Future of Exploratory Fishing and Gear Research

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First of all, we should always consider that we are dealing with dynamic systems of living renewable resources. Renewable also in the wider sense that as the ecosystems change, and not least by the action of man, new resources may very well rise and fall; there are several examples of this. For instance, in the North Sea in the last 10-15 years, after the herring stocks and similar stocks were fished on, there was a fishery for sprats. Fairly large quantities were present which were never there before, certainly not in such quantities. So in that way we got other resources instead of the herring which was fished on.

Secondly, if we look upon the most recent fisheries developments--in the last 10 years or so--you will see that we have a number of examples of new resources that have indeed been identified from time to time, and new explorations have started. In some cases, these have been new discoveries. In others, it has been rediscoveries of what we might call old resources in the sense that some knowledge about them existed, but it is only recent research and explorations that have shown they were exploitable. In other cases, new developments in technology as well as in market conditions have made certain known resources attractive which previously were not commercially exploitable. For example, the blue whiting fishery was developed in the northeast Atlantic since 1971-72 and has turned out to be one of the major fisheries in that part of the world.

It was known before 1971-72 that blue whiting was fairly numerous and that the species usually inhabited deeper parts of the ocean. It was only after the research institutes in the area had determined that this was indeed a very big resource that subsequent exploration, experimental fishing, and gear development laid the basis for a multi-national fishery which has now passed 1 million metric tons in annual catch.

Another perhaps similar example is a recently developed deep slope fishery for blue and white ling off the Norwegian coast. Although both species have long been fished in other localities with longlines, it was not until the deep slopes were fished experimentally with the very efficient monofilament gillnets, that very good catches were obtained, consisting partly of very large fish (which were seldom caught with longlines).

Recently in Norway, we have started a creel or pot fishery for nephrops, a small ocean crayfish. This has come about as a result of exploratory and experimental work over the last 4-5

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years. The species was taken as a bycatch in our shrimp fisheries, but nobody knew that we had such a large number of localities with this resource (which was also good from the gourmet point of view) in our fjords and off the islands, until we started our trap experiments.

Similarly, to go a bit further afield, off the southwest coast of India an international survey project, set up to explore and assess the sardine and mackerel resources, also resulted in the quite unexpected discovery that indeed the greatest pelagic resource in the area was that of anchovies, which were previously believed to be only of restricted distribution and of minor importance.

And so we could go on quoting examples from different parts of the world, which all suggest that although the amount and perhaps also the rate and the perfection of exploratory activities have greatly increased in recent years, there are still most likely many improperly explored areas and/or depth zones which may contain unidentified resources, and I can see no reason why we have just come to the end of further exploration. Furthermore, in spite of what Dr. Dayton (Lee) Alverson told us this morning, I think it is a fact that the methods and the techniques used in most explorations in the past, which have mainly been done by trawling--of course, there are many notable exceptions--are only applicable and reliable for certain conditions and kinds of fish. In fact, for some types of resources, adequate technology for their proper exploration and subsequent commercial harvesting does not yet exist and can only be developed through research and painstaking experimentation and tests.

Thus, for demersal fish and other creatures inhabiting rough grounds or steep slopes, particularly deep areas that cannot be fished with standard bottom trawl techniques, there are few, if any, expedient methods of reliable exploration which can be readily applied. Similarly, for pelagic, non-schooling quality fish, such as the Spanish mackerel, small tunas, and so on--and not the least, cephalopods--standard exploratory technology is simply not available and will probably have to be tailor-made in each case for specific conditions and target species.

We have a number of examples of explorations which have been carried out around the world with trawls or other gears that are selective with regard to size and species of fish and type of fishing ground or area, and these methods and gears were only suitable for these resources. And, very often the methods and gears were used indiscriminately in the sense that the results obtained were assumed to verify the presence or absence of potential commercial fishing resources. However, without firm knowledge about the efficiency and the selectivity of the gears toward the relevant species, the results were misleading. I think a glorious example of this is one of the first, if not the first, shrimp surveys in the Gulf of Mexico. This failed altogether to show that there were enough shrimp for commercial fishing, and as you all know, in an area where the world's greatest fishery for shrimp subsequently developed. The reason for this failure was that the survey was carried out in the daytime.

Similarly, on the west coast of Africa in the early 1960s, the Guinean Trawl Survey was carried out. It was a major international undertaking, and one of the results was that nowhere could they find large enough resources of flatfish to be the basis of a commercial fishery. Again, subsequent developments have shown that surely in certain areas off West Africa, there are both soles and other flatfish which can be fished commercially. Here again, the reason was that in this survey, the trawl gear was standardized for roundfish and was inefficient for flatfish.

Now when we get to the pelagic schooling fish off West Africa, the situation was perhaps a bit better. They can usually be relatively easily detected, located, and assessed by means of acoustic methods; with suitable sampling gears, one can obtain necessary samples for identification and biological studies. But, as I mentioned previously, there are many pelagic resources which do not occur in dense concentrations and cannot be easily located with echo sounders and sonar.

Again, to draw an example from the survey off southwest India, with the pelagic trawls and purse seines that we used for sampling, from time to time a few high quality fish, Spanish mackerel, frigate fish, pomfrets, and so on, were caught. These fish were all very high priced in the area, and they were never taken in large quantitites (not considered to be plentiful). While the outcome of this investigation has not resulted in any further exploration or exploitation of the small pelagic fishes, there is now a prolific fishery with 700 vessels, fishing with gillnets, for the larger pelagic fish which we didn't consider numerous enough for commercial fishing.

And so, if we are to answer this first question, through changes in the ecosystems, many of the resources taken now may come and go. We have to accept that. Secondly, new resources have in recent years, continuously more or less, been identified and become exploited. Thirdly, developments in technology in markets make unharvestable resources of yesterday harvestable resources of today and tomorrow. Fourthly, the technology for surveys and exploration often are inadequate to address unharvestable resources and this has hampered results of previous surveys and will probably continue to hamper future work. My conclusion is, all resources of the ocean have most probably not been identified, and accordingly, further explorations can certainly add to our present understanding. In order to do so, we have to know much more about the fishing gears and methods that we are using; we must know, for example, how efficent they are and how selective they are with regard to the species or the creatures we are trying to explore. It follows, therefore, that more exploratory work in the future must be strongly integrated with research and development of gear and methods.

In addition, it is my conviction that such developments must be integrated activities of both technological engineering and investigations of fish behavior; because, if we do not know about the general distribution and behavior of the species, as well as their reactions to various stimuli, we could very well risk the same blunders--like failing to detect the large shrimp resources in the Gulf of Mexico.

Nevertheless, in my view, the main aim of gear research is not to provide resource survey biologists with better tools to explore and assess resources. In my view, this is only a secondary objective of gear research and development. I should like, however, to stress that if in the past some survey biologists--and I've been one myself--had known more about the fishing gears and methods that they were using and if they had had a better understanding of the needs for evaluating the efficiency and selectivity of the sampling gears, more resources would probably have been identified.

The main objective of gear research and development is to assist in providing the fishing industry with better and more economic methods of harvesting the resources--more economic in the sense of catching efficiency and manpower requirements and not hampered with the present escalating fuel costs and energy requirement. Furthermore, we need better and more efficient methods to harvest the resources in such a way that we take only the wanted species and sizes of fish and we do not destroy young fish and their basis for growth and reproduction in the sea.

And this brings me to another topic that Lee wanted me to touch on, selectivity. There has been a lot of talk about selective fishing and the belief that fishing technologists should indeed aim at developing species selective methods of fishing so that the problems, for instance, in connection with multispecies fishing, can be, if not solved, at least reduced. Now, selective fishing is in my view a paradox or a misnomer because it is reciprocal; non-selective fishing in my view does not really exist because all fishing is in one way or another a matter of choice. While this may sound like splitting hairs, let us now look upon the necessities and the prerequisites for selective fishing. There are two basic requirements which might facilitate selective fishing in the sense that one can choose the kind or size of fish to catch. Either it is required to sort out the fish or sizes of fish after capture, or at some stage or some time or some location to separate the desired fish from others so that they can be fished without a chance of catching anything else. In this case, selection is achieved by choice and time or location but, in order to do that, it is also necessary to know the pattern of distribution or size of target species, so that one can predict where they can be selectively captured or to know methods for instant detection or observation of the desired species.

Now purse seining for schooling species or aimed trawling for aggregations or schools of fish of particular kinds are typical examples of the one type of selective fishing, but quite often the purse seiners also are in for surprises, and here you have a problem with not only fish, but with purposes also. The other alternative is to design and operate a fish capture technology which utilizes the differential behavior and reaction of fish towards the fishing gear. This is simple enough with regard to size and, in some cases, it may be possible to design trawl systems so that they will be efficient for one type or kind of fish.

But, nevertheless, I believe that the prospects for species-selective fishing with active gears are rather dim, except in some cases when selection can be performed by choosing the exact time or location and depth. The basic reason for this pessimistic outlook is that the methods relating to the active types of fishing gear do not depend to a large extent on the actual behavior of fish. You are utilizing, so to speak, the brutal force of technology to catch the fish and, therefore, I sometimes like to call them man-active methods in contrast to the passive, or what I call fish-active methods. Here, the catching process can exploit what the fish does and not what the man does, and there is a much greater potential for species selective fishing by utilizing the differences in fish.

The progress and development which have occurred in the passive fishing methods have come gradually and as a result of trial and error. Sometimes, they have come from the occasional--maybe not so occasional--bright ideas of fishermen and, in some cases, by suppliers of fishing gear and equipment. We have obtained new materials, synthetics. These materials became available as a result of general technological evolution, but there have been very few systematic studies aimed at the general improvement of the passive fishing methods. As far as I know, with some exceptions, there have been rather few systematic studies anywhere in the world, and the reasons are quite simple. There has seldom been sufficient funding to study these fishing gears. The units of gear are generally small, the volume of their sales is small, and perhaps there are not enough engineering problems to challenge technologists. Furthermore, it requires detailed studies of fish behavior and reaction to make progress; technology alone is not enough, and so far, most of the gear work has been ruled by the engineers.

In contrast, the trawl and purse seine fisheries generally consist of large, expensive capital intensive units. In these fisheries, there are large sales of gear and equipment and also challenging engineering problems. Accordingly, in the past, millions of dollars, rubles, marks, kroner, or yen have been used to develop the technology of the active fishing methods, while in the case of the passive methods, the corresponding efforts can probably be better measured in cents, pfennigs, or kopeks.

In general, therefore, the state of the art today is that the active--or as I call them man-active methods of fishing--have been developed to a level of performance where the potential for further improvements, at least with regard to engineering of the gear itself, is pretty low--pretty limited. Take demersal otter trawling; further gear work is probably needed, and a lot of work is being done in various places in the world, to reduce towing resistance. Introduction of the large-mesh technique, which has been so efficient in pelagic towing, can (I believe) be tried extensively also for bottom trawls. There are also improvements to be made with regard to trawl doors; new types are available which are economically better than most of those in use today. It's perhaps a matter of more economic production, and we can see that towing resistance can be reduced but probably not reduced more than 25% today, because contact with the ground is necessary to catch any fish. And similarly, we may witness a new development in net handling which will improve the operational ease on board the trawlers. But perhaps the greatest break-through in increasing efficiency of trawling is introduction of pair trawling, because here the herding area is increased without increasing power or energy requirements. Nevertheless, the potentials for improvement of the trawl fisheries, in my belief, can be counted in tens of percent. In purse seining, the actual capture process has been brought to a very high level; I believe that future prospects are mainly on the operational side. Maybe sometime in the future a purse seine system will be available which can fish deeper, be well-balanced, and can sink, and depth will not be as limiting or restricting as in current seines. But we have to remember that this is the type of gear which is suitable only for schools of fish, but there are limitations here also. When we get to the passive, or fish-active methods, the situation is different. Here, because of the lack of study and development, I'd say that these methods are still largely in their infancy. The methods of capture themselves give room for probably very great improvement. To back this up, I shall relate some information on the studies which have been carried out in recent years by our institute.

In our longlining investigations, we quickly deduced that probably the hooking efficiency of the normal Norwegian cod longline is not very high. We discovered this from detailed fishing behavior studies--studies of how the fish actually attacks the baited hook. These were done both in tanks and with underwater TV on the fishing grounds, and it confirmed quantitatively how inefficient the normal longline really is.

Permit me to go a little bit into detail. When the fish attacks a baited hook, it will suddenly open its mouth, suck in the bait, and then if it doesn't spit it out right away--because it's displeased--it will rush to get away with the bait it has taken. Of course, the fish is stopped by the snood or branchline. The snood trails beyond the fish, along the body, but the hook actually is just in the mouth, and when the fish is stopped, it may after some time, stop and shake the head vigorously and try to swim away again or spit it out. The fish is not hooked. To get the point of the hook to penetrate the tissue, the mesh line has to be at an angle to the body of the fish; with a normal straight hook, where the hook is parallel to the shaft, this doesn't happen so easily. In data of studies I've been given, estimates of the hooking efficiency indicate that of 100 fish that do attack and take a baited hook only about 20 or perhaps 25 are caught. This immediately showed us that here is a very great potential for improvement, and it is not only in tens of percent, but in hundreds of percent.

The same fish may attack the same bait several times or go to another one. Probably it feels the point and/or the barb of the hook and experiences some discomfort; after several attempts, it probably learns that something is wrong. When this experience is associated with a visual picture such as the picture of the traditional heavy lines in front of it, the learning process is relatively quick. And we have found that if transparent monofilament lines are used, the fish probably sees practically nothing except the bait itself and will continue for a much longer time to attack the bait--to try again. In comparison with traditional lines, we have found that monofilament transparent lines fish three to four times better, catching 300 to 400% more fish. Not only that, we have found that on the monofilament transparent lines, not only are there more fish, but also the bait is still on the hook. In comparison to traditional lines, there is still a lot of bait intact, but on the monofilament line, the fish apparently continue to attack the bait until they are finally hooked or manage to steal the bait. The main outcome of the behavior studies is that they have given us a lead towards better hook designs that will increase hooking efficiency. The detailed studies of how a fish attacks the bait gave us the idea that the chance of hooking will be better if the hook is formed in such a way that the pull of the snood--the branchline--is really an extension of the point. There are such hooks already, such as the Mustad Wide Gap type. They are also like the ones which are used by the Japanese for tuna fishing; we have tried those and found they immediately give an increase in catch rate of about 30%, compared to the standard flat hook which is used by the Norwegian longline fishermen.

We have also demonstrated that the traditional hook spacing used in Norway is too narrow to give the highest relative catch rate, and it's better to cover as large an area as possible than to put out many hooks in a restricted locality, but this is, however, a function of fish density. Similarly, we found that increasing the snood length, which in Norwegian longlines is about 50 centimeters (18-20 inches) long, to 70-80 centimeters gives a higher catch rate.

We also looked into the bait and hook size. Bait is one of the major expenses in longlining; and, in Norway, the government is subsidizing the bait to the fishermen to the tune of some 40-50 million Norwegian kroner a year, which is 2-1/2 times the budget of our institute, and we thought that we might be able to reduce the bait size somewhat without significantly reducing the catch rate. In the first experiment, we tried by comparing standard bait sizes and sizes of hooks with half bait. The result was, to our great astonishment, that we hooked about 40% more fish on half baits. We have repeated this in other fisheries and this has been confirmed--not that you get 40% more, but that you get at least the same catch rate and slightly better with a reduced bait size. So there's a considerable potential for economic savings here.

And of course, on top of this, comes the results of the many promising efforts of mechanizing and automizing the gear handling and other operations in longline fishing, which are being conducted not only in my country, but certainly also here in North America. In general, we have found that there is a very great potential for increasing the catching efficiency of these methods, as well as for economical improvements. We also found this with regard to other types of passive fishing methods--gillnetting, for instance.

The catching efficiency of the traditional gear in Norway is certainly not optimal; for instance, by a better matching of the mesh size used in a gillnet fishery to correspond with the available size of the fish, we could make improvements. One year we could show that by simply a better mesh size, you could have 60% increase in the catch with the same number of nets--the same effort, really, and probably the nets would be cheaper because it had larger meshes. Further, you could improve the gillnets by modifications of hanging ratio; by improved net geometry; and by changes in operational methods; and by better gear handling, equipment, and deck layouts.

Gillnet fishing is often blamed for bad quality of fish because the mortality it generates is much more than what is really landed. And, in addition, lost nets ghost fish, killing a lot of fish. I believe that these are problems which in all probability can be satisfactorily solved.

These are the general conclusions from all our work in recent years, but the potentials can only be realized by research and systematic technological development in other places as well. I should like to make the point that while in the fisheries where there is big money where the big units and great sales are, such research and development may very well be undertaken by the industry itself. They can afford it; and, in some countries, the economic and political system promotes research. In others, it is public money which supports that kind of research and development; but, in the small fisheries, at least in the beginning, it will not. The necessary money for gear and research and development will not be available from the industry itself to carry out development in a systematic, orderly fashion; consequently, it is only research and development based on public funding which can realistically bring these methods of fishing up to what they could and should be. In Norway we can clearly see now that because our stocks have been fished down and our fuel costs are escalating, we may soon be approaching the time when we have to develop modern efficient longlining and gillnetting in order to be able to harvest some of our native resources. I believe that no modern fishing nation can continue to survive without the support of research and technological development; the fishing technologists in the other parts of the world, I believe, are now eagerly waiting for the time when this challenge will also catch more of the attention of the tremendous potential force of research and development in the United States.