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Examination of Living Resources Associated with the Sea Bed of the Continental Shelf With Regard to the Nature and Degree of Their Physical and Biological Association with Such Sea Bed

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EXAMINATION OF LIVING RESOURCES ASSOCIATED WITH THE SEA BED OF THE CONTINENTAL SHELF WITH REGARD TO THE NATURE AND DEGREE OF THEIR PHYSICAL AND BIOLOGICAL ASSOCIATION WITH SUCH SEA BED

MEMORANDUM BY THE FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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CONTENTS

FOREWORD

The United Nations has requested the Food and Agriculture Organization to prepare a statement on the relations of living aquatic resources with the sea bed of the Continental Shelf as defined in article 67 of the articles concerning the law of the sea, adopted by the International Law Commission at its eighth session, in 1956. The following paper has been prepared in answer to that request and although not an exhaustive treatment of the question it does endeavour to show fully the complexities of the situation under examination. After indicating the kinds of relation that may exist between an individual organism and the bed of the Continental Shelf, it examines the changes in this relation that may take place throughout the life of an individual organism. It then, making use of the very extensive work on this subject, submits a classification of the organisms normally occurring as members of shelf communities in adult phase with an indication of the habitat, etc., of the juvenile phases of these adults.

Every effort has been made in preparing this paper to preserve a simplicity of language, but the subject is such that it has been necessary to employ certain terms which may not be familiar to the lay reader. It has, therefore, been thought advisable to append a brief glossary.

EXAMINATION OF LIVING RESOURCES ASSOCIATED WITH THE SEA BED OF THE CONTINENTAL SHELF WITH REGARD TO THE NATURE AND DEGREE OF THEIR PHYSICAL AND BIOLOGICAL ASSOCIATION WITH SUCH SEA BED

In considering the relations of living organisms with the continental shelf it is important to remember that this shelf is not merely a platform within or upon which there is a resting place for an organism for part or all of its life. The position of the shelf in relation to the continental (or island) land mass on the one hand, and to the continental slope and the abyssal bed on the other, causes it to exercise an influence on the play of hydro-dynamic forces in the water-masses that overlie it, and these are related to the forces operating in adjacent water-masses, both those of the ocean and the water outflowing from the continent. Moreover, the shelf receives, and provides a storage place for, a great diversity of materials. As a consequence the shelf is not merely a passive platform, but contributes to the creation of particular physical and chemical conditions that are of considerable significance to the living organisms. Conversely, the organisms exercise some influence on the characteristics of the shelf and contribute to creation of a milieu that is unique to those areas of the earth's surface where the shelf exists. Such facts are of importance because of their relation to the simple yet easily overlooked fact that whatever association aquatic organisms have with the shelf proper, they nevertheless live in water. Discussion of these associations therefore must recognize the role of the waters overlying the shelf as well as that of the physical shelf.

A discussion of the association of living aquatic resources with the continental shelf should then begin with an analysis of the types of relation or connexion that may exist, such relations being direct with the physical shelf proper, or indirectly with it through the

overlying water. The importance of this analysis will become clear when it is recognized that the existence of each organism may involve several different kinds of relation, and that the pattern of relations may vary as between different life phases. The value of this analysis will be made even more apparent when we come, later, in this paper, to consider a conventional classification of the organisms that make up bottom communities.

The relations involved can be classified with respect to the organism's requirements (1) for appropriate living space, (2) for its general physiological functions, (3) for its food and nutrition and (4) for reproduction. Although nutrition and reproduction, of course, are physiological functions and could be included under the second heading, and conversely, the second heading could be divided into many particular functions, we believe that the present plan is most convenient for present purposes, and most clearly reveals the nature of the relations involved. This plan can be elaborated, as follows:

A. Living space

The organism lives:

(*a*) Within bottom materials,

(*b*) On bottom materials, by attachment,

(*c*) On the bottom surface, lying,

(*d*) On the bottom, but moving,

(*e*) In the water overlying the shelf.

B. General physiological functions

The organism finds physical and chemical conditions appropriate to its metabolism, movement and behaviour; included are factors such as temperature, salinity, light-intensity, water movement, and the nature and particle-size of the bottom materials.

C. Nutrition

Food supply of the organism is provided by:

(*a*) Bottom detritus,

(*b*) Bottom living organisms,

(*c*) Organisms that live in shelf water.

D. Reproduction

The organism finds:

(*a*) Conditions for maturation and spawning only on the shelf,

(*b*) Favourable situation for placement of eggs in the bottom material or on it,

(*c*) Conditions for larval development (after hatching) only on the shelf and in the water above it.

These organisms that have a "living-space" dependence on the shelf (especially those that live within, or fastened to bottom materials) find there, also, their general physiological nutritional and reproductive requirements, and thus are completely dependent upon the shelf. For this reason where examples are given of these relations, in Table 1 below, we combine the spatial and physiological relations. In contrast, other organisms have only one or more of the other relations with the shelf, as, for example, by visiting it for a brief period to spawn; nevertheless the importance of these other relations to the organism should not be underestimated. The denial or destruction of a breeding ground could presumably lead to the extinction of the stock that made use of it.

In only very few species of aquatic organisms is the entire life of each individual spent in close association with the shelf sea bed and the water lying immediately above it; in most organisms there is a free-swimming phase, in middle or surface waters. However, since in most cases the conditions of life for such a pelagic phase are found only in shelf waters, there continues to be for them a necessary and dependent relation between the organism and the shelf even in the free-swimming phase. This pelagic phase probably is a distribution mechanism which at the time may be very wasteful, because often large numbers of pelagic larvae drift from the shelf and are doomed to die.

TABLE 1 A

Examples of different types of relation of eggs with the shelf

Living Space (and General Physiological Functions)	
1. Within bottom	Eggs deposited in nests or cavities (rare). E.g., the amphipod *Corophium arenarium* deposits eggs in small buried brood-tubes.
2. Fastened to bottom	Eggs fastened to stones, or vegetation (e.g., Pacific herring), deposited in capsules, fastened to substratum (e.g., Periwinkle, *Littorina litorea*), or in gelatinous layers fastened to substratum (e.g., *Littorina obtusata*).
3. Surface of bottom and water immediately above it	Eggs deposited loose on bottom (e.g., Atlantic herring), or in gelatinous masses (e.g., Nemerteans), or in capsules (e.g., rays) or encrusted with sand (e.g., *Naticidae*). Brood protection common.
4. Supernatant waters at various depths	Many species, from all taxonomic groups of neritic, oceanic and benthonic animals have planktonic (freely floating) eggs; (e.g., nearly all starfish (echinoderms) and clams (bivalves); most *Actinia*, several polychaetes).

TABLE 1 B

Examples of different types of relation of larvae and young with the shelf

Living Space (and General Physiological Functions)	
1. Within bottom	This is a rare relation, found in the fauna of sand and of the intertidal zone. E.g., *Bledius spectabilis* and eunicid of polychaeto-*Diopatra neapolitana.*
2. Fastened to bottom	This also is a rare relation (e.g., a few tunicates).
3. Surface of bottom and water immediately above it	All non-pelagic larvae, e.g., larvae of most sand-fauna (e.g., ostracods, copepods), the young of haddock and of species whose young develop in egg-capsules deposited on bottom.
4. Supernatant waters at various depths	Planktonic larvae and young of majority of shelf organisms. (Most larvae feed while living planktonic life, some larvae however do not feed, but are planktonic only for distribution.*)
Nutrition	
1. Bottom detritus	Relatively rare (e.g., the feeding of settled larvae and those developed in the bottom substrata).
2. Bottom organisms	E.g., the feeding of young of haddock, and of the young of most organisms with non-pelagic larvae.
3. Neritic nekton and plankton . . .	Majority of pelagic larvae feed on phytoplankton, some exclusively on zooplankton (e.g., decapod larvae).

* That is to say, the significance of their sojourn in the planktonic community lies in the distribution brought about by the transport of the plankton by currents, sometimes resulting in the plankton being carried into unfavourable situations where it dies.

TABLE 1 C

Examples of different types of relation of mature animals with the shelf

Living Space (and General Physiological Functions)	
1. Within bottom	Organisms buried in bottom material through which they can move ; or living in cavities or holes e.g. certain molluscs ; or in tubes they have constructed e.g. worms.
2. Fastened to bottom	Organism with root or anchorage in the bottom, or with outer skeleton cemented or in some way fastened to rock or other hard bottom.
3. Surface of bottom and water immediately above it	Immobile organisms lying on bottom (forams and some oysters) ; partially mobile but not swimming.
4. Shelf-waters at various depths . .	Strictly neritic forms, which include the majority of demersal fish.
Nutrition	
1. Bottom detritus (and micro-organisms living in it)	Most animals which are buried in the sediment feed on the detritus ; there are also animals which pick detritus particles from the surface of sediment (e.g. polychaetes (worms), gastropods (shellfish), some decapods (crabs) etc.).
2. Bottom organisms	Hunting animals, e.g. starfish, species of fish (e.g. plaice and cod) feed on small bivalves and crustaceans.
3. Neritic nekton and plankton . . .	Many sessile animals, e.g. clams, oysters etc. (filter feeders and " lurkers ") ; animals which visit bottom for rest and protection (e.g. shrimp) ; many fish species.
Reproduction	
1. Maturation and spawning	Many viviparous organisms and organisms which have brood protection, are benthonic because, perhaps, of a need for support. Many otherwise pelagic species spawn on coastal areas.
2. Deposition of eggs	In bottom (rare), loose on bottom in capsules or gelatinous masses, fixed to it, with gelatinous masses or capsules fixed with strings, or deposited in cavities.
3. Embryonic development	Brook protection is common among benthonic organisms. In pelagic larvae development occurs in the pelagic stage. Waters overlying the shelf usually have higher turbulence, which is important for pelagic larvae and young.

We have referred above to the existence of a special shelf (or neritic) environment, established by virtue of the presence and particular form of the shelf in relation with the continental land-mass on one hand and with oceanic water masses on the other; we also referred to the contribution made by the living organisms to the particular characteristics of this environment. It is necessary at this point to say something further about these two aspects.

Firstly, with respect to the identity (and in some cases autonomy) of a shelf environment. As indicated in earlier paragraphs, it should not be thought that there is to be found overlying the shelf a mass of water that derives its characteristics exclusively from the shelf and remains unaffected by influences exerted by water masses and current systems of the oceanic side. On the contrary, the shelf water characteristics may be very considerably affected by the oceanic waters, as indeed they are by the outflow from the continent. Again, the limits of a "shelf environment" may not be assumed to coincide with the limits of the shelf itself, as that might be defined in geographic and geological terms; instead, the limits may extend seawards beyond the edge of the shelf, or be confined landwards, according to the interplay of oceanic continental influences.

Secondly, with respect to the part played by aquatic organisms in determining the characteristics of the shelf and its overlying waters. In perhaps the most obvious case, the reef-building corals make very great bottom structures; other organisms make similar incrustations, still others contribute, by their dead-shells, to the formation of enormous deposits; in a different kind there are the rock-boring organisms. Of quite different significance is the presence of a considerable population of micro-organisms living on the surface and in the superficial layers of sediments; these include bacteria, benthonic diatoms, and other forms, all of which serve as food for filter-feeding organisms. Finally, we may not overlook the effect on the water of the physiological activity of the great mass of living material which is feeding, respiring and excreting, and thus causing a constant flux in the chemical characteristics of this water.

Having given in Table 1 examples of the various kinds of relation, in each life phase, regardless of any connexion between successive stages, we now give, in Table 2, examples of the changing pattern of relations as between the life phases of an individual organism.

TABLE 2

The association with shelf of various representative organisms during different phases of life

Organism	*Eggs*	*Larvae and young*	*Adults*
Sponges and Hydroids			
(general)	Usually pelagic. Asexual reproduction also occurs.	Short pelagic life of larvae.	Fixed on rocky bottom or on shells, plants, etc. Filter feeders of suspended matter and plankton.
Ficulina ficus	Pelagic (asexual reproduction also occurs).	Pelagic (relatively short time).	The young settle on empty mussel shells (usually *Astarte*) which lie loose on the bottom around them.
Cliona celata	Pelagic.	Pelagic (relatively short time).	Burrows into limestone or into great mussel shells.
Tubularia larynx	Brood protection.	Pelagic.	Fixed on rocky bottom or on stones lying on bottom.
Corals			
(general)	Asexual reproduction common; pelagic eggs also occur.	Mostly pelagic.	Usually fixed to bottom or on hard objects on it.
Ceriantharia	Pelagic.	Pelagic, feeding on plankton.	Usually live in sand. Important as fish food. Detritus feeders.
Lophohelia prolifera . .	Mostly asexual reproduction by budding.	The larvae of sexual production pelagic ?	Fixed to the bottom. Reef-building coral in deep cold waters.
Sagartia troglodytes . . .	Pelagic in some localities, viviparous or larviparous in other places.	Pelagic eggs develop into pelagic larvae that feed on plankton. Viviparous larvae are benthonic crawling around the bottom.	Fixed to hard bottom or to hard objects on it.
Nemertines (worms)			
(general)	Usually in lumps on the bottom, but many species have pelagic eggs.	Species with non-pelagic development are rare; species with pelagic larvae,* some of which feed on plankton, are common.	Live mostly on bottom, but can also move through water; most species live among seaweeds. Feed on detritus and small algae. Many are carnivorous, attacking Polychaetes.
Lineus ruber	Deposited in lumps in a green gelatinous mucus on the bottom.	Non-pelagic larvae develop on the bottom.	Lives on muddy bottom in shallow water. Feed on detritus and small algae.

* The asterisk refers to larvae that do not take in food, but derive their nourishment from the remaining yolk material of their egg. Such larvae are known as lecithotrophic.

TABLE 2 (*continued*)

Organism	*Eggs*	*Larvae and young*	*Adults*
Cephalothrix linearis . .	Deposited on the bottom.	Pelagic.*	Lives usually among sea-weeds.
Cerebratulus marginatus .	Deposited on the bottom.	Free swimming feeding on plankton.	Lives in deeper waters on hard bottom. Can also swim in the water.
Bryozoa (sea mosses) (general)	Mostly viviparous, but egg-laying species also occur.	Short time pelagic larvae * are most common, but larvae of few egglaying species are long time pelagic feeding on plankton.	Fastened, mostly on hard bottom. Filter feeders.
Alcyonidium albidum . .	Pelagic ?	Pelagic feeding on plankton.	Fastened on hard bottom. Filter feeders.
Flustella hispida	Pelagic ?	Pelagic.*	Fastened on sea-weeds.
Polychaetes (worms) (general)	Few viviparous. Usually eggs fastened to the opening of tubes or are truly pelagic. Asexual reproduction also occurs. Some species can change the mode of reproduction according to the surrounding conditions.	Mostly pelagic and planktotrophic. Larvae of non-pelagic development in about 25% of species. Pelagic larvae * also occur. Polychaete larvae are eaten by herring, actinians, amphipods and Cumacea.	Mostly live in bottom materials. Some species can leave the bottom for spawning in water mass. Detritus feeders.
Scoloplos armiger . . .	Laid in gelatinous, pearshaped cocoons and attached to the sand by a rough string.	Larvae hatch from the cocoon in the crawling stage, without any pelagic life.	Lives in mud and muddy sand. Catch microfauna and organic detritus. Very important as food for demersal fish.
Nereis diversicolor . . .	Either loose on the bottom or pelagic.	Short time pelagic.*	Lives in sandy mud. Leave the bottom during spawning, which occurs near the surface.
Nereis pelagica	Both pelagic, and lying on the bottom.	Developing on bottom in a crawling stage or pelagic feeding on plankton.	Lives on rocky bottom, but can also swim in the water.
Nephthys caeca	Ova are well developed in the coelom of a female before release into the water.	Long time pelagic feeding on plankton.	Digs into the mud, but can also swim in the water.
Crustaceans (shrimps, lobsters, etc.)			
HARPACTICOIDS	Mostly pelagic.	Mostly pelagic and feeding on plankton.	Live mostly on all kinds of bottom, but can also swim ; mostly detritus feeders.
CIRRIPEDS	Brood protection common.	Usually pelagic.	Fixed on stones, ships, etc. Filter feeders.
CUMACOA	Brood protection common.	Usually pelagic.	Live mostly on bottom, but occur sometimes in water mass. Important as fish food ; detritus and plankton feeders.
AMPHIPODS	Brood protection common.	Mostly pelagic.	Most species pelagic, some species on bottom substrata with ability to swim (e.g. *Gammarus locusta* on sea-weeds), some living in bottom substrata (e.g. *Hippomedon, Haploops,* etc.). Bottom living species are detritus feeders.
DECAPODS (general)	Brood protection and also pelagic eggs.	Most larvae have long pelagic life and are feeding on smaller zooplankton organisms.	Mostly live on bottom as well as in the water above, but also crawling only on bottom. Many species of great economic importance. Mostly detritus and plankton feeders.
Pandalus borealis (shrimp)	Brood protection.	Pelagic feeding on plankton.	Lives mainly on bottom, feeds on smaller organisms and partly on organic detritus. During the night may swim around.

* See footnote p. 190.

TABLE 2 (*continued*)

Organism	*Eggs*	*Larvae and young*	*Adults*
Carcinus maenas (beach crab)	Part-time brood protection. Eggs are released in an advanced state of development.	Pelagic feeding on plankton.	Lives usually on sandy bottom in shallow water.
Eupagurus bernhardus (eremite crab)	Brood protection.	Pelagic.	Lives in empty gastropod shells (e.g., *Littorina*) crawling around the bottom in this shell; important fish food.
Homarus vulgaris (lobster)		Pelagic.	Lives under stones and among seaweeds. Economically exploited.
Mulluscs			
GASTROPODS (general)	Most deposit their eggs in capsules which are fastened to the bottom. Few genera spawn their eggs in a gelatinous layer, attached to a substratum. Primitive gastropods spawn eggs freely into the water. Egg and brood protection as well as viviparous species occur.	The larvae, developed from gelatinous eggs or from capsules, usually remain on the bottom. More than half of the species have larvae with long pelagic life, species of short pelagic life are relatively rare. The gastropod larvae are eaten e.g. by herring, mackerels, etc.	Different species are adapted for different conditions of life. Most species live in bottom substrata or lie on it; crawling gastropods also exist. Mostly detritus feeders.
Littorina littorea (periwinkle)	Deposited in capsules which usually are pelagic but may also be fastened to the bottom.	Pelagic feeding on plankton.	Lives on bottom in shallow water.
Littorina obtusata . . .	Deposited in gelatinous mucus, fastened to stones or seaweeds.	Larvae develop to crawling stage with small shell within the gelatinous mucus, on bottom.	Crawls slowly on the bottom or lying on it.
Gibbula cineraria . . .	Pelagic.	Pelagic.	Lives on hard bottom. Good fish food.
BIVALVES (mussels) (general)	Brood protection is common. On the bottom fastened eggs as well as pelagic eggs occur.	Mostly pelagic. The young of bivalves, unable to move in adult stage, are for a long time able to move in water mass or crawl on the bottom.	Majority occur in bottom substrata and fixed on it. Several crawling species exist. Many species important as fish food and as food for man (oysters, edible mussel, etc.). Detritus feeders.
Nucula nitida	Pelagic.	Pelagic.	Lives in soft bottom.
Mytilus edulis (edible mussel) . . .	Pelagic.	Pelagic, feeding on plankton.	On hard bottom fastened to bottom substrata in shallow water to a depth of ca. 50 m., or lying loose on it.
Ostrea edulis (oyster) . .	Egg and brood protection (Embryos develop in mantel cavity to veliger stage).	Pelagic.	In shallow water and on tidal flats, fastened or on artificial support. Is cultivated. Filter feeder.
Cyprina islandica . . .	Pelagic.	Pelagic, planktotrophic.	Buried in the fine sandy mud or sand. The siphon reaches the sediment surface. Important as fish food.
Teredo megotara (shipsworm)	Brood protection.	Pelagic.	Burrows into wood, often doing much damage to wooden ships, harbour constructions, etc.
CEPHALOPODS (Squids and octopi) . .	Eggs usually lying on bottom in long capsules.	Pelagic.	Most species pelagic; some live on bottom substrata only; large octopi live on and in bottom substrata and can also swim. Detritus feeders, and feeders on other benthonic animals.

TABLE 2 (*continued*)

Organism	*Eggs*	*Larvae and young*	*Adults*
Echinoderms (general)	Usually the eggs are pelagic, brood protection occurs, specially in colder areas; few species are viviparous.	Usually with long pelagic planktotropic life, but also pelagic lecithotrophic life occur.	Most species crawl on bottom feeding on other benthonic animals. Some live in the bottom substrata and some are fixed on it.
Asterias mülleri (starfish)	Brood protection.	The young leave the mother as fully developed young bottom stages.	Crawls on the bottom.
Solaster endeca	Pelagic, floating singly at the surface.	Pelagic.*	Crawls on the bottom.
Ophiura robusta (brittle-star)	Pelagic.	Pelagic feeding on plankton.	Lives mainly on bottom.
Tunicates	Mostly asexual reproduction. Eggs are pelagic but brood protection occurs in some species.	The larvae of sessile tunicates are mostly fixed to bottom substrata; larvae are pelagic for only a very short time.	Most species are pelagic, only Ascidians are fixed on hard bottom. Filter feeders.
Pisces (fish)			
Rays and Sharks	Eggs deposited in capsules on the bottom.	Larvae developed in capsules; young live on bottom.	Often on bottom substrata feeding on other benthos animals.
Herrings	Most species have pelagic eggs (e.g. pilchard, sprat, menhadden). By some species lying on bottom (Atlantic herring) or fastened to the vegetation (Pacific herring).	Pelagic, feeding on.	Pelagic.
Plaice	Pelagic.	Pelagic.	Spend most of their life on bottom, feeding mostly on benthonic animals.
Haddock	Pelagic.	Pelagic, young lie often on bottom, feeding on bottom animals.	Often on bottom, feeding partly on benthonic animals.

* See footnote p. 190.

It will be seen that the task of examining the association between organisms and the continental shelf is complicated by two principal considerations. Firstly, there is the difficulty of biologically designating precisely the limits of the shelf and the limits of the influence exerted by it. Especially is this so since, remembering that the organisms concerned live only in aquatic medium, the shelf cannot be considered only in terms of the solid materials of which it is constructed: the water overlying the shelf is as important as the shelf-material. Secondly, there is the complication of the differences of relations for different life-phases; this complication is the greater because of the diversity of organisms in this zone: most principal groups of animals, and many groups of plants, are represented in the shelf-communities.

The conventional approach to the analysis of the complex communities of the shelf is to consider the organisms which normally appear in these communities, chiefly in adult form, and to classify them according to habits and normal habitat. Several classifications have been made along these lines; table 3 sets out in the first column a classification drawn up in accordance with the more generally accepted views on this question. The second column describes the habits and habitats of different groups of adult organisms that enter or live in this zone. The organisms in the first three classes have living space dependence on the shelf, both materials and water, during their adult life; those of the fourth class have other kinds of dependence on the shelf during adult life, and these are chiefly with water overlying the shelf, but sometimes with shelf-material. The third column shows the habitat, habits, etc., of the eggs, larvae and young of certain organisms representative of each group where their young stages are associated with the shelf.

TABLE 3

Classification of organisms normally occurring as members of shelf communities in adult phase, with indication of habitat, etc., of juvenile phases

Classification	*Definitions, examples, habits and habitats*	*Larval life*
A) **In-biota** . . .	*Organisms which spend all their post-larval life within the material of the bottom, feeding and growing there.*	
(*a*) Meso-biota . . .	*Animals which are completely buried in the substratum itself; some in its interstitial spaces.* They may move within this medium by digging while feeding, for example, or move about within the interstices. Some examples of animals in this group are: certain annelid worms, such as *Polygordius* and *Protodrilus*; certain copepods (crustaceans), *Paramesochra, Evansula*; and certain bivalved molluscs and gastropods.	The majority of animals living in sand deposit their eggs in the sand and the larvae develop there or in the overlying water. Mesobiota living in mud usually have pelagic larvae, but viviparity and brood protection also occur.
(*b*) Endo-biota . . .	*Animals which live in cavities or holes and tubes which they construct in the bottom substratum.* It is possible for some of them to leave these holes or tubes if, for example, the immediate environment becomes unfavourable, or in order to spawn. Examples are: certain annolids, such as *Arenicola*; certain clams, such as *Mya*, and boring isopods, such as *Sphaeroma*. Others, such as the boring clams or *Pholadidea*, bore into rocks and become prisoners in their own cavities. There are also animals such as the sea cucumber, *Cucumaria pseudopopulifera*, which, because of growth after entrance, may become imprisoned in the old burrows of rock-boring clams.	Spawning often on the surface of sand and mud or in free waters. Eggs can also be deposited in the tubes in the mud (e.g. *Corophium arenarium*) or in capsules and in gelatinous masses on the surface or near the mouth of their tubes (e.g. some polychaetes). Pelagic larvae are most common for these animals. Asexual reproduction occurs.
B) **Epibiota**	*Organisms that in post-larval form are fixed to the bottom and feed, grow and reproduce there.*	
(*a*) Fixo-sessilo . . .	*Organisms which fasten themselves to the hard bottom substratum or to hard objects on it (such as stones, big shells etc.) during their entire adult life or during a great portion of it.* There are organisms that fasten themselves to the substratum by means of their outer skeleton or by secretions; the hydroids (Hydrozoa) fasten themselves by means of their chitinous periderm; gooseneck barnacles have a leathery stalk; the tunicates are fixed by their cellulose-like test; certain molluscs fasten themselves by means of calcareous shells; sea mussels (edible mussels), such as *Mytilus*, use a byssus (a bundle of threads secreted by the foot). The large brown algae (kelps) are held to the substratum by a root-like hold fast.	Asexual reproduction occurs in many species. The larval stage is usually neritic-pelagic. Feeding on plankton. Viviparity occurs in this group. Before settlement the young of many species can crawl along the bottom.
(*b*) Rhizo-sessilo . . .	*Organisms which are fastened to the soft bottom (sand or mud) by various means.* For example, a root-shaped plexus is formed by the crinoid, *Rhizocrinus*; alcynonarians, such as *Pennatularia*, have a basal stalk which is embedded in the sand or mud. Higher plants, such as *Zostera*, have rhizomes and roots for attachment.	The larval stage is usually neritic-pelagic, feeding on plankton. Asexual reproduction occurs in many species as well as viviparity. Many species have non-pelagic larvae.
C) **Suprabiota** . . .	*Organisms that lie on or more freely about on the bottom and feed, grow and reproduce there.*	
(*a*) Libero-sessilo . .	*Organisms that lie on the sea bed in the adult stage, but are not fixed to it, and are incapable of active travel.* Examples are: flat oysters and foraminifera.	Larval stage usually planktonic. Brood-protection also common. The non-pelagic larvae and young can crawl around on the bottom.
(*b*) Hemi-sessilo . . .	*Organisms which, although capable of moving on the substratum during their adult life, usually settle in one place and remain there for variable periods of time, or do not move very far away.* The animals are sessile during feeding, but move when disturbed. Change of location may be caused by environmental conditions adverse for certain purposes, e.g. breeding, etc. Some of these organisms (as certain annelids) may encase themselves in fixed tubes. Some are held against the substratum by spinous projections. Chitons, limpets and other molluscs crawl slowly over very small distances only — although some may be almost sessile on a so-called foot.	Most eggs and larvae are pelagic. Eggs can be shed singly and adhering separately to substrata. Brood protection occur. Planktonic, lecithotrophic larvae are rather common in this group.
(*c*) Reptovagilo . . .	*Organisms which during their adult stages are capable of movement, but only on the sea bed.* This group of orgamisms includes forms such as starfish and some large crustacea (e.g. large crabs) and octopi which range more widely than do the forms described above and which do not hold themselves in one place for long periods of time.	Brood protection common, but majority have pelagic eggs and larvae. The larvae feed usually on phytoplankton, but in some groups also on zooplankton (e.g. decaped larvae).

TABLE 3 (*continued*)

Classification	*Definitions, examples, habits and habitats*	*Larval life*
(*d*) Bivagile	*Organisms which can crawl on the bottom and also move freely through the waters.* As examples are: *Cumacea,* some shrimp species, *Mesidotea entomon, Gammarus locusta,* etc. To this group belong also haptic animals which are vagile on the bottom while searching for food, but attach themselves when disturbed (e.g. tardigrade *Batillipes,* annelid *Diuredrilus*).	Mostly pelagic eggs and pelagic planktotrophic larvae.
D) **Swimming organisms**	*Organisms that swim freely in the shelf water, some of which remain in the shelf water all their post-larval life whilst others visit these waters for only part of the post-larval life; of the former, some spend most of the time on or near the bottom or even in it whilst others live in middle and/or surface waters; of the latter, some visit for reproductive purposes, others for feeding, some for both these purposes, and others merely cross these waters.*	
I. PERMANENT AND SEMIPERMANENT		
1. *Demersal fish* . .	*Fish which spend most of their post-larval life over the shelf and close to the bottom or on the bottom substrata and feed mainly on the benthonic organisms.* This group can be divided into three sub-groups:	
(*a*) *Flatfish*	*Fish which have very flattened bodies, and spend much of their time on the sea floor.* The main food is taken from the bottom. Generally, but not always, the range of migration of these fishes is smaller than of the following sub-groups. Examples are the plaice, soles, halibuts, turbots, flounders, etc.	Mostly pelagic egg and larvae. The floating eggs are found in different layers of water.
(*b*) *Gadids*	*Cod-like fishes closely related to the sea bed, but which move from deep to middle or shallow waters usually for feeding and breeding purposes.* Some species migrate long distances over deep oceanic areas (e.g. cod). Part of the food is taken from the bottom and part from the water mass. Examples of this sub-group are: cods, haddock, whitings, pollacks, etc.	Mostly pelagic egg and larvae. E.g. the egg of the hake floats freely to the surface from deep or shallow waters, where they are laid. They drift on the surface, where they hatch. Few dermesal larvae also occur (e.g. haddock).
(*c*) Percomorphs . . .	*Perch-like fishes which live preferably in rocky or coral bottom or wherever they may find shelter and food near the sea bed.* (E.g. perches, croakers, breams, basses.)	
2. *Pelagic fish* . . .	*Fishes which spend most of their life in the upper layers of the water and feed mainly on plankton or other pelagic fish.* Here two sub-divisions can be made:	
(*a*) Clupeoias (and ecologically related species)	Herring-like fishes which live comparatively near to the shore, dwelling either at or near the surface are: herrings, sardines, sprats, anchovies, menhaden, etc. They make extensive wanderings comparatively close to the coasts, appearing at certain times and places for the purposes of feeding and spawning.	Eggs lying on the bottom or fastened to it or are pelagic. E.g. the Pacific herring which lays adhesive eggs in coastal waters, attached to vegetation or which deposits them on the sea floor (Atlantic herrings). Sardines' eggs drift in the upper layers of the water. Mostly pelagic egg and larvae.
(*b*) Others	Other examples of fishes which live in bays, inlets, channels and offshore at or near the surface are: jacks, pompanos, amberjacks, etc. Oceanic pelagic fish (e.g. tunas, mackerels, sharks) may in most places live in the waters above the continental shelf where there in higher concentration of food available.	
II. VISITORS		
1. To reproduce . . .	*Fish and mammals which migrate to coastal areas for spawning.* E.g. Pacific herring which fastens its eggs to the vegetation near coast and in estuaries, channels (milkfish), which spawns in coastal areas. Mullets spend most of their life in coastal lakes, rivers and bays, spending only short periods in marine waters, spawning probably occurring in sea water, near the coast. Coastal breeders of aquatic mammals which give the birth to the young on coast or on ice, belong to this group. They migrate long distances and feed mainly on fish (e.g. seals).	

TABLE 3 (*continued*)

Classification	*Definitions, examples, habits and habitats*	*Larval life*
2. To feed	Most demersal fish and majority of pelagic species feed on continental shelf, either on the benthonic animals (demersal fish) or on the rich plankton crop (pelagic fish).	Most pelagic larvae feed on the plankton in the waters above continental shelf, which is generally more productive than offshore areas.
3. In transit	*Fishes which move from the sea to the fresh water, or from fresh water to the sea for spawning purposes.* (E.g. salmon, anadromous fish and eel, *Anguilla,* catadromous fish). Shads and smelt are other examples. Lagoon and brackish water fish can also be considered as a sub-group of migratory fish. This group of fish live near the bottom in coastal waters and brackish water bays in river mouths, but migrate for certain periods into sea water.	Salmon spawn in fresh water (most species in rivers). The young develop also in fresh water. Eels cover vast oceanic areas during their spawning migrations, and spawning takes place on definite grounds in the ocean at mid water.

List of Special Terms

Abyssal (adj.)	Of the deep sea (usually below 1,000 m. depth).
Amphipod (n.)	A group of crustaceans.
Anadromous fish	Fish which spend most of their adult life in salt water, but periodically migrate into fresh water for spawning purposes.
Asexual (adj.)	Sexless ; without involving sexual differentiation.
Benthonic (= benthic) (adj.)	Pertaining to benthos.
Benthos (n.)	Aquatic animals and plants spending most or all of their life on or in the bottom.
Biota (n.)	Plants and animals, generally referred to a region or a special environment.
Bivagile (adj.)	Of organisms which can crawl on the bottom and also move through the free water.
Bivalves (n.)	Two-valved aquatic animals, such as clams, mussels.
Brood protection	Protection of eggs after being shed from the ovary until hatching, or until the young are able to move and feed.
Byssus (n.)	A bundle of threads by which certain mussels adhere to rocks or other substrate.
Catadromous fish	Fish which spend most of their adult life in fresh water, but migrate into the sea (salt water) for spawning.
Chitin (n.)	A horny substance, forming the harder part of the outer integument of insects, crustaceans, etc.
Clupeoids (n.)	Herring-like fishes ; (adj. — clupeoid).
Coelom (n.)	The body cavity.
Community (= association) (n.)	A group of species living under the particular conditions offered by a particular situation (in a biotope).
Copepod (n.)	A minute crustacean, belonging to the family Copepoda.
Demersal animals, (fish, etc.)	Animals which spend most of their life close to or on the bottom.
Detritus (n.)	Non-living particulate matter in the water.
Echinoderm (n.)	A member of the phylum Echinodermata, marine organisms including starfishes, sea urchins and their allies.
Endo-biota (n.)	Organisms, which live in cavities, or holes and tubes which they construct, in the bottom.
Epi-biota (n.)	Organisms which occur entirely above the bottom surface, but are fixed to it or have some special anchoring organ sunk in the bottom.
Fixo-sessile (adj.)	Of organisms that fasten themselves to the hard bottom or on hard objects on it, during their entire adult life or the greater part of it.
Gastropod (n.)	A member of large class of molluscs, which includes most forms that have a univalve shell.
Habitat (n.)	The site in which an organism normally lives ; refers also to the environment to be found at that site.

Haptic Hemi-sessile (adj.)	Of organisms which, although capable of moving on the bottom during their adult life, usually settle in one place and remain there for extended periods and do not move far away.
In-biota (n.)	Organisms which spend most of their post-larval life within the sea bottom material.
Intertidal zone	The area between high and low water.
Larviparous (adj.)	Of organisms in which embryonic development proceeds to larval stage within the body, the young being produced as larvae which continue development outside the body of the parent.
Libero-sessile (adj.)	Of organisms which lie on the sea bed in the adult stage, but not fixed to it, although incapable of active travel.
Lurker (n.)	An animal whose feeding habit is to lie in wait for prey.
Meso-biota (n.)	Organisms completely buried in the bottom itself or living in its interstitial space.
Nekton (n.)	The free-living actively swimming organisms (e.g. fish).
Neritic (adj.)	Of or pertaining to the coastal and shallow waters of the aquatic environment above the continental shelf.
Pelagic (adj.)	Of or pertaining to surface waters ; e.g. pelagic fish — fish which spend most of their life in the upper layers of the water.
Periderm (n.)	The cortical tissue derived from the phellogen growth.
Phytoplankton (n.)	See plankton.
Plankton (n.)	Small organisms suspended in the water mass without or with only very limited mobility : phytoplankton — plant plankton. zooplankton — animal plankton.
Planktonic (adj.)	Of or pertaining to plankton.
Planktotrophic (adj.)	Of organisms feeding on plankton.
Polychaet (n.)	An organism belonging to the order of annelide worms, Polychaeta.
Repto-vagile (adj.)	Of organisms which during their adult stage are capable of movement only on the sea bed.
Rhizo-sessile (adj.)	Of organisms which are held to the soft bottom (mud or sand) by various means.
Sedentary (adj.)	Of bottom living organisms which, although not fixed to the bottom, move little if at all.
Sessile (adj.)	Attached and not free to move about.
Supra-biota (n.)	Organisms which lie on or move freely about on the bottom substratum.
Suspended matter	Particulate matter in the water.
Turbulence (n.)	Irregular nonlinear movement of water particles in a water mass.
Vagile (adj.)	Wandering, mobile.
Viviparous (adj.)	Of organisms in which development in the parent body continues to assumption of adult form.
Zooplankton (n.)	See plankton.