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The University of Washington—Center for Quantitative Sciences
The University of Costa Rica—Centro de Investigación en Ciencias del Mar y Limnología
The University of the Philippines—Marine Science Institute (Diliman)—College of Fisheries (Visayas)

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"Some Impacts of Remote System Technology
on Future Fisheries Management"
by
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SOME IMPACTS OF REMOTE SYSTEM TECHNOLOGY ON FUTURE FISHERIES MANAGEMENT[1]

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Abstract

The fisheries profession is not immune to the pressures for increased efficiency which have characterized the history of human society. Currently, much of fisheries research and management suffers from inefficient and labor-intensive techniques. One of the highest potentials for increased efficiency is remote system technology. Examples are the application of remote, automated hydroacoustic sensing devices and remote operating vehicles (ROVs). Remote hydroacoustic systems are currently used to monitor salmonid escapements, measure downstream salmonid migration past hydroelectric dams, evaluate environmental impacts and investigate long-term trends in fish abundance and behavior. Remote operating vehicles, especially with hydroacoustic as well as video sensors, allow for routine assessment of many fish stocks and for study of fish behavior in response to fishing gear.

Introduction

The history of mankind has been marked by several dramatic changes in production efficiency which revolutionized human society. These include the change from a nomadic to agrarian society, the Industrial Revolution, and more recently a technological revolution. The fishing industry retains elements of primitive nomadic society in the sense of a focus on wild or natural stocks. However, with the exception of artisanal fisheries, major advances in both catching and processing efficiency have been made through industrial and technological developments, and aquaculture is growing in significance. Fisheries research and management have also been impacted by technology, especially with the increased use of computers. More recently, developments in hydroacoustic assessment techniques have benefited management in several fisheries (Thorne 1983a). Nonetheless, fisheries research and management still retain many primitive elements and are relatively labor intensive and inefficient. If the current trend toward increased efficiency through technology continues, societal and financial pressures will force changes in fisheries research and management.

Remote System Technology

The technology that offers one of the highest potentials for increased efficiency is remote system technology. This refers to systems that collect data from a distance, usually by automated means. Present procedures for acquisition of environmental and resource data are often limited and labor-intensive. Development of hydroacoustic assessment techniques has augmented fisheries observational capability in the last several years, but the potential of automatic data acquisition is virtually untapped. The assessment

problems of many fisheries are amenable to these remote system applications that offer observational advantages which far exceed the capability of current systems. Two prototypes of remote systems are presently used in fisheries research and management. These are the fixed-location hydroacoustic systems and the remote operating vehicle (ROV). In the remainder of this paper I will explore the potential extensions of these systems into various types of fisheries problems and show the considerable advantage of remote technology over conventional fisheries approaches.

Stationary Remote Systems

The prototype stationary remote system is the fixed-location hydroacoustic system that is being applied to several fisheries problems, especially in environmental impact and riverine studies. The motivation for development of fixed-location hydroacoustic systems was the limited capability of conventional, mobile acoustic systems to detect fish near surface and bottom boundaries. Good resolution near boundaries can be obtained with stationary, or fixed-location, systems. Thorne (1980) used a fixed-location transducer to investigate fish behavior around the cooling water intake of a power plant in 1976 and again to examine fish behavior under the ice in the nearshore Beaufort Sea during winter 1979. However, such deployment greatly reduces sampling power, since the same volume is scanned continuously. Since the location does not change, additional samples are added only through water and fish movements, which occur slowly compared to mobile survey operations. The problem can be alleviated by using multiple transducers, each looking at different volumes, and sequentially scanning or multiplexing the various transducers. This approach was first used to study fish behavior around

hydroelectric dams in 1980 (Carlson and Acker 1981) and is now used extensively for this purpose, sometimes with over 20 transducers multiplexed to a single transceiver. In addition, it is possible to compensate for the lack of spatial sampling power by temporal sampling (i.e., collect samples over a long period of time).

Automated Systems

The problem with the stationary transducer approach in combination with current fisheries acoustic systems is the high manpower cost of long-period data collection. The solution is the application of completely automated systems for hydroacoustic sampling. This concept was first suggested by Lord et al. (1976) for assessment of salmon in Bristol Bay. Data were to be gathered from an upward-looking transducer floating above the bottom and telemetered to shore via a satellite (Fig. 1). Unfortunately, the feasibility of fish detection near surface with fixed-location transducers was unexplored at that time, and the existing technology was inadequate.

The feasibility of fish detection near boundaries was demonstrated subsequently in several environments, including that of juvenile salmon near the surface in lakes (Thorne and Thomas 1984). The technology for such a system is now available. The problem of power for a remote system is solved both through recent advances in batteries, including solar, and the availability of low power drain CMOS electronics. A CMOS microprocessor would also solve most data handling and storage problems. The raw data from fishery acoustic systems normally require sampling rates on the order of 10 kHz; typical echosounders used for fish assessment usually transmit at a rate of several times per second, depending on depth or range. These data rates are far too

great for either data storage or transmission. However, high pulse rates are unnecessary for stationary deployment since the volume of water changes slowly. A CMOS microprocessor could not only control the pulse rate, but could also greatly compress the amount of data through preliminary processing, such as echo integration over time and depth intervals (Thorne 1983b). The compressed data could then be stored on floppy diskette or digital cassette or telemetered to a central laboratory.

There are several management circumstances where application of this technology would be efficient. One is the management of salmon terminal area fisheries. Timely information on the abundance of various runs needs to be obtained efficiently in many localities. Recent research has shown that salmon returning to terminal areas can be detected by a hydroacoustic system with bottom-mounted transducers (Fig. 2). Arrays of these transducer systems at the entrances of terminal areas, combined with automatic data acquisition and processing equipment, could monitor entrance of fish into the terminal areas and even transmit the data from several locations to a central location where decisions on harvest procedures could be made. Similar arrays and information acquisition procedures are feasible in the riverine environments and could automatically acquire data on salmon escapements.

In addition to the monitoring of returning adult salmon, another example of the potential of remote, fixed-location hydroacoustic systems is the application to monitoring of downstream migrating salmonids past hydroelectric dams. This is currently the most common application of fixed-location hydroacoustic systems. Most hydroelectric dams on the Columbia River are instrumented with transducer arrays that monitor numbers and behavior of downstream migrants .

Decisions on generation or spilling are made on the basis of quasi-real-time estimates of migrant abundance. However, data are processed manually from echo chart recorders. This manual processing could be replaced by automatic signal processing techniques. This would allow continuous monitoring of migrant abundance at all hydroelectric dam locations. Again, data could be telecommunicated to central offices (e.g., Portland, Oregon), where decisions on spill and generation could be made with real-time information, automatically acquired and processed.

A third area of application for remote stationary systems is environmental impact research. Many environmental problems are well suited to fixed location monitoring since the concern is often focused on a particular area of limited extent. Automatic remote sensing techniques can provide long-term and detailed information on fish abundance, behavior, and response to perturbations in such locations in a non-destructive manner and with little manpower (Fig. 3). Although most applications of this type have used hydroacoustic systems (Thorne 1980), use of alternate or complementary sensors, such as video, may be practical.

The scientific echosounding systems that are currently used in fisheries are versatile, complex and relatively expensive (around $10,000). Technologically complex applications, such as systems in ocean buoys with satellite links, would be much more expensive. However, for many remote system applications, simpler and much less costly systems (under $5,000) should be feasible. Continued advances in technology will further reduce these costs.

The Potential Applications of ROVS

In many fisheries assessment problems, the areas involved are too large for practical application of fixed-location systems. The remote and automatic data acquisition capability of fixed-location devices needs to be replaced with a mobile vehicle. The prototype for such a system is the remote operating vehicle (ROV). The ROV is essentially an unmanned submersible. The past decade has seen major expansion of the use of ROVs for offshore drilling and underwater search and salvage. Most ROVs are operated from a surface ship or offshore platform by means of a tether. However, development of free-swimming ROVs is advancing rapidly.

There are several ways in which ROVs could have potential application in fisheries. One is in the investigation of fishing gear performance. Remote Operating Vehicles with video systems can be used to observe trawls underwater, and monitor headrope position, relation to the bottom, and fish responses. This information can be used to determine gear selectivity and catchability parameters that underlie resource assessment with fishing gear. An ROV deployment has been used by the Northwest and Alaska Fisheries Center of the National Marine Fisheries Service for a study of gear performance in the Bering Sea (Fig. 4). Information was needed on the impact of trawling on the bottom habitat and possible gear modifications that might minimize the impact. The approach was to experiment with various trawling operations using a ROV with video camera to observe the effects. After a particular trawl to be evaluated was set, the ROV was deployed and guided toward the trawl until visual contact was established. Observations were then recorded on video cassette while the ROV was maneuvered into various areas of interest. The observations were

repeated with various types of trawls and trawling procedures to determine the combinations that have least impact on the bottom habitat while maintaining reasonable catch efficiency on fish.

While the present focus of ROV use in fisheries is to monitor gear performance, further advances in technology may result in elimination of the "middleman" (i.e., fishing gear) in resource assessment. Direct underwater observation is valuable for assessment of near- or on-bottom resources. The common mode of visual assessment in fisheries has been by diving (Brock 1982). These techniques are inefficient and limited in depth range. Video systems have been used in stationary modes to observe fish behavior in an important location, such as around a water intake for a power plant (Thorne et al. 1979). However, the sampling power is limited by the stationary deployment. Video systems also have been deployed from sleds towed on the bottom. This deployment improves sampling power, but is susceptible to entanglement and subsequent damage (Uzmann et al. 1979). A remote operating vehicle would provide an efficient means for these assessments and ultimately might be more efficient, and much less variable, than the fishing gear which is currently being used for assessment and whose limitations are the focus of current ROV application.

With only video sensing, the ROV is limited to near- or on-bottom organisms. Further, need of artificial lighting under some circumstances can alter fish behavior and bias observations. The logical further development is the combination of video and hydroacoustic technology on the ROV. As noted earlier, mobile hydroacoustic survey techniques are limited in resolution near surface and bottom boundaries, leading to the application of stationary systems.

However, although stationary systems are very effective when interest is centered on a limited area; this type of deployment greatly reduces sampling power.

Application of the ROV in conjunction with hydroacoustic techniques could solve this problem. Deployment of uplooking transducers from an ROV would allow detection of near-surface fish, a capability not achievable with the typical down-looking deployment from a surface vessel (Fig. 5.). In addition, resolution of near-bottom targets is greatly enhanced when the transducer can be deployed at relatively short range from the bottom, again a feat not achievable with a hull-mounted transducer from a surface vessel in deep water. Further, the combination of video and ROV provides a tool with high sampling power (from the hydroacoustics), direct video observation and identification of targets (overcoming a critical limitation of hydroacoustics), and capability for operation under any light conditions since hydroacoustic sensing can operate at night with only subsampling with the video for identification.

Although many of the potential applications of ROV systems in fisheries today are appropriate for tethered or towed ROV systems, the potential of the free-swimming ROV is particularly exciting. Inexpensive, free-swimming ROVs are currently being used to investigate krill abundance under the ice near Antarctica. It is not inconceivable to visualize free-swimming ROV systems, instrumented with hydroacoustic and other sensors, which can be released to independently and automatically conduct surveys of fisheries resources in specified localities and return with the complete results.

Conclusions

Although major development of technology has never been practical for fisheries science, on many occasions technologies are developed for military or industrial purposes and become economically feasible for fisheries applications. The remote technology described in this paper has reached that stage and is available and economically accessible to fisheries. The responsibility of the fisheries profession is to be open and creative about how this capability might contribute to the solution of some of our fisheries problems. Fisheries managers and administrators need to realize that the information requirements of management will not only become more complex, but the financial and human resources to achieve those requirements will become more limited. Increased efficiency is needed and will only be obtained by taking advantage of available technology. We must be willing to change and advance while the choice is still available to us.

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Figure Captions

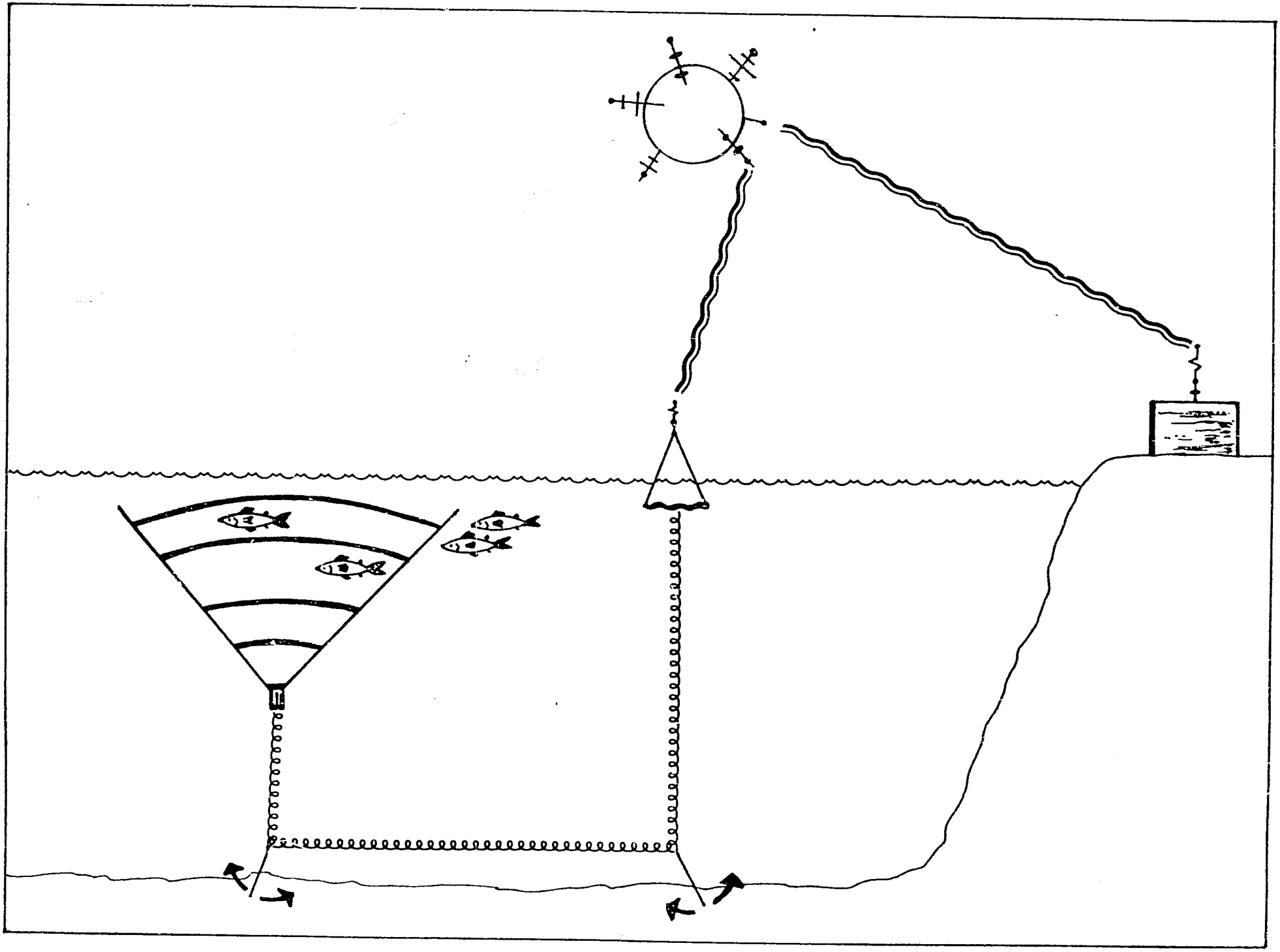
Fig. 1. An automated, remote hydroacoustic system for detection of near-surface fish.

Fig. 2. Echogram of salmon school from bottom-mounted system in Neats Bay, Alaska. Bottom depth is 40 m.

Fig. 3. Illustration of potential fixed-location hydroacoustic remote system

Fig. 4. Example deployment of ROV for study of trawling effects.

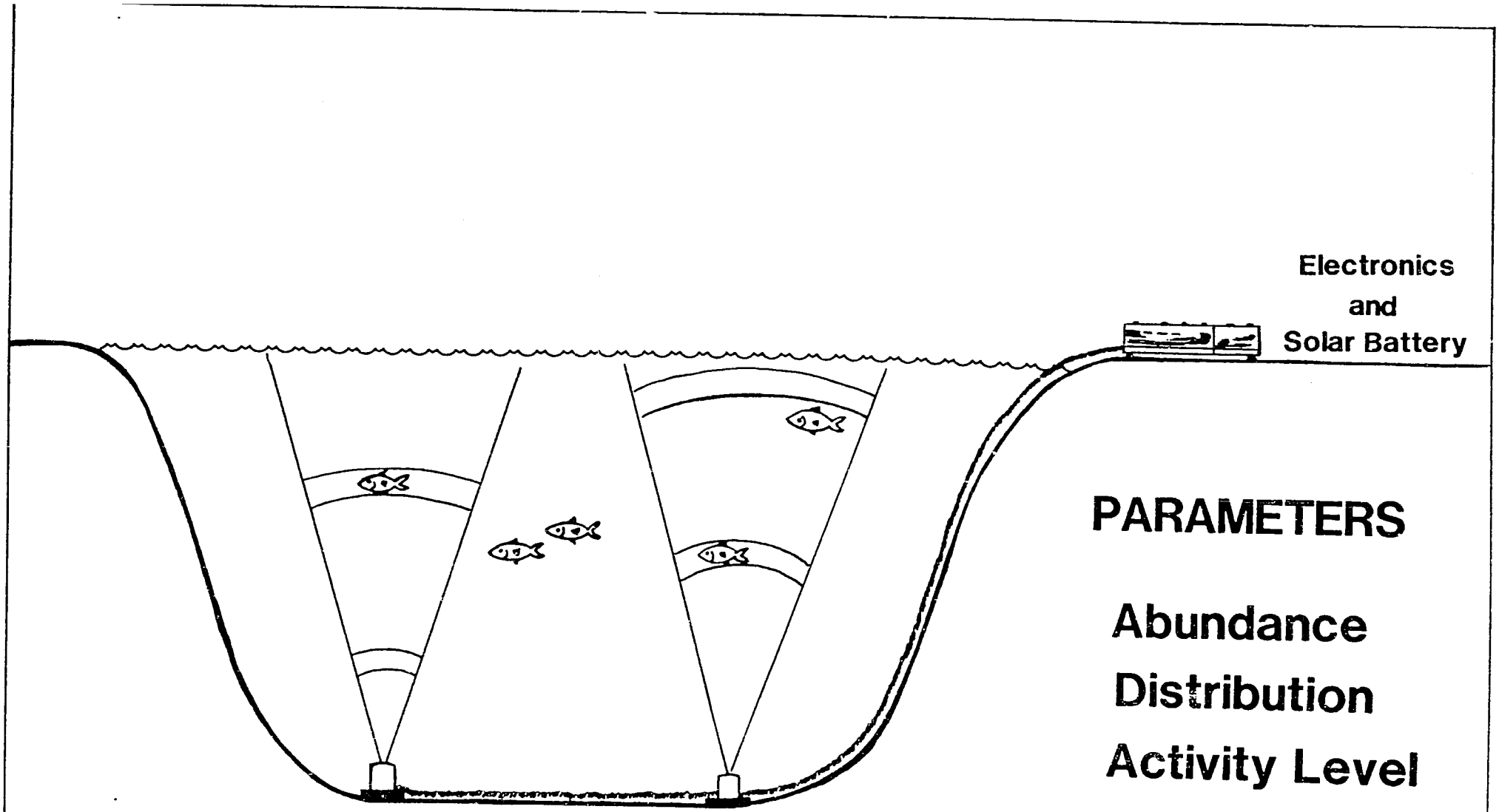
Fig. 5. Potential deployment of ROV with hydroacoustic sensors.



Bottom

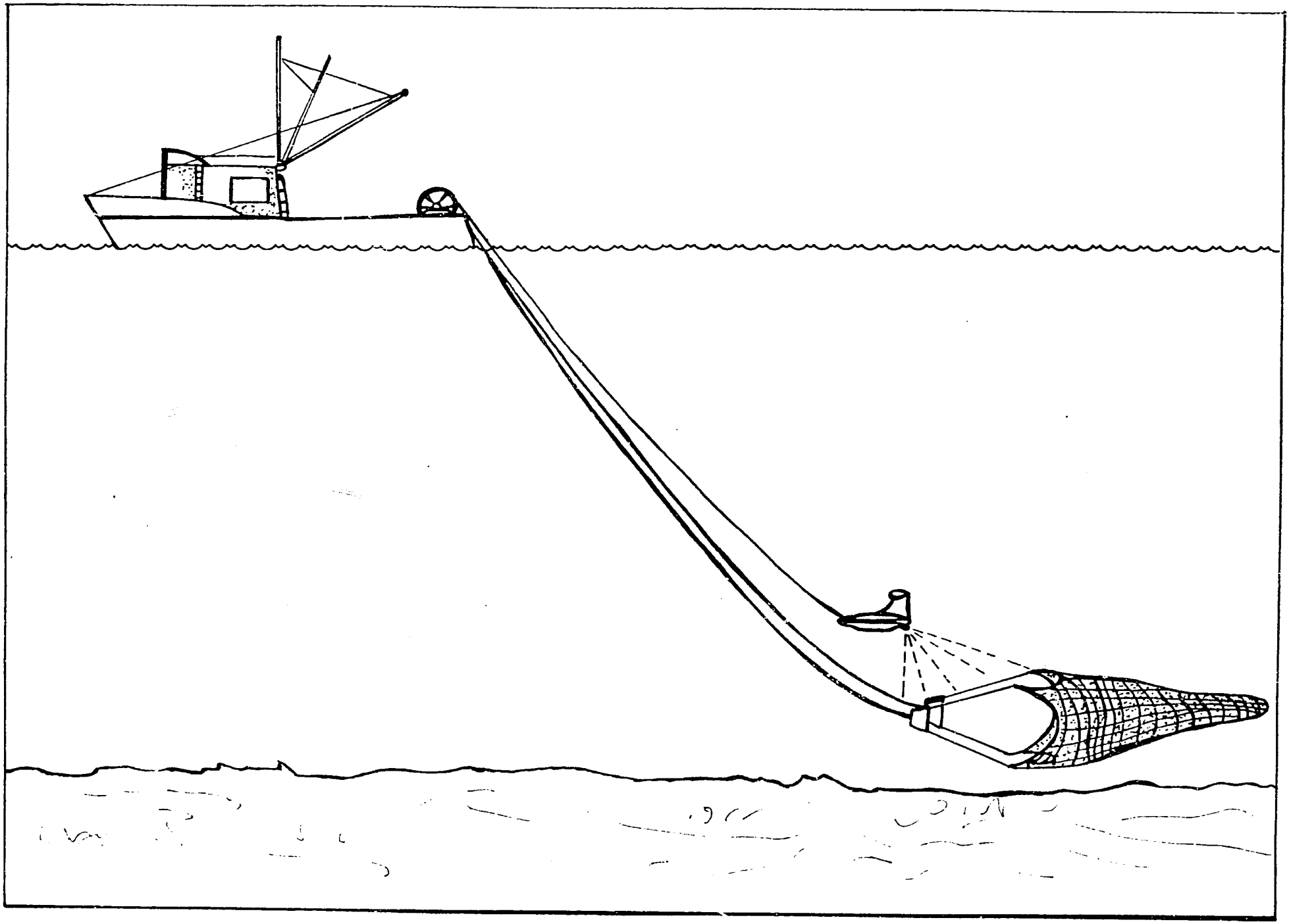
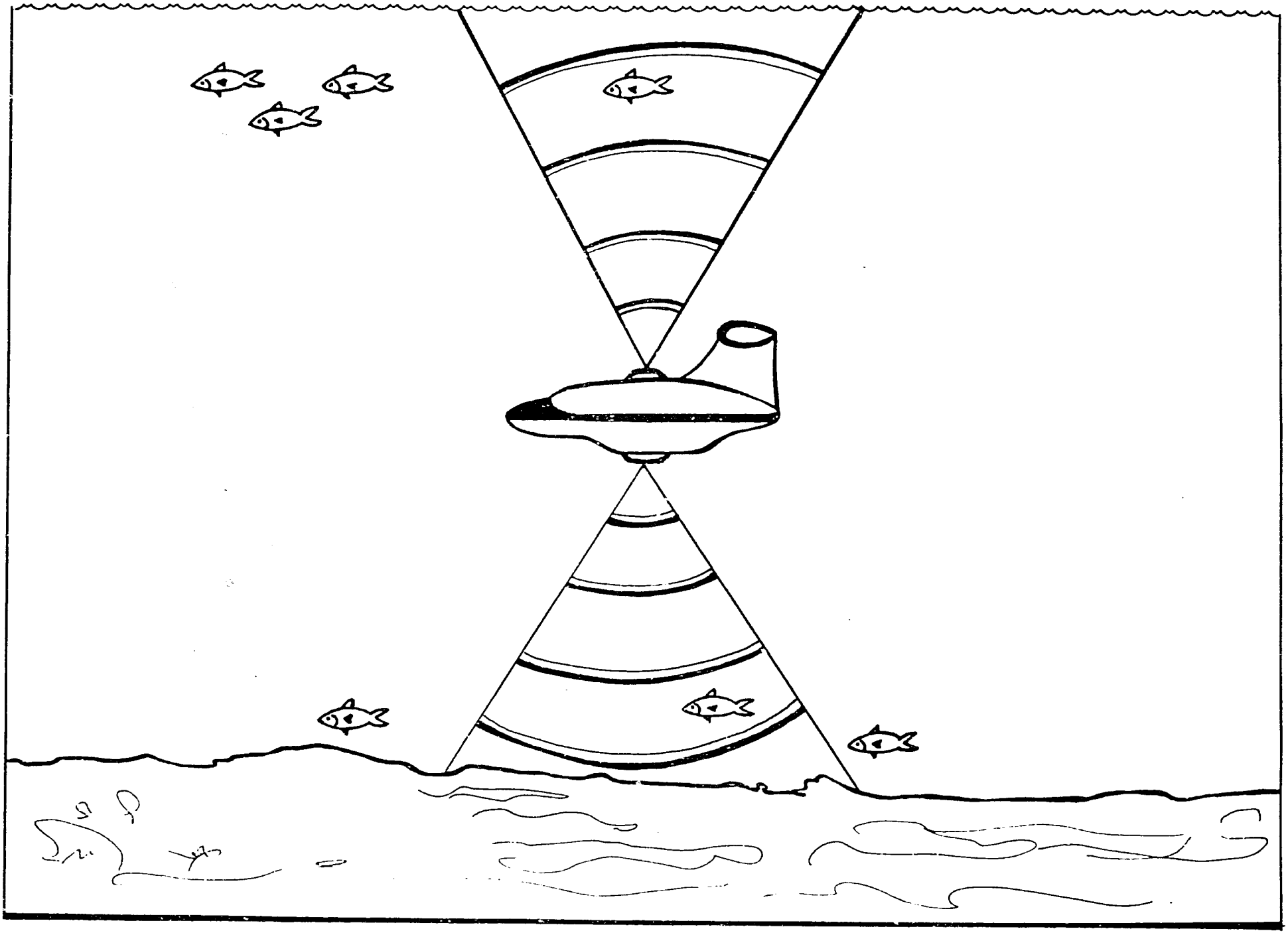
Salmon school

Surface



PARAMETERS

Abundance

Distribution

Activity Level