projects initiated by the officers concerned would be dropped.

For example, he and his Department were by no means satisfied that any justification could be found for halting crayfish work here. If this were done it would mean another half-finished job, and the State was most anxious that as much data as possible be got together on the life history, length at maturity and general behaviour of the crayfish. This was essential so that proper management programmes could be developed. At the moment, a complete picture of the crayfish could not be obtained.

As far as prawn research was concerned, continued Mr. Kelly, it should be pointed out that most of the work done hitherto in this field had been undertaken by the State Fisheries Department with its research vessel "Lancelin", although C.S.I.R.O. had assisted in certain material ways. The activities of "Lancelin" in the immediate future would comprise prawn and scallop surveys in Shark Bay, and the marking of whales in that area.

"It is very difficult to understand what appears to be a new policy on the part of C.S.I.R.O.", concluded Mr. Kelly. "The concentration of the fisheries research staff at Cronulla, N.S.W., may have some good points, insofar as it will permit greater co-ordination of effort and to some extent reduce costs. However, fisheries research is of such a nature that a considerable amount of field work is essential all the time, and if all the research personnel are to be stationed in New South Wales, it stands out clear as a pike-staff that practically the only field work which will be done will be in the waters of south-eastern Australia, which are so handy to the headquarters of the Division of Fisheries and Oceanography. Evidently the fisheries of W.A., South Australia and Tasmania are not considered to be of sufficient importance to warrant work being done on them by Commonwealth authorities."

SUCCESS OF "FAIRTRY"

In previous issues of this Bulletin (see Vol. IV, Nos. 4 and 12 of April and December, 1955), reports of the design of the "Fairtry" and her early catches were published. Later reports from England revealed the efficiency of this new type factory-trawler. In the $2\frac{1}{2}$ years that have elapsed since her first trip, the "Fairtry" has landed more than 5,000 tons of fish (nearly all packaged fillets), about 1,000 tons of fish meal and over 100 tons of cod liver oil.

In the early stages the "Fairtry" suffered teething troubles, but once her crew grew accustomed to stern trawling and became skilled in the manipulation of her production-line processing machinery, her landings reached what are to us astronomical heights.

As early as September, 1955, she returned from an 82-day tr p to Greenland and Newfoundland waters with one load of 662 tons of frozen fillets, 162 tons of meal and 350 gallons of liver oil. No part of her catch is wasted, as after the fish have been through the filleting machines and the liver oil extracted, the whole of the residue is converted to fish meal.

ANOTHER JOB FOR INSPECTORS

All inspectors whose duties take them into contact with the crayfish industry, are requested to find out and report what use of insecticides has been, or is being made by fishermen, freezer-boats, carrier-boats and processing works.

In a recent issue of "Fishing Gazette", marine biologists working in the Sea and Shore Fisheries Department in the State of Maine, U.S.A., warned that extreme care should be taken in the use of insecticides which might conceivably come in contact with live lobsters. It was reported that the biologists have demonstrated that several of the new insecticides, particularly Lindane, are toxic to lobsters, even at such low concentrations as one part of insecticide to 10 million parts of water, and that even the use of sprays to control flies around stored bags, crates and bait can prove dangerous.

It is thought probable that our crayfish would succomb as readily as the American lobster, and it is possible that some mortality suffered by our crayfish in the past, between catching and processing, may have been due to insecticide poisoning.

SPERM WHALING

Cheynes Beach Whaling Co. finished a successful season on December 11 when they captured their sixty-first whale. This season has proved the value of the Company's original investigations, and the proceeds, approximately £600 a whale, will enable the Company to install some much-needed new plant.

DUCK BANDING

Technical Officer J. Traynor reports that during the period November 29, when banding operations recommended, to January 22, 301 ducks were banded. Of these, 146 were black duck and 100 grey teal. The remainder consisted of 42 mountain duck, 9 maned geese, 3 white-eyed duck and one pink-eared duck. They were banded at stations in the Wagin, Woodanilling, Metropolitan and Dandaragan districts. At the present time, Mr. Traynor is operating again in the Metropolitan district.

Recoveries.

Since the commencement of the open season on December 22, quite a number of bands have been handed in. As will be seen from the table hereunder, a surprisingly large proportion has been recovered from ducks of this season's bandings.

Band No.	Banding		Recovery		Distance Flown
	Date	Place	Date	Place	
			Black Duck		
3740	29.2.56	Queen's Gardens	25.5.56	Dale River, 23 miles W. Beverley	55 miles
3434	28.3.55	do.	May '55	9 miles from Boddington	65 "
3697	27.2.56	do.	approx. 30.10.56	On property at Riley Rd. Riverton	(found dead) 6 "
2698	29.4.54	do.	approx. 28.11.56	North Lake Hamilton Hill	10 "

Band No.	Banding Date	Banding Place	Recovery Date	Recovery Place	Distance Flown
			Black Duck (contd)		
6279	19.12.56	Flagstaff Lake	26.12.56	Coyrecup Lake	35 miles
6218	8.12.56	Gundaring Lake	Opening Day '56	Gundaring Lake	- "
2923	25.10.56	Cockle-shell Gully	30.12.56	Walyengarra n. of Lan-celin	50 "
3964	28.3.56	Wardering Lake	13.1.57	Swamp S. Gundaring	20 "
6254	16.12.56	Flagstaff Lake	20.1.57	Fitches Swamp, 12 M. Nth Kojonup	10 "
3424	9.2.55	Cape Riche	9.1.56 or 10.1.56	Near Pingrup	80 "
6243	16.12.56	Flagstaff Lake	27.1.57	Woody Lake	14 "
			Grey Teal		
2818	21.5.54	Eyre River Cape Riche	19.5.56	Frankland River	about 120 "
4165	6.12.56	Gundaring Lake	9.1.57	5 mls N.W. Lake Grace	55 "
3791	11.3.56	Dumbleyung	22.12.56	Kondinin	65 "
4159	5.12.56	Gundaring Lake	6.1.57	Gundaring	- "
2622	7.4.54	Karrinyup Lake	30.12.56	Gundaring	140 "

Band No.	Banding		Recovery		Distance Flown
	Date	Place	Date	Place	
			Grey Teal (contd)		
3828	23.3.56	Wardering Lake	1.1.57	Parkeyer-ring Lake	12 miles
4152	5.12.56	Gundaring Lake	23.12.56	Gundaring	- "
4161	5.12.56	Gundaring Lake	22.12.56	Wagin	
3851	24.3.56	Wardering Lake	27.1.57	Taarblin	45 "
4166	6.12.56	Gundaring Lake	19.1.57	Gundaring	- "
4068	13.4.56	Yathroo Station	22.12.56	Taarblin Lake	195 "
3200 3201	24.1.55) ")	Yealering Lake	not known	Yealering	- "
			Mountain Duck		
6268	17.12.56	Flagstaff Lake	26.12.56	Coyrecup Lake	35 "
6275	8.12.56	do.	1.1.57	Park	10 "

EXCESSIVE TELEPHONE EXPENDITURE

The Under Treasurer has called attention to the need to economise in the use of telephone facilities. Trunk calls are only to be made or telegrams dispatched when the nature of the business is so urgent that their use is imperative. Alternative mailing facilities are generally good and on all but a few occasions, with a little forethought, can serve adequately.

THE CLEARING HOUSE

Is This Just a Fishy Pipe-Dream?

If an American inventor's dream comes true, fish will be caught in future by being sucked into pipes laid on the ocean floor through huge stainless steel funnels and pumped out at the canneries and processing plant.

Trawler owners and fishermen, with their costly vessels, would disappear, to be replaced by a number of marine engineers and a combination of "Heath Robinson" underwater contraptions and electrical apparatus.

The inventor, Mr. Hugo Gernsback, describes his idea for revolutionising the fishing industry in National Fisherman, U.S. fishing industry journal.

Fishing is Prehistoric

Man, he points out, still uses virtually the same fishing methods which were used by savages and prehistoric man 100,000 years ago. "Weather still stops our fishing boats; we still use nets to catch a comparatively few tons of fish even when using a modern ship. All this is slow, inefficient, and very expensive.

"Worse yet, we go after the fish, when it's far easier and cheaper to have fish come to us!"

He claims that fish could be supplied at a reasonable cost "to every human in the world" - either fresh, canned, frozen, extracted or processed. "The way to harvest this never-ending crop is comparatively simple - catch the fish by pipeline" he declares.

Mr. Gernsback claims further that his plan to lay pipelines on the shallow ocean floor, running them from 10 to 25 miles out into the ocean is today quite feasible. He points out that within 25 miles of the U.S. coast in many sections the water is only 75 feet deep, "ideal for pipe-laying purposes."

To lay these ocean pipes a special ship would be required that would not rock or pitch. "Such ships can be built today." At the land end of the pipe, sea water would be admitted, so that the entire pipeline would be continuously filled with water.

"Fifteen, twenty, or twenty-five miles out, wherever there is known to be a steady supply of fish, the pipe-line would terminate. Here a special installation would be a huge stainless steel funnel, from 50 to 75 feet in diameter at its large end. This funnel would be from 50 to 60 feet or more below the surface of the ocean, depending on the locality, observed fish density, and other technical requirements.

"The open funnel would be kept afloat and in position by a number of steel tanks welded near the upper rim. It would be kept from swaying laterally by special anchors.

"Around the rim of the funnel there would be a number of specially-coloured electric lights. These would serve to attract the fish. Experience soon would teach what types of fish were attracted to a given colour and a given light intensity. The lights would be operated from shore, through a special electric cable running parallel to the pipeline.

Pump from Shore

"At the shore fishery establishment, powerful pumps attached to the pipe-line would suck in the water (along with the fish) in a continuous stream. The suction at the end of the funnel could not be too strong nor too rapid or the fish would get away. Once down in the funnel the fish would find it difficult to swim back into the ocean. A goodly percentage of the fish swimming at and across the level of the funnel would be sucked into the pipe-line and on to the processing plant."

Mr. Gernsback goes on to estimate the yield of fish which might be caught by his device. "Supposing at a very low estimate, that only ten fish, weighing but one pound each, were captured per second.

That would give us the respectable amount of 432 tons of fish for a 24-hour day."

As to by-products derived by the same method, Mr. Gernsback declares that the fish processing plant owner need never worry. There are other treasures in the sea water. One is vegetable plankton, "an excellent food for land animals and humans. New processes soon will make it profitable to harvest."

After the extraction of fish and plankton, the processing plant need not return the sea water to the ocean immediately, he adds, for this contains valuable metals and minerals. One is magnesium, which has already been profitably extracted from sea water for a number of years.

("The Fishing News" London November 9, 1956.)

Colour Shrimp Tagging

C.E. Dawson, 33-year-old scientist working at the University of Texas' Institute of Marine Science at Port Aransas, recently developed a revolutionary method of colour shrimp tagging, which is expected to be the key toward helping marine biologists to unravel the mysteries of shrimp migration, a subject they admit knowing little about.

Taking his cue from the unsuccessful efforts of another American scientist who attempted to tag shrimp with colour, Dawson came to the Institute on a grant from the U.S. Fish and Wildlife Service, and began his experiments. He tried one kind of dye after another, varying the amounts used, until he found a type and quantity which are harmless and permanent. Only a fraction of a milligram of dye is needed to colour one shrimp, and once the shrimp is "colour-tagged", he remains that way.

At first, Dawson injected the colour into the shrimp with a hypodermic needle, but this procedure was slow and required him to handle each shrimp separately. He then tried dyed food and found it worked successfully. It eliminated the handling; also speeded up the tagging.

Only the body of the shrimp under the shell is coloured. The tails are not affected. Neither is the colour lost when the shell is molted. To-date three colours - red, green and blue - can be used, however, Dawson believes further experiments may produce others.

Many methods of tagging shrimp have been used in the past, but most of these failed because a shrimp sheds its hard shell several times during a lifetime. Therefore, a tag attached to the shell is useless. A shrimp's tail is too soft to hold a tag which makes "tail tagging", likewise, of no value.

When a plastic disc is used, the nickel wire which holds the disc in place is seldom right. When it's too loose, it makes the shrimp an easy mark for a hungry fish. When it's too tight, it retards the shrimp's growth. Often the nickel wire corroded, so Dawson substituted tantalum. The numbers were stamped on the flat wire to identify the shrimp, thus eliminating the use of discs. But this method was time-consuming and required too much handling of the shrimp.

Dawson's experiments with dye tagging have met with favourable comment from various fishery officials. Albert Collier of Galveston, an official of the U.S. Fish and Wildlife Service, labels them a "big step toward the study of the life history of the shrimp". Bob Kemp, of the Texas Game and Fish Commission at Rockport, calls the discovery "a valuable tool, removing a barrier that has limited the knowledge of shrimp for many years."

Dawson was assisted in his work by Harold R. Bonorden, a teacher and assistant football coach at Aransas Pass, and the experiments were financed by the Fish and Wildlife Service with funds provided by the Saltonstall-Kennedy Act (which imposes tariffs on foreign fish products imported into the United States.) Experiments using the dye will have to be co-ordinated, Dawson said, otherwise two scientists working in the same area with the same colours could learn nothing. A central agency to assign different colours for biologists working in the same waters would be necessary.

But Dawson is moving on to other fields. He left Texas the middle of August for a 6- or 7-months' visit to Arabia where an American oil company has hired him to study fishing conditions in the Persian Gulf. He will attempt to find new fishing grounds and increase the catches of old ones.

("Fishing Gazette" New York September, 1956)

No Future for the Blue Whale?

"The days of the blue whale are numbered. The stock of fin whales is also declining, but not so noticeably", said Mr. Hans Farmen, manager of the 25,000 ton Norwegian factory ship Norhval, which sailed from Larvik for the Antarctic last week.

"Boats have to be constantly on the move, instead of lying still at one spot. During the second season after the war we got 600 blue whales, last year only twenty."

Mr. Farmen, with 30 years of whaling experience, urges greater international control. "There is no doubt that certain foreign expeditions take whales before and after the permitted hunting season, and take whales smaller than the permitted size. If expansion continues, and this looks likely with Japan sending five expeditions this year and Russia planning to build a new 40,000 ton factory ship with 20 catcher boats, the stock of whales is bound to die out completely. But with effective international control, whaling could be operated profitably for decades to come."

Mr. Farmen added: "The way whaling has developed since the war makes it necessary to use the very best technical equipment, and, as stocks decline, the equipment has to be improved constantly."

The Norhval, recently lengthened by 60 ft., was the first of nine Norwegian factory ships to leave Larvik. With its 12 catcher boats and equipment, the value of the vessel is put at £5,000,000. Cost of fitting out for this winter's operations, and wages for crew and workers, is estimated at £25,000.

("The Fishing News" London November 2, 1956.)

Fish Stick Production Lags 34% Behind 1955

U.S. production of fish sticks for the first six months of this year was 34% less than for the corresponding period last year.

Production shows a steady decline from the first of the year. During the six months period, three firms stopped production of fish sticks completely. Twenty seven of the producing firms are located in the Atlantic Coast states, six in the interior and Gulf States and 10 in the Pacific Coast states, for a total of 43. Last year, there were 47 firms producing fish sticks.

Production to the end of June, 1956, totalled 27.9 million pounds, compared to 36 million pounds for the same period last year.

("Western Fisheries" Vancouver, B.C. September, 1956)

Electric Process Removed Fish Smell -and the Dog Came Back!

To get rid of the offensive smell from powdered fish in a borough of Hamburg (Germany), engineers have devised a "smell cracker", which converts the offensive molecules into useful acids, says a Fishing News correspondent..

The residents have been fighting a desperate battle for years against the nuisance, which came from a factory producing powdered fish. Similar complaints came from people living near similar factories at Bremerhaven and Cuxhaven.

It is now hoped that the smells will stop by next summer. To instal the smell-killer will cost the factories about £40,000.

The fishes are first heated in large boilers, producing strong smells which are not allowed to reach the open air. The fish are dehydrated and directed into a large vessel in which the temperature is 600 deg. C., and particles of the smelling compounds disintegrate on contact with the glowing walls of the vessel. They decompose into sulphuric acid and phosphoric acid.

Water Spray Blown

In the drying plant the mass of fish again gives off offensive odours. Here the air is first dried and then washed, and a fine water spray is blown into the plant. The tiny droplets comprising the spray are charged electrically at 50,000 volts. The particles of the odorous substances, attracted by the charged droplets, gather around them, and the air leaving the plant is purified.

Dr. Freungel, a director of the company concerned, who invented the process, experimented in his home with the fish. As a result, even his own dog fled, says the correspondent, but science helped once again. The house was irradiated with ultra-violet rays and the smelly substances were destroyed.

("The Fishing News" London December 7, 1956.)

'Cigarette' Fish is New Find

Thin as a cigarette, two feet long, brown-black in colour, with three short bristles on its nose, a strange fish caught some months ago off the Kaituna River, in the Bay of Plenty, New Zealand has been identified as the first of its kind ever seen.

It was caught in a whitebait net set 150 yards from the river mouth, and was sent to the Dominion Museum, and later to Victoria University College to allow Professor L.R. Richardson to describe it in a forthcoming scientific publication.

("The Fishing News" London December 7, 1956)

Times Were Hard

A rock-like substance caught in the net of a Whitstable (England) oyster dredger owned by Mr. E. Laker has been identified by the British Museum as a 50-million-year-old fossil of an extinct lobster.

("The Fishing News" London December 7, 1956)

Dynamite for a Ten Ton Shark

A big basking shark, 28½ ft. long and weighing about ten tons, captured by four Nova Scotia fishermen in their herring weir, was disposed of by dynamite, according to a correspondent of Main Fisherman.

The fishermen thought they were "seeing things" when they found the monster gobbling herring a bucket load at a time. Using long poles they placed the dynamite under the shark's abdomen, setting off the charges with a battery discharger. "Twenty-one sticks of dynamite later the big brute had been rendered 'hors de combat', and with the help of two motor boats the shark was towed ashore and beached."

Only saleable part of the shark - ten barrels of liver - was disposed of at two cents (about 2d.) per lb.

("The Fishing News" London December 7, 1956.)

Swordfish Provides 'Real Steaks'

Frozen swordfish is increasingly popular as a restaurant dish in the U.S., according to Mr. Robert S. Russell, president of the Compass International Food Coorporation, New York, writing in the journal Quick Frozen Foods. Formerly a novelty, it is becoming so familiar an item on the menus of good restaurants that it will not be long before it takes its place as one of the best staples of the industry, he declares.

The fish has a pleasing taste, and is something like halibut in texture but the flesh is firmer. "A swordfish steak is a steak in every sense of the word, solid meat and no small bones", says Mr. Russell.

Largest tonnage of swordfish to U.S. comes from Japan - from 8 to 10 million lb. annually - frozen in the form of fillets. The Americans consume about 15 million lb. annually, with the figure rising rapidly.

("The Fishing News" London November 23, 1956.)