Experimental Approach to Marine Biology

by

Donald S. McLusky

Dept. of Biology, University of Stirling, Scotland (U. K.)

Marine biology has for long been concerned with the study of the distribution and abundance of marine organisms. Data on the location of plant and animal populations have been used for the description and prediction of fisheries in particular. In recent years the experimental study of the physiology of marine organisms has come to be an important part of the work of marine laboratories throughout the world. The study of physiological aspects of marine biology owes its development to two principal reasons—firstly, the hope that physiological studies may explain the mechanisms underlying the observed distribution and abundance of marine life, and lead to a greater understanding of the effect of various environmental factors on the success of organisms; and secondly, man's innate curiosity which ever drives him to seek explanation for what he sees in the world around him. The physiologist seeks to explain the mechanisms which adapt an animal to a particular environment. If the study of physiological mechanisms is linked with the study of the distribution of field populations, this gives rise to the study of physiological ecology.

Many important fisheries, especially for shellfish, are located in estuaries, and estuaries also often form important nursery areas for fish. The master ecological factor in estuaries is generally considered to be salinity and its variations. When an animal enters an estuary, usually from the sea, it leaves behind a stable salinity regime, and enters conditions of marked salinity variation. The ecologist can describe the location of the animal populations in relation to salinity or other environmental factors, but the physiological approach can reveal the precise critical factors which control the location and success of the particular animals. Tolerance, or survival, experiments can indicate the salinity regime in which an animal can live, and also the effect of salinity on reproduction, growth etc. can be observed. If performed at different temperatures, salinity survival experiments may indicate the mechanisms which underlie the seasonal migration found in many important estuarine species. For example, the shrimp Crangon, a commercially important species in West Europe, can not tolerate low salinities in conjunction with low temperature, and consequently migrates out of estuaries in winter time. Populations of fish which use estuaries as nursery areas, may only do so under specific environmental conditions, and a study of the physiology of the fish may indicate what controls this migration, and leads to successful reproduction. Studies of the eggs and larvae can indicate a great deal about the ideal conditions for development. In the developing industry of fish farming, data on the optimum conditions for growth etc., are invaluable. Changes in temperature and salinity also cause
marked changes in the oxygen content of the water, which may especially in the tropics, adversely affect some animals.

In many parts of the world, estuaries and inshore coastal areas are subject to extensive pollution by domestic sewage and industrial effluent; and at the present time increasing attention is being paid to these sensitive areas. Ecological surveys can indicate the effects of pollutants on animal populations, but experimental approaches to marine pollution may be able to indicate the levels of pollutants which are acceptable to marine populations in the laboratory before the adverse and often disastrous and irreversible effects of pollution are observed in the field. Studies of the effect of temperature on marine organisms can indicate the likely effects of thermal pollution of the sea by power stations etc. They may, for example, indicate the effect of increased temperature in increasing metabolism, growth rate and developmental rate up to a limit, beyond which catastrophic mortality may occur. Experimental studies on heavy metals (e.g. Copper, Zinc, Mercury, Cadmium etc.) may indicate the lethal or sublethal effects of the metals on marine organisms, and whether accumulation is occurring before the metals are released to the sea, or before man eats contaminated fish. Organic pollution often results in a decreased oxygen content of the water, and the effect of reduced oxygen content can be readily studied in the laboratory. Oil spills at sea have in the past been dispersed by the use of detergents, but subsequent experimental studies have shown that the detergents can be far more lethal than the original oil.

The energy of sunlight is trapped by plant material (phytoplankton) in the process of photosynthesis. The phytoplankton forms the food for zooplankton, or filters-feeding shellfish, which in turn form the food for young-fish, which in turn form the food for large fish, which may be eaten by man. This trapping of energy to yield ultimately food forms the study of biological production, one of the marine areas of physiological ecology study. The physiologist by experimental means can identify the production and conversion of energy. For example, he may be able to indicate any critical dissolved nutrients, or other factors which can limit plant production, or he can indicate the source and fate of energy in an animal population. Studies of the feeding intake of animals indicate the energy assimilated, and studies on oxygen consumption indicate the fate of most of the energy which is taken in, namely, that it is lost to the ecosystem ultimately as heat.

Only a relatively small amount of the energy taken in by any animal is retained as extra body weight, or used for reproduction. Studies on physiology can indicate the mechanisms which limit growth and production of animals and plants, which ultimately limits the energy available for man’s food.

The study of physiology is closely linked with the study of animal behaviour, and the study of fish behaviour in particular may be of immense value in assisting the design of fish catching gear, so as to enable maximum efficiency to be achieved. Underwater TV attached to trawl nets has already revealed much of the behaviour of fish when being captured.
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As mentioned previously, the study of physiology may be of interest for its own sake. The recent experiments of Denton for example, on the silvery sides of fish, showing the mechanisms underlying fish camouflage, or on the buoyancy of the Cephalopod molluses, *Sepia* & *Nautilus*, are of intrinsic biological interest and greatly enhance man’s knowledge of the world around him.

A great deal of valuable physiology can be done by careful observation, and by the use of simple techniques, such as survival experiments for salinity and temperature tolerance, or feeding and oxygen consumption for productivity studies, using well-tried techniques. A lot more can also be done with sophisticated electronic equipment, but this need not be essential. Two essentials for all laboratory work are the ability to keep healthy animals under controlled conditions, and a supply of good clean aerated sea water. Little significance can be attached to results obtained from sickly or dying animals. One useful criterion is if the animals grow and/or breed in the laboratory. The results of all experimental studies need to be critically appraised; careful controls need to be kept and strict statistical evaluation of results is vital. The basis of valuable physiology is sound experimental design.

The results of experimental studies should always as far as possible be compared to the field situation, to ensure the maximum utilisation of the results obtained, and it is with a close link between physiology and ecology that the experimental approach to marine biology can make particularly valuable advances.