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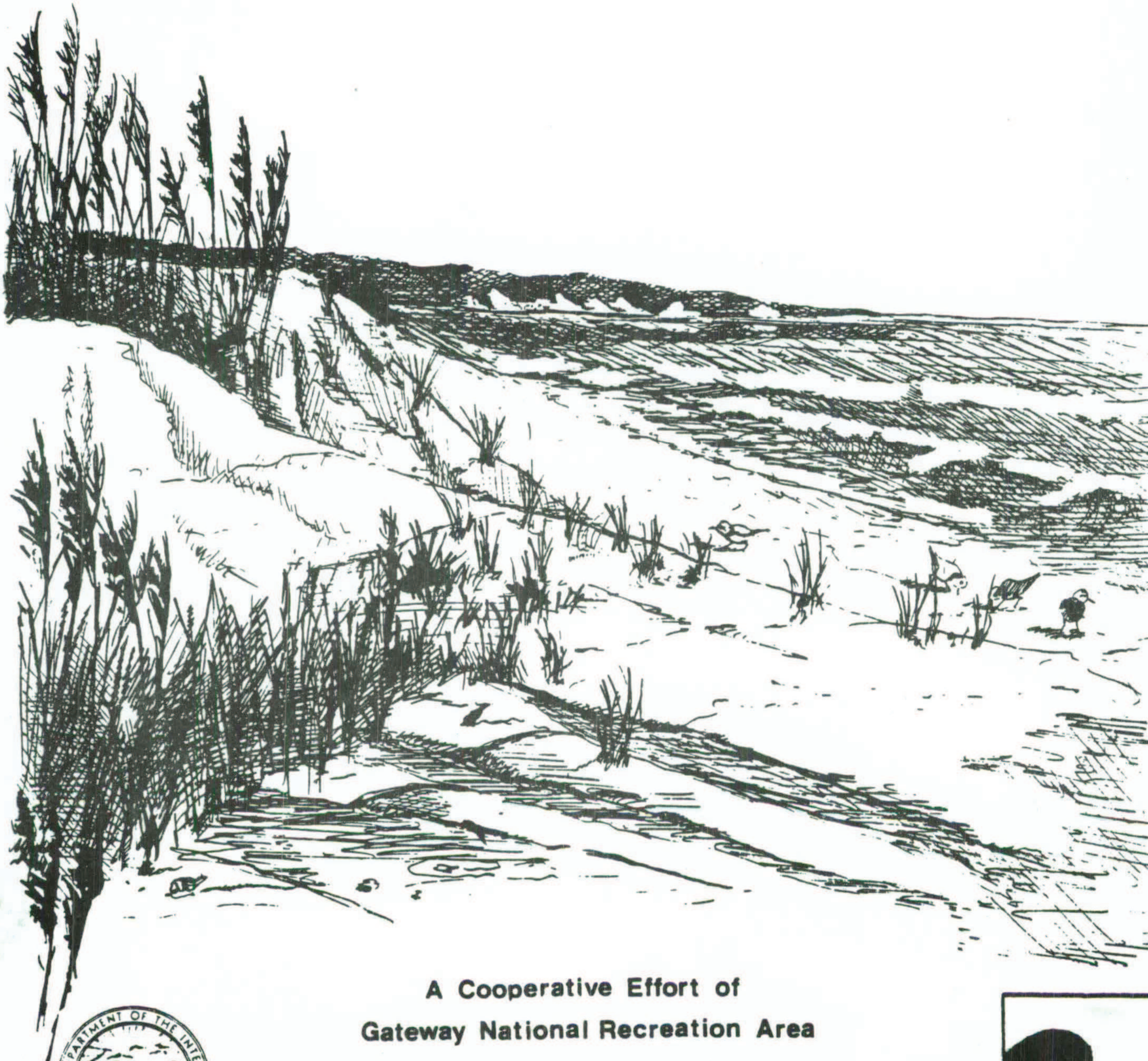
Gateway To The Sea

Lecture Series

In Celebration of The Year of the Coast



A Cooperative Effort of
Gateway National Recreation Area
The National Park Service
and
New York State Sea Grant

From the Superintendent:

In response to 1980 being designated as the "Year of the Coast", the National Park Service and Gateway National Recreation Area, in cooperation with New York Sea Grant, presented a series of lectures by a representative sampling of research scientists, university instructors, marine education specialists and administrators from the New York metropolitan area involved with a variety of coastal activities.

As you will see as you proceed through the manuscripts, we covered a wide gamut of disciplines in this lecture series, some traditional and some not so traditional. In trying to strike a balance between these seemingly diverse approaches to coastal resources use, I believe we accomplished something interesting. The lecture audiences comprised of the "general public", became involved in the topics discussed. The public's involvement went beyond just gaining information regarding our coastal resources. There appeared to be a genuine concern for this dynamic yet in many respects, fragile portion of our globe.

Each American, on the average, spends 10 days per year in some form of coastal activity. During the period from 1940 until 1970, the number of people living within 50 miles of the coastal shorelines has increased by 47.8 million. In 1970, 54% of the United States population lived within 50 miles of the coast. It is not surprising, therefore, that the pressures altering this fragile edge will increase precipitously over the next decade. We must do a better job of conveying to the general public and administrators the importance of our remaining coastal resources.

Similar to Aldo Leopold's "land ethic" concept, Bostwick Ketchum has suggested adopting a "sea ethic". This "sea ethic" would create a sense of responsibility for the health of the coastal zone and an ecological conscience in its management. Deliberate changes in man's activities must occur to reverse negative environmental impact trends.

I hope that this small effort will contribute to that end.

I am grateful to John Tanacredi of the Gateway staff and to Linda O'Dierno of Sea Grant for planning and presenting the lecture series and for preparing the manuscript for publication.

Herbert S. Cables, Jr.

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Waves, Currents, and Beaches
Along the New York Bight Shoreline

by

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The shoreline is an important location where recreation, tourism, and residential development all converge. As demands for use are put on the shore zone, conflicts arise and decisions must be made concerning the allocation of this scarce resource. Numerous institutions become involved in the allocation process such as local communities, county planners, state agencies, and federal offices, such as the National Park Service each contribute their unique perspective and attempt to resolve conflict issues.

Prior to treating the myriad of problems enveloping the shore zone, it is important, indeed necessary, to comprehend the basic dynamics that apply. To approach a problem without this understanding is to guarantee that the proposed solution cannot succeed. As a part of the appreciation of shoreline dynamics, it is important to grasp what may be referred to as <u>basic concepts</u>. These concepts become the guidelines for understanding and in themselves describe and define the dynamics with which all planning interacts.

WAVE SYSTEMS CONCEPT

The initial concept is that of recognizing that waves are the principal mechanism for producing change at the shoreline. Inherent in this concept is that waves are the manifestation of wind energy transferred to the water body. Waves have magnitude and direction and these values are related to the values of the wind that have passed across the water surface. In the New York Bight, the predominant winds are out of the west and northwest. These however, are not responsible for the waves that strike our Atlantic shoreline. They do produce waves that occur in our bays and estuaries, however, and they are a factor in the total system. Our principal ocean wave generating winds are produced by winds that come out of the northeast, and winds from the southeast. During calm weather, such as we experience during most of the summer, the light southeasterly winds generate low long waves. These waves do not cause much sediment movement. On the other hand, the northeasterly winds are associated with strong winter storms and we note that the high wind speeds generate large waves during the winter and these waves erode and transport great quantities of our beach sands. Over the span of a year, we find that our beaches tend to be dominated by low energy waves out of the southeast during which time the beaches tend to build out or remain stable. However, the winter storms that may occur weekly, with an especially severe storm occuring several times each winter, produce the most drastic changes by providing episodes of intense wave action and massive sediment removal.

The amount of sediment removal is dependent upon the severity and duration of the storm. The amount of return of sediment seems

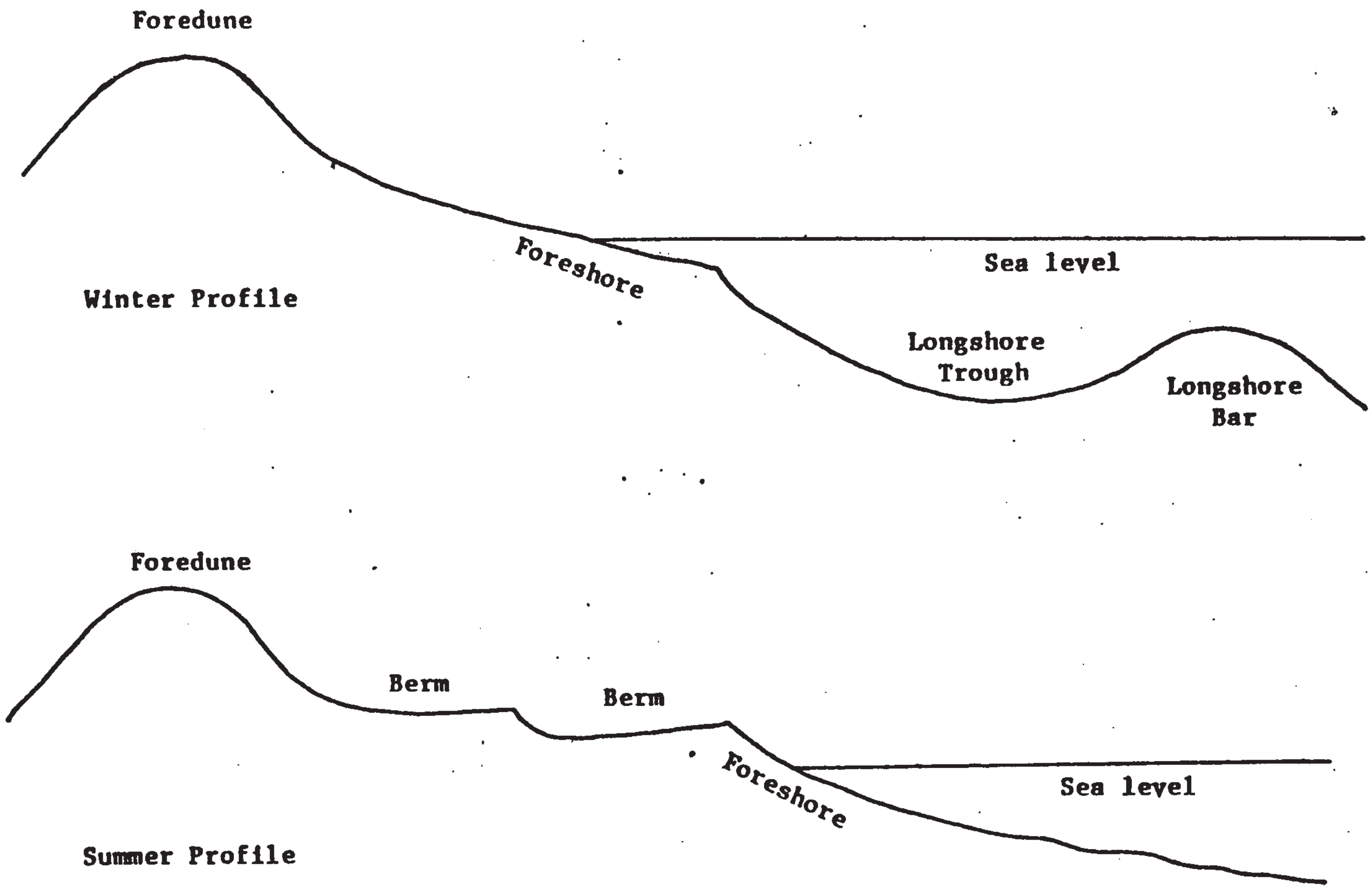

Figure 1. Seasonal beach profiles.

to be largely dependent on the duration of the low wave system. In one study, it was found that the beach lost as much as 500 cubic yards of sand from particular section of beach per day but recovered at a maximum rate of 50 cubic yards per day. It is obvious under this condition that if the storm frequency was greater than one in 10 days, the beach must suffer a net loss of sediment and therefore manifest erosion over a long term.

BEACH PROFILE CONCEPT

Beach profiles incorporate the area from the location of the coastal dune seaward to the position of the longshore bar (Figure 1). The profile may be thought of as an equilibrium form which is composed of several segments. Each segment responds to certain processes and each segment may expand, contract, or shift up or down the profile in response to its formational processes and sediment abundance.

During the winter storm period, the longshore bar is usually well developed and farther offshore. The bar is created in response to high wave energies which transfer sediment from the beach berm to the position of the bar. During calm weather waves, which transfer sediment up the profile to accumulate on the berm and foreshore.

The general configuration of the beach profile tends to go through changes that are related to the seasonal contrasts in wave energies as well as to the changes between storm events and the non-storm intervals. The culmination of the long period of summer accretion results in a beach that will have a very wide berm as the foreshore zone shifts seaward. In the process of building, the beach may have a series of berm crests which have been stranded on the profile. Thus, the summer beach may possess a series of topographic crests or ridges. On the contrasting winter profile, the beach tends to become smoother in its upper portion while the longhsore bar is enlarging. Thus, the winter beach may be described as having a planar surface compared to the more complex summer profile.

SEDIMENT BUDGET CONCEPT

It is important to realize that a beach cannot exist unless a sufficient quantity of suitably-sized sediment was available at some time which permitted its development. The beach itself is a manifestation of a sediment supply at least equal to the loss from the beach zone.

There are only three possible sources of sediment that may contribute to the beach budget. One source is derived from the erosion of headlands. As the headlands lose sediment, much of this material is carried by the longshore currents to accumulate on nearshore beaches. The extreme eastern end of Long Island, near Montauk, serves as a headland and contributes sediment to the western beaches. The area near the Highlands on the New Jersey shoreline also functions as a headland and loses sediment both northward and southward. In both cases, the headland portions do not have good beach development because the sediments are being transported out of the system.

A second sediment source is the material which is being carried by rivers from the mainland and eventually deposited at the shoreline. This is a very poor source of nourishment in the New York Bight because our rivers do not lead to the shoreline. Instead, the great quantities of sediment flowing through the river systems are deposited in the bays and estuaries that lay behind on shorelines. These water bodies are sediment traps and no sediment will reach the beaches until these bays are completely filled.

The offshore zone is the remaining source of sediment that may contribute to beach development. This has been a very important source in the past but is contributing very little at present. When the world's ocean was rising several thousand years ago with the melting of the continental glaciers, the rising waters flooded great quantities of sands which were then reworked by waves and currents. The initial offshore profile was not in equilibrium with the wave and current processes and great quantities of sediment were moved about, much of this up the the profile during constructive conditions. However, as sediment shifted, the equilibrium profile eventually developed and the upward transfer ceased.

At present, the sources of sediment that would serve to nourish the beach profile contribute less than the quantity that is eroded during an annual cycle. The product of this negative sediment balance is an erosional beach profile. That is, the beach profile is maintaining its form components but the profile is migrating inland into the barrier islands that line our shore. So long as the islands can make up the sediment deficit, the beach can maintain its form. But the beach is constantly migrating inland to gain the necessary sand required to establish its sediment budget.

The sediment budget concept dictates that the shoreline will experience erosion whenever the quantity of sediment removal exceeds the quantity of sediment entering the system. Because there are no sources presently contributing large quantities of sediment to the shoreline, all of the beaches are functioning with negative sediment budget and thus eroding.

BARRIER ISLAND CONCEPT

Nearly all of the shoreline of the New York Bight consists of a geomorphological feature known as a barrier island, after the terminology defined by Price (1952). The barrier island is a strip of land separated from the mainland by a lagoon or bay. This situation characterizes our shore except for the areas around Montauk, Long Island, and Bay Head to Long Branch in New Jersey. On the basis of the concepts discussed above, we learned about the beach profile and the general establishment of sediment transfer in an alongshore direction. However, there is also another dimension to the shoreline change and it is related to the rise of sea level and the development of the island forms.

The geologic record demonstrates that barrier islands have existed a number of times. There is evidence of a succession of barrier islands along the Atlantic Coast and Gulf Coast that currently rise to positions several hundred feet above modern sea level and scores of miles inland. The processes that gave rise to those forms are active today and their identification assists us in understanding the dynamics of our shore zone. Initially, the barrier islands form on the margins of gently sloping coastal plains in areas where there are large quantities of sand-sized sediment available. The barrier island is an elaboration of the beach profile and it grows because of a positive sediment budget causing the shoreline to build seaward However, because we have recently passed through a period of climatic fluctuation with glacial waxing and waning, the level of the seas has been changing and thus there has been some migration of the shoreline because of this phenomenon.

Given that a sizeable beach profile developed along a gently sloping coastal plain, a rising sea level would partially inundate the beach profile and would inundate the low-lying coastal plain behind it, causing a barrier island to form. As sea level continued to rise, the barrier island would migrate inland as sand is transferred from the seaward side to the landward margin by washover and inlet processes. The rising sea level would continue to drive the barrier island upward and inland over the bay deposits. Evidence of this migration is drawn from cores taken through the barrier island (Stuiver and Daddario, 1963) that depict bay sediments and peats that were originally deposited to the lee of the island and near sea level which are now below the island and much below sea level. Thus, the barrier islands we see today originated at a lower sea level and moved into their present position. Sea level is still rising slowly and the barrier islands continue to migrate. Further, because of a negative sediment budget the islands are becoming narrower and narrower.

CONCLUSION

The long term changes that occur along our shoreline are products of the waves and currents that create dynamic systems at our shore. The changes that are being manifest are the result of sea level rise and a negative sediment budget. Small scale alterations such as groins and jetties have little effect on the sediment budget and thus do not reverse the general trend. The overall direction of change on the barrier islands is a landward migration that averages slightly more than one foot per year for the entire New York Bight shoreline. Given this condition, land uses such as recreation, residential development, and commerce should be restricted on the barrier island. Structures should be placed with care and certainly should be capable of relocation as the changing situation demands. The islands are dynamic and all uses should be compatible with the processes active in producting the changes.

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FISH AND MAMMALS OF THE SEA: EVOLUTION AND ADAPTATION

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Our oceans encompass more than 71% of the earth's surface. Within this tremendously broad expanse of relatively unknown media resides more than half of all living vertebrate species. The sea is mostly frigid (below 4°C), mainly dark, and extremely deep, averaging 3.8 km and exceeding 11 km (more than seven miles) in depth in places. The majority of fishes and all other vertebrate forms, are confined to the upper 200 meters of the marine environment. Of the more than 20,000 living species of fishes, there are more than 12,000 marine species. There is however, a far lower percentage of mammals adapted to the marine environment. Only approximately 117 species of more than 4,500 living species of mammals inhabit marine waters.

Characteristics of Sea Water

In order to appreciate the tremendous array of adaptations needed to survive in the marine environment, one must first examine some of the unusual physical and chemical properties of sea water.

Water is not only important as the external environment of marine fishes and mammals, it makes up to 80 to 90% of their body weight. Water is approximately 800 times more dense than air. The high density of water imparts an increase of one atmosphere's pressure for each 10 meters of descent. The polar character of the water molecules results in enormous attractions between the molecules. As a result, water has a relatively high viscosity or resistance to flow. The consequences of these characteristics are well appreciated by those of us who have attempted to swim for any extended period!

Unprotected and prolonged immersion in water reveals to us the extremely great ability of water to conduct heat. Water is among the highest of all liquids in its ability to absorb heat. Water can carry about five times as much heat as an equal weight of air, or 7,000 times as much as an equal volume of air. This property plays an enormous role in the lives of all aquatic mammals and some active fishes.

The capacity of water to conduct sound is exceedingly high. Sound travels at approximately 1,700 meters per second in sea water, or more than five times faster than in air. Underwater sounds may travel many kilometers with ease. Many fishes and marine mammals utilize sound transmission for echolocation or communication.

The presence of dissolved salts in the sea presents a problem of body water loss for its inhabitants. The blood of aquatic mammals and most bony fishes is only approximately 40% as concentrated as sea water. As a result, water tends to equalize by flowing out of the organism into the surrounding sea. Water loss cannot be tolerated long without regulatory mechanisms. However, water loss is not a major problem in cartilaginous fishes, which have evolved blood containing high levels of urea, making the blood equal or slightly more concentrated than normal sea water.

Water generally contains only about 2-3% of the oxygen found in air. In addition, diffusion is only one-ten thousandth as fast in water as in air. This, of course requires surface breathing by all aquatic mammals and a highly specialized respiratory specializations for fishes.

Evolution of Fishes

It should be no surprise that the fishes are the most diverse and well adapted vertebrates in the sea, as they have been on earth at least since the Upper Cambrian, some 500 million years! The fishes are divided into two major groups (superclasses) of the subphylum Vertebrata.

The first group contains the fishes without true jaws, the agnathans. These ancient fishes probably evolved from a common ancestral form of jawed fish more than 510 million years ago. The oldest fossil fish yet discovered was a jawless form. The agnaths flourished during the Silurian and Lower Devonian, becoming rare during the Middle and Upper Devonian (about 300 million years ago), with only a comparatively few (63 species) surviving today.

Living jawless fishes (sometimes termed cyclostomes) are represented by the eel-like lampreys and the strange hagfishes. Lampreys are about equally represented by both free living and parasitic forms. They are both marine and freshwater inhabiting. All spawn in fresh water, but some mature in marine waters. The hagfishes are blind marine scavengers, and like the lampreys, are cartilaginous fishes lacking both scales and paired fins. The hagfish can justly be considered bizzare since the time it was first observed by Linnaeus in the eighteenth century and considered to be an intestinal worm! The hagfish has four hearts, teeth on its tongue, can produce a bucket of viscid slime in an instant, and it can tie itself into a knot. The Copenhagen Academy of Science offered a substantial prize to anyone who discovered the reproductive habits of this mysterious fish. To date no one has claimed the prize, despite the fact it was offered in 1864!

By far, the majority of living fishes belong to the second major group of fishes the jawed or gnathostome fishes. These fishes are found virtually everywhere on earth where there is water. They can be found in hot springs and alkaline lakes such as those in Africa where temperatures may exceed 45°C, or beneath Arctic or Antarctic ice at temperatures of -2°C. Jawed fishes are found from the shallowest tidal pool only a few centimeters in depth to the deepest area in the world, the

Challenger Deep nearly 11,000 meters below the surface of the western Pacific Ocean. In the great depths of oceanic trenches, the environment is perpetually black and frigid, with crushing pressures that can exceed 1,000 atmospheres or about one metric ton per cm^2!

The living jawed fishes are placed into two groups. First, the cartilaginous fishes or Chondrichthyes (including the sharks, skates, rays and chimaeras). The second group includes the bony fishes or Osteichthyes comprising the remainder of all fishes.

Cartilaginous Fish

Presently, the cartilaginous fishes number some 300 species of rays and skates, about the same number of sharks, and about 25 species of ratfishes or chimaeras. Fossil forms of cartilaginous fishes go back to the Middle Devonian (approximately 365 million years ago), while the modern sharks as we know them go back to the Jurassic (about 150-180 million years). Fossil ancestral sharks often consist of only a few teeth, dermal denticles or fin spines. The cartilaginous fishes have been evolutionarily separate from the bony fishes since the earliest dawn of the jawed fishes.

Among the cartilaginous fishes are the largest fishes in the world. The whale shark (Rhincodon typus) reaches 18m in length and can weigh more than 20 tons. The basking shark (Cetorhinus maximus) is nearly as large, reaching 14m in length. Both of these gigantic creatures feed entirely on microscopic plankton or small fish. Teeth on these gentle giants are reduced to tiny remanents. So then we have the largest vertebrates on earth, including the enormous baleen whales (reaching 30m in length) dining on some of the smallest organisms in the sea.

Large carnivorous forms are also well represented. A fossil shark (Charcharodon megalodon), a close relative of the living great white shark (Charcharodon carcharias), probably reached 13m (about 43 feet) in length based on tooth size (Randall, 1973). Indeed, a formidable fish of the ancient seas. The largest living predaceous shark is the great white shark. It was formerly erroneously attributed to reach a length of 11; 1m (36.5 feet). Dr. John E. Randall (1973) examined the jaws of the largest specimen in the British Museum. Although the jaws were impressively large (a vertical opening of nearly 60cm), he concluded the former estimate was a mistake. These jaws compare to a specimen of 5m (17 feet) long. The largest documented great white shark was a 6.4m (21 foot), 3,220 kg (7,100 pounds) specimen caught off Cuba. From bite marks on a whale carcass off southern Australia, individuals as long as 7.5 to 8m (25-26 feet) may remain to be caught. At the other end of the size spectrum, certain scyliorhinid (cat sharks) mature at 300-400mm, while some squaloid sharks (Squaliolus laticaudus) mature at only 150mm (6 inches) in length.

Most of the sharks are relatively non-aggressive, attacking only defensively, or when provoked. Sharks are generally stereotyped as all behaving as man-eaters, worthy only to be exterminated as our natural enemies. The shark family Charcharinidae or requiem sharks contain most of the "bad actors" among the sharks. Particularly, the grey sharks (genus *Carcharhinus*), tiger sharks (*Galeocerdo*), blue shark (*Prionace*), and lemon shark (*Negaprion*). Other families of sharks do contain aggressive species such as the hammerheads (Sphyrnidae) and the mackerel sharks, makos and great white sharks (Isuridae).

Although the number of unprovoked shark attacks (over 1,000 since the early 1800's) appears high, the number is comparatively small when weighed against the millions of people who swim daily in shark inhabited waters around the world. The probability of being struck by lightning far exceeds that of being attacked by a shark, yet few of us flee in terror when being caught in a summer thunderstorm! The sight of sharks indeed illicits a primordial fear that has its roots in events or objects that man cannot understand nor control. Common sense and caution should prevail when one ventures into a realm where the shark has been the supreme predator for nearly 200 million years. Man now has become the dominant predator of the seas, a role he will hopefully assume responsibility.

Research has begun to uncover some of the mystery behind shark attacks on humans. It now seems that most of the attacks are not a result of a sharks' appetite for humans, but as response of the shark to an intrusion or challenge related to its home territory. Territorial defense is a common behavior among most animals, including man. This interpretation is based upon two facts: 1). Sharks are now know to roam within certain regions for long periods, and will display distinct behavioral postures when an intruder (such as skindiver) encroaches into its territory; 2). Most wounds suffered by shark attack victims are puncture or tearing in nature, caused by a shark biting, shaking, and usually releasing the victim, while in most cases the victim could have been easily devoured if the shark intended to do so.

Bony Fish

The bony fishes are so diverse (more than 20,000 species) a brief survey is nearly impossible. The three major divisions include the Dipnoi (or lungfishes), the Crossopterygii or fringe-fin fishes (including *Latimeria chalumnae*, the only living species), and the largest division Actinopterygii or ray-finned fishes. The ray-fins are in turn subdivided into the Chondrostei (strugeons and paddlefishes), the Holostei (Bowfin, and gar pikes) and like the chondrosteans, a primitive and largely extinct group.

It is suggested that a holostean ancestor led to the Teleostei (or modern ray-fin fishes). The teleosts have exhibited an explosive evolutionary radiation since the Cretaceous, ranging form the 1 cm gobies to giant tuna and marlins that reach nearly 5 meters in length. The interrelationships of the extremely diverse teleosts is intricate and difficult to demonstrate.

Evolutionary adaptations among teleosts include a tremendously wide morphological, behavioral and physiological spectrum. Virtually every conceivable body form, a reflection of niche, can be found within the teleosts: from extremely compressed as in the ribbonfishes, flatfishes, or eel larvae, to the depressed goosefishes and clingfishes, or the truncated body of the ocean sunfish, and the ribbon-like body of the snipe eel or needlefishes. Fin shape and position likewise reflect a fish's habitat and niche. Including a pelvic fin modified as a crawling appendage as in the sea robins, and walking catfishes, or shaped into a sucking disc for attachment to rocks as in the clingfishes. Pectoral fins may be absent as in some eels, or greatly enlarged for soaring as in the flying fishes. Eyes may be greatly enlarged as in the nocturnal squirrel fishes, or completely absent as in certain deepsea fishes and cave fishes that inhabit regions essentially devoid of light. In the deepsea, fishes may have evolved luminescent organs for species recognition, feeding or advertisement. Feeding modes cross the full gamut from herbivores (plant feeders) and filter feeding herring, to predacious carnivores such as the barracuda and piranha. Also, there are a few examples of parasitism, such as in the sea cucumber inhabiting pearl fishes that occasionally chews off pieces of its host. Among certain deepsea ceratoid angler fish, an extremely unusual relationship has evolved between the male and female. The tiny male angler becomes attached to the underside of the female. The male's head is eventually nearly enveloped by the tissues of the female, becoming entirely dependent upon her for his nutrition. In turn, the male serves only as a sperm reservoir for the female.

Marine Mammals, an Endangered Species

Marine mammals are truly magnificent examples of evolution among the approximately 4,500 species of living mammals. However, in contrast to fishes, marine mammals are evolutionary neophytes. Cetaceans (whales, propoises, and dolphins), for example, probably evolved from a terrestrial mammalian ancestor during the Eocene (60 million years ago), while fishes have been around for nearly nine times as long. Nevertheless, the evolutionary adaptations found among marine mammals are incredible considering the relatively short time span in which they have evolved.

Since the era of early Greece in the 4th century B.C., cetaceans have been recognized as being distinct from fishes. It was known that cetaceans breathed air through lungs, not gills, had hair, and had young that were internally developed and nourished on milk. Despite such recognition, many early scientists such as Aristotle, Pliny (around the time of Christ), and Rondelet and Belon (in the 16th century) included cetaceans with fishes in their classification schemes. Apparently, their common habitat and general external resemblance were the deterministic factors. The botanist John Ray (late 17th century) was among the first to classify cetaceans as true mammals. Even today one might occasionally overhear a misinformed parent lecturing his their children in an oceanarium about the "porpoise-fish".

By the mid 18th century Carrolis Linnaeus, the father of our modern system of classification, further divided the cetaceans into the baleen whales (Mysticeti) and the toothed whales (Odontoceti). Presently, there are approximately 117 species of marine mammals according to Rice and Sheffer (1968). The following is a classification of marine mammals according to Nishiwaki (1972).

- Class Mammalia
  - Order Carnivora
    - Suborder Pinnipedia (33sp. seals, walruses)
      - Superfamily Otarioidea (sea lions)
        - family Otariidae (eared seals)
          - subfamily Otariinae (hair seals)
          - subfamily Arctocephalinae (fur seals)
        - family Odobenidae (walruses)
      - Superfamily Phocoidea (earless seals)
        - family Phocidae
          - subfamily Monachinae (monk seals)
          - subfamily Cystophorinae (hooded seals)
    - Suborder Fissipedia (1 sp. sea otter)
      - family Mustelidae
  - Order Sirenia (5 sp. dugongs, manatees)
    - family Hydrodamalidae (manatees)
    - family Dugongidae (dugongs)
  - Order Cetacea (whales, porpoises, dolphins)
    - Suborder Anrshaeoceti (extinct)
    - Suborder Odontoceti (68 cp. toothed whales)
    - Suborder Mysticeti (10 sp. baleen whales)
      - family Eschrichtiidae (gray whales)
      - family Balaenopteridae (rorquals)
      - family Balaenidae

All marine mammals are protected in U.S. waters by Congress under the Marine Mammal Protection Act of 1972. While many of the marine mammals are presently listed as endangered and also protected by Congress in U.S. waters under the Endangered Species Act. The bowhead, right and gray whales were granted protection by international agreement in the 1930's. The humpback and blue whales gained protection in 1966. Lamentably, the steady decline and extinction of many marine mammals is a well documented history based on man's mismanagement and greed. For example, the Stellar sea cow was a large and slow creature of the Bering Sea. The organism was hunted to extinction within 30 years of its discovery in 1741. The Alaskan fur seal was discovered in 1786 also in the Bering Sea. At that time the herd was estimated at 2.5 million seals. By 1834, the species was hunted to near extinction levels of 150,000 individuals. Fortunately in this case, extinction was prevented by strict management procedures (Riley, 1967). The Alaskan fur seal is now generally restricted to a small breeding colony on the Pribilof Islands off Alaska, although a recent colony has been established on San Miguel Island off California.

Whales are another example of a valuable resource that has been generally mismanaged. As a result, many of our most magnificent marine mammals are apparently destined for extinction. Particularly endangered are our seven species of great whales, including the blue whale, the largest animal to ever inhabit the earth. Some highly motivated groups and individuals such as the Fin Alliance, Greenpeace, Drs. Roger Payne, and Peter Beamish, to mention jsut a few, have been notable in their contributions toward cetacean preservation. However, reversing hundreds of years of whale herd decimation is an extremely difficult task.

The International Whaling Commission (IWC) was established in 1946 in order to establish guidelines for maintaining whale stocks. Quotas that were established are often not followed by some member nations, and most non-member nations. Self-interests and a lack of enforcement powers by the IWC has resulted in a steady decline of catches and stocks of most whales over the years.

The Evolution of Mammals

Mammals probably evolved in the Late Triassic (200 million years ago) form a therapsid reptilian ancestor. Mammalian fossils date from the mid Jurassic, about 165 million years ago. Cetaceans probably evolved from a terrestrial carnivorous mammalian ancestor during the Eocene, 60 million years ago. The cetaceans include 137 extinct and 35 living genera.

The Archaeoceti is the most primitive group, flourishing during the Eocene and know only from fossils of North Africa. Archaeocetes had a serpentine like body reaching 22 meters in length. The skull was long and low, with no evidence of the 'telescoping' of the skull found in modern forms. The jaws of archaeocetes contained 44 teeth. The front teeth were short and peg-like as found in some modern forms, but the jaws also contained incisors, canines, premolars and molars. These whales were probably fish-eaters. The archaeocete skull also had a well formed nasal opening on the snout, not as in modern cetaceans where the opening is on top of the head. The hind limbs have become reduced to vestiges and are not responsible for propulsion.

In modern cetaceans, the body has become streamlined and stouter in cross section and the skin has become essentially devoid of hair (only a few hairs may be found on the jaws). The head has lost external ears, and the body lacks protruding nipples. The external ear canal has become reduced or filled with wax, while the inner ear is suspended by ligaments and enclosed in a bony capsule. The ear capsule is surrounded by an oil foam to insulate it from the organisms' sound transmittion (Purves, 1966).

The appendages of modern cetaceans are highly modified for swimming. The anterior limbs, containing five digits, are developed into flippers for use in steering, attitude control and as heat regulatory mechanisms (Norris, 1963). The flipper is almost entirely comprised of the hand and forearm. The pelvic limbs have been evolutionary lost,or may be found as internal remanents. Interestingly, developing cetacean embryos have both anterior and posterior limb buds (Norris, 1963).

The fluke is a uniquely developed specialization at the posterior end of cetaceans. It projects laterally and consists of fibrous tissue enveloped in a sheath of ligaments. The fluke is the main propulsion mechanism and serves as a cooling structure to eliminate heat buildup due to the thick body fat layer (Felts, 1966). A rigid dorsal fin similar in structure to the fluke may be present. Another major cetacean body modification is the shortening of cervical vertebrae resulting in the absence of a neck (Romer, 1966).

The pinnipeds (seals and walruses) probably evolved during the Lower Miocene (20 million years ago). Their appendages have been modified into flippers, the hind limbs project back for use in propulsion. The eared seals can rotate their rear flippers forward for maneuvering out of water.

Sirenia (dugongs and manatees) are plant eaters of tropical oceans. Although once found worldwide, they are presently rare in most areas. Oldest fossils date from the Eocene of Egypt and show similarities to mastodons and conies. The forelimbs of manatees and dugongs form paddles, the hindlimbs are vestigial, and the tail is a broad flattened structure. The skin has a few scattered hairs, and the eyes are greatly reduced.

Diving Adaptations of Mammals

The problems of extended deep dives for air breathing mammals are considerable. Some marine mammals can spend a surprisingly long time (90-120 minutes) at relatively great depths (1,000m) with no traumatic effects. Man's free diving maximum limits are on the order of 2-3 minutes and about 100m. How can marine mammals accomplish this remarkable diving feat?

Marine mammals undergo apneustic breathing (rapid inhaling, exhaling and holding air in lungs) prior to a deep dive (Ridgway, 1972). Cetaceans can also fill their lungs to 80-90% of capacity with each breath while we can utilize only about half of our lung's capacity. The total volume of a cetacean's lungs are not particularly great for their size. However, their muscles have about eight times as much oxygen carrying blood pigment (myoglobin) as we do. In addition, blood can be shunted away from peripheral body regions and restricted to the critical areas of the heart and central nervous system. Muscles of marine mammals are capable of functioning anaerobically (without oxygen) for prolonged periods and tolerating high levels of lactic acid. The blood also has a high red blood cell count. Enormous quantities of blood can be stored in the muscles, large blood vessels and a perfuse capillary bed called the rete mirabile.

The heart rate drops (bradycardia) in marine mammals during diving, as in all air breathing vertebrates (Irving, 1966). Heart rates of diving seals have been recorded to drop from 120 beats per minute to 10/min, dolphins from 110/min to 50/min, and man from 70/min to 35/min. During dives, the lungs will collapse as the external water pressure increases, probably collapsing completely at about 188m. Here, the air is forced out into larger passages away from the tiny blood capillary beds. This phenomenon decreases much of the compressed nitrogen from being absorbed into the blood and thus decreasing the problem of 'diver's sickness' or the bends. The so-called whale blow spout often seen as whales surface from a deep dive is a result of the rapid expansion of air compressed through a narrow nasal opening. Up to 2,000 liters of air is expelled in one or two seconds resulting in a rapid cooling and condensation of its water vapor.

The Echolocation of Fish and Mammals

As previously mentioned, the capacity of sea water to transmit sound (5-6 times greater than air) has resulted in acoustic specializations in fishes and marine mammals. Echolocation has been demonstrated among the toothed whales, a few baleen whales and some pinnipeds. Among terrestrial mammals, bats have been intensively studied. Communication is also apparent through sound playback experiments. Most commonly studied communication studies have been with porpoises and dolphins. Baleen whales such as the southern right whale (Eubalaena australis) and the humpback have also been investigated (Clark and Clark, 1980; Payne and McVay, 1971).

During cetacean echolocation a series of low frequency clicks serve as a general scanning, while high frequency clicks or whistles (up to 150 kHz) are used for fine detection (Caldwell and Caldwell, 1972 and Norris, 1969). Human hearing only extends to about 20 kHz. Fine detection is evidenced from experiments where an Atlantic bottlenosed dolphin could discriminate with 100% accuracy between a steel ball 5.40cm and one 6.35 cm in diameter (Caldwell and Caldwell, 1972). Sound reception among cetaceans appears to be mainly via the lower jaw (Norris, 1964). The auditory canal is commonly plugged with wax in baleen whales, or reduced to a tiny pore or completely covered by skin in the toothed whales.

Feeding Habits of Fish and Mammals

Feeding. - The range of feeding modes among marine mammals are nearly as diverse as found among marine fishes. The largest marine mammals are the baleen whales. These whales feed entirely on small planktonic organisms and small fishes and invertebrates filtered from the sea. The largest blue whale (reaching 150 tons) cannot swallow an object much bigger than the diameter of a large cantelope! Baleen whales (mysticetes) have parallel rows of hardened skin or whalebone that extends down from the roof of the mouth like pages of a book (Nemato, 1970). The grey whales feed on the bottom for soft invertebrates by sweeping their head back and forth over the bottom and scooping up the organisms by the mouth-full (Nemato, 1970). The humpback, right, blue and fin whales swim through plankton patches with their mouth open, the ventral throat grooves enable their mouth to greatly expand. The planktonic organisms are trapped in the baleen with the tongue acting as a great piston to force the water along, the plankton is then swallowed (Nemato, 1970). The sei whales swim with their mouth partly open, and the plankton is swept off the baleen with the tongue (Nemato, 1970). The toothed whales (odonticetes) lack baleen and are mainly predaceous on large squid and vertebrates. The stomach of a large sperm whale (15m) contained an intact giant squid nearly 11m long, although the average size squid is about 1m in length. Killer whales have been found to contain sea lions, porpoises, elephant seals, sharks, squid, and fish. Sea otters feed mainly upon mussels and sea urchins, and crustaceans. The otters can often be seen floating on their back among the Pacific kelp beds and cracking open the mussels and urchins on their stomachs using rocks as tools. The dugong and manatees (Sirenia) are herbivores, and feed upon rooted aquatic vegetation in shallow coastal waters.

The following selected list of references from the vast literature will permit more detailed examination of the fascinating subject of marine fishes and mammals.

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MARINE BENTHIC ECOLOGY

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1. Introduction

Benthos is the term referring to the plants and animals which are associated with the sea floor. Benthic organisms are extremely important as food for commercial fish species and larger invertebrates such as lobsters and crabs. Organisms ranging from bacteria to the large crustaceans as well as the finfish are components of the benthic environment.

Special terms are used to describe different types of marine benthic animals. The term microfauna refers to the tiny organisms that are generally 500 microns (1/2 millimeter) or smaller in size. Animals ranging between 500 microns and 1.0 millimeter are generally referred to an meiofauna. Animals larger than 1.0 millimeter are usually called macrofauna.

Microorganisms such as the bacteria, fungi, and protozoans, while they are not generally regarded as animals, are important in benthic community structure. These organisms play a leading role in the decomposition of dead plants and animals and serve as a food source for other micro-meiofauna.

2. Distribution and Abundance

Marine benthic organisms are worldwide in their distribution. At one time oceanographers and marine biologists believed that they would not be found at depths greater than a few thousand feet. However, at the turn of the century, oceanographers found marine life in dredge samples from the sea floor at water depths of over 10,000 meters (30,000 feet).

At one time, it was also believed that marine benthic or bottom dwelling life probably would not be found in the cold water of the Arctic and Antarctic. In recent decades, marine scientists have made collections in these waters by using submarines or by drilling holes in the ice masses. They found that marine life exists under the huge ice flows of both the Artic and Antarctic. These cold water marine organisms are in many cases similar to those that live in the warmer of the Middle Atlantic Bight off the coasts of New York, New Jersey and Delaware.

Benthic organisms are also an important part of the tropical marine ecosystem where they are often associated with the massive reefs of the tropical islands in the Caribbean and in the South Pacific. These reefs, which protect the Caribbean atoll islands during severe storms, were built up over the centuries as benthic organisms died and added their calcareous exoskeletons to the growing structure. These ecosystems contain some of the most colorful and diverse faunas found anywhere in the world.

Benthic organisms live in water depths ranging from the splash zone above the highest tide marks to the deepest trenches in the world such as those found north of Puerto Rico and off the Phillippine Islands.

Animals that live on the sediments within the intertidal zone or littoral zone, i.e., that part of the sea floor between the highest high tides and the lowest low tides, must adapt to living with periodic exposure to air. Such exposure can result in animals' over heating or freezing depending upon the ambient temperature in temporal and boreal environments. Unless the animal can burrow into the sediments or draw its shell tightly closed, it runs the risk of desiccation or drying out. Intertidal animals are also exposed to periods of intense rainfall when the normal salinities of coastal or intertidal waters are greatly reduced. This reduced salinity can endanger the animals unless they have special adaptations to deal with the problem.

Many benthic ecologists believe that only animals that live below the intertidal zone or within the sublittoral zone should be referred to as being benthic organisms. Most frequently, scientists define the sublittoral zone as from the lowest tide mark to the edge of the continental shelf or where the water is 200 meters (600 feet) in depth. At this point, frequently called the shelf-slope break, there is often a very precipitous increase in depth known as the continental slope. The continental shelf leads into areas known as the continental plateaus in waters ranging from 1,000 to 5,000 or 10,000 meters in depth. These deeper zones are often referred to as the abyssal or hadal zones. The greatest depths are usually part of the oceanic trenches.

Marine benthic organisms are often categorized according to where they live upon the ocean's floor. Animals which live on hard rock outcroppings are called epibenthic organisms. These include sea anemones, hydroids, barnacles, mussels, and other such animals. Large kelps and other forms of algae are also found attached to hard substrates and they too form part of the benthos.

Other forms of marine invertebrates live on or in soft bottoms. Certain worm-like animals make burrows in soft substrates and line the burrows with tubes that may extend above the surface of the water-sediment interface. The feather duster worm spends its entire life within a protective tube. There is also a sea anemone that is specialized for living in a tube that is formed from body secretions.

Such animals are referred to as infauna. Other non-tube forming infaunal organisms spend their lives burrowing in the sediments anywhere from a few millimeters below the surface to depths of several meters. Certain worms move through the substrate ingesting sediment into their gullet and passing it through their digestive tract. Enzymes in the digestive tract are capable of digesting organic material. Frequently, small curls or castings of material which are passed through the digestive tract are left at the surface as evidence of the location of these worms.

Many forms of larger marine animals such as the ghost shrimp are capable of excavating extensive burrows which range from 5 or 6 millimeters to 2 or 3 centimeters in diameter. These shrimp move through the burrows and by using their appendages cause water to circulate through the burrow, bringing both food and fresh water containing oxygen to the animals.

Benthic organisms occur in varying degrees of abundance. If one were to walk along the Rockaways or the ocean beaches of Sandy Hook during low tide and look for signs of marine life, it would be quite difficult to discern immediately the presence of marine organisms. However, if a few shovelfuls of sediment were collected and filtered through a screen, it would be possible to locate hundreds of animals. Because of the stressful nature of the intertidal zone, the number of animals is often reduced when compared to the number found in deep water sediments. In areas where there is heavy wave action and beaches are constantly being eroded and moved, organisms must be adapted to rapid reburrowing. Since many types of marine life have been unable to adapt to these changing conditions, there are fewer organisms in the intertidal zone.

Beyond the intertidal zone it is possible to find within a square foot of surface area, that there are literally millions of organisms living together in a complex arrangement known as a community structure. The animals range in size from tiny worm-like creatures to large crabs and lobsters, as well as bottom dwelling fish. It is also possible to find billions of individual bacteria or fungal cells as well as various forms of single-celled life which come directly from plankton in overlying waters. With sufficient light penetration, single celled plants known as phytoplankton are also found associated with the surface layers of the sediment.

Coral reefs and large rock outcroppings characteristic of the west coast contain thousands or even millions of benthic invertebrate organisms. One might question where all these animals are situated. In such areas, there are large numbers of kelp and flowerlike marine organisms called hydroids. These organisms form a "forest" on the surface of the rocks or coral, as well as on pilings and other man-made structures. This forest provides a habitat for a wide range of small animals which crawl on and through the overstories growth. The abundance of life in such environments is extremely important to the marine food chain which culminates in the fish and invertebrates that man utilizes for recreational and commercial purposes.

3. Feeding Types

Benthic organisms obtain their food in many ways. Some animals ingest sediments and remove organic material from these sediments. Certain worm-like animals can take up food directly through their skin. Bacteria digest organic material and often release simple nutrients such as sugars and amino acids as a byproduct. These simple nutrients then pass across the skins of other animals.

Suspension feeders use tentacles or other similar structures to remove plankton and detritus from the water. Once collected, tiny structures called cilia sweep the planktonic material into the mouth of the worm or sea anemone. Barnacles, which are actually modified crustaceans related to shrimp and crabs, use their feet-like appendages called cirri to sweep suspended material into their mouths.

Deposit feeding animals have a wide variety of adaptations. Some worms have long tentacles which extend over the surface of the sediment where they pick up organic material. Cilia then move the material to the mouth of the worm. Some snail-like animals move slowly across the surface of the sediments digesting organic material. Obviously, deposit feeders generally exist in areas where water currents are reduced and the organic substances of plankton tend to fall out from the water column and accumulate on the surface of the sediment. Conversely, suspension feeders tend to occur where water currents are moderately strong and thus keep materials in suspension.

Sediment ingesters are often worm-like in form so that they can easily burrow through such dense sediments and impacted clays or mixtures of silts, sands and clays. Tiny nematode worms often fit into this category. Some can be quite discriminating picking organic particles away from tiny particles of sand or silt, whereas others move the entire sediment through their gut. These animals move vertically as well as horizontally and as they do this, they allow the movement of water containing proper amounts of oxygen into the deeper layers of the sediment. Because not all of the organic matter is digested, these animals play an important ecological role by distributing organic matter throughout the sediments. Finally, the activitiy of such organisms provides for the aeration of deeper layers of the sediment.

Carnivores prey on other forms of marine life. Many of the larger crustaceans such as carbs and lobsters will actively prey upon snails, clams worms, and other invertebrates. In turn, crabs and lobsters may be fed upon by certain bottom dwelling finfish or octopus. Eventually the bottom dwelling finfish or octopus may be fed upon by still larger animals such as certain species of teleost fish and sharks. Some carnivores are also scavengers and feed upon animals that have died naturally thus, providing an important clean-up function.

4. Benthic Organisms as Prey

Life within the benthos is a constant matter of eating or being eaten. It cannot be stressed too highly, however, that this is an extremely important and dynamic situation which culminates in the many commercial species that are important to man. Certain benthic organisms can live to be extremely old. For instance, certain sea anemones are known to be well over one century in age, and it is known that certain of the large horse mussels live to be over a half a century old.

Generally, animals survive to these ripe old ages by having certain protective mechanisms. Large sea anemones, like all coelenterates, have small specialized cells called stinging cells or nematocysts. These cells contain a particularly virulent form of toxin which can kill smaller marine species and seriously affect larger species. The cells are discharged as predators approach or touch the sea anemone. Mussels and other shellfish, once they grow beyond the juvenile stage can survive for long periods by virtue of their hard shells. As the animal matures, the shell grows ever thicker and thus cannot be easily crushed by crabs or lobsters or by the teeth of fish which normally feed upon such species. Clams can survive to considerable size and old age by burrowing deep into the sediments and maintaining contact to the surface by a long tube-like structure called a siphon or neck. Water currents in these siphons move food materials to the animal.

5. Reproduction

Reproduction takes a number of different forms. Some single-celled protozoa periodically divide in two to form two new daughter cells from an original mother cell. Most animals, however, have male and female individuals within the species At certain times of the year, female seastars and sea urchins release eggs. Often a substance released in conjunction with the eggs causes the males to release their sperm. Eventually a sperm will find an egg, fertilize it and development proceeds. Usually there is a larval stage which lives within the plankton for a period of time often up to two weeks. Eventually this larval form evolves into a miniature adult which settles to the bottom.

Many organisms do not have such a simple form of reproduction. Most crab species, a male must seek out a female and copulate with her in order to transfer the sperm to special openings within the underside of the female. As the eggs develop within the female, they are eventually released passing by small packets of sperm where the eggs are fertilized. The eggs are then attached to appendages on the abdomen of the crab or lobster where they are carried for a period of time while development takes place The mother provides protection and by movement of her abdomen and special appendages aerates the eggs so that proper amounts of oxygen are provided. Eventually the eggs hatch into larvae which look nothing like the adult. These larvae, called zoea, leave the adult and swim to the surface of the ocean attracted by light. At the ocean surface, there is a sufficient amount of phytoplankton to be used for food by the developing larvae. Eventually the larvae moult into a form similar to the adult and settle back to the benthic environment where they continue to go through a variety of developmental stages or instars through the process of moulting.

Other forms of marine invertebrates have a more direct form of development. In certain snails, a male will locate and copulate with a female inseminating her with his sperm. The fertilized eggs may be deposited or attached to the shell of the female and within the egg there is a direct development including a larval form, but a final form which hatches out as a miniature adult. Often such development occurs in waters which are extremely cold or deep. It is thought that if animals living in the abyss produced larval forms which had to travel great distances to the surface layers there would be too much chance for predation and they would never survive in proper numbers to assure the survival of the population.

An important part of reproduction involves the process of dispersion. Benthic animals which tend to live in particular environments produce larvae which often become part of the plankton and can be carried considerable distances. An animal which lives in the Hudson Shelf Valley may reproduce itself and the larvae may be carried hundreds of kilometers to a new environment where the animal settles out and begins a new life. In a way, this is a protective function for most species of planktonic larvae. It insures that if some tragedy befalls the adult population, the reproductive products or larvae are carried some distance away to recruit new environments. Eventually these animals will reestablish themselves as adult reproducing populations.

Dispersion is also important in permitting certain species to travel around the world. Certain species which occur on both sides of the Atlantic Ocean originally evolved in one area, and by having planktonic larvae were able to colonize entirely new areas.

6. Behavior

Many scientists are studying how animals are able to detect subtle differences in temperature salinity or suspended material and to appropriately respond to the cues which are provided by slight changes. Many forms of marine life must live within a certain range of salinity. Mussels and oysters generally can live within a wide range of salinities, but once salinities fall below a certain level, the animals cannot survive. Both organisms have the ability to detect sudden changes in salinity. Such bivavles living in estuaries will open their shells during flood tides when oceanic waters are moving into the estuarine or riverine environment. During such periods the animals actively feed, aerate themselves and may even carry on reproduction and other activities. However, when the tide turns and begins to ebb and the fresh riverine or low salinity estuarine waters begin to flow over the animals the animals are able to detect such changes and immediately close and seal their shells for the period when unsatisfactory salinity levels are present.

During high tide, depending upon the season oceanic temperatures of the Middle Atlantic States may range between 0^{o} and 24^{o}C. Animals within the intertidal or littoral zone, are exposed during low tide. On sunny days the temperatures on the surface of the rocks may rapidly increase to over 30^{o}C. Such temperatures might be lethal to animals such as limpets and snails. Such animals may crawl into crevices or beneath large pieces of kelp where they can remain and with normal evaporation rates and lower temperatures may maintain themselves.

Many animals such as the squids and octopuses have complex behavioral patterns which are equivalent to the higher vertebrates. They have complex eyes and scientists have only just discovered that they respond to visual signals.

Many animals respond to the presence of pollution. Salmon and other fish can detect heavy metals and other toxic substances that exist in streams entering the ocean when such substances are present in amounts as small as one or two parts per billion. Crabs and lobsters are capable of detecting petroleum at even smaller amounts or levels within an environment. A few parts per trillion of petroleum products can be sensed by a crab

Animals that live on the sea floor are able to detect and respond to other forms of environmental perturbation such as increased suspended materials. Where considerable tidal currents or wave action exist, animals can detect such increases which might carry increased sediment loads or increased amounts of suspended substances. When a particular animal detects this increased amount of material which might bury it or could become encrusted on its gills or other essential body structures, the animal can burrow below the surface, move into the water column, move away from the current, or if it has shells and valves, close these so that the increased sediment loads will not interfere with its activites in a lethal fashion.

7. Diversity of Species

There are a number of different types of bottom dwelling invertebrates. These range from forms such as sea anemones which attach themselves permanently to hard surfaces or live in tubes, to the larger crustaceans such as crabs and lobsters which are extremely active predators. A student or observer of natural history might find, as he/she walks along a seashore or explores the pilings and breakwaters that are characteristic of many environments in the New York metropolitan area, a large variety of bottom invertebrates.

Coelenterates

The coelenterates include rather simple animals which are characterized by having stinging cells. The sea anemones are among the larger attached coelenterates and are often as the name implies extremely colorful, beautiful organisms. The anemones range in size from less than 1 millimeter in diameter to giant sea anemones which may be over a foot in diameter and fully extended measure over a meter in length They generally consist of a column which is attached to a hard surface and a "head end" which is surrounded by a ring of tentacles used to capture food. A group of coelenterates closely related to the sea anemones includes the corals. In corals, the simple column-like animal is surrounded by a secreted layer of calcareous material.

Within the more northern waters there are small coralline forms that are usually present as solitary corals. Hydroids are usually tiny organisms less than a millimeter in diameter but exist in tree-like forms which comprise a colony. Often there is a single attachment and a stalk which branches repeatedly. At the end of each branch, the small animal is encased in part of the branch or stalk. Sometimes there are hundreds or even thousands of individuals within a colony of hydroids.

The coelenterates also include animals such as the Portugese man of war. These animals drift in the plankton and often times may be extremely large and their stinging cells may be very toxic. The Portugese man of war consists of an air sac and a series of tentacles which may dangle many meters down into the water to entrap unsuspecting fish which come in contact with their tentacles. The same is true for medusoid-like animals which are shaped like saucers and may be up to one meter or more in diameter.

Related to the coelenterates are the ctenophores or sea walnuts. These organisms do not have stinging cells but have a wide variety of other mechanisms for capturing the planktonic organisms upon which they feed.

Polychaete Worms

The polychaete worms are an extremely diverse group. They are all vermiforme or worm-like. Some form tubes of a parchment-like nature. Others form calcareous tubes which would be attached to hard surfaces. These can be either suspension or deposit feeders. Certain of the polychaetes are active carnivores and spend their life moving through the surface layers of sediment capturing other worms or small marine life. Some of these worms have large tooth-like structures that can suddenly be everted to grasp and seize prey. Polychaete worms range in size from one millimeter in length to the large nereid worms which may be over one meter in length to two or three centimeters in diameter. The nereid worms frequently have large tooth-like structures and are easily capable of nipping the unsuspecting collector's fingers, however, the wounds are rarely serious.

Because of their soft bodies, the polychaete worms are favorites for many of the bottom living finfish. In the tropics certain forms have long spines which when touched cause a stinging or firey sensation. The polychaete worms, in general, are characterized by lateral appendages each of which contains a small bundle of spine. These spines normally are not toxic or injurious in any way. Toxic forms are often brightly colored and conspicuous. One would wonder why they are not easily fed upon by reef dwelling fish. Quite obviously, unsuspecting fish which grasp such a worm have an immediate response to the toxic spines and thus avoid feeding on such worms in the future.

Molluscs

The molluscs or shelled organisms occur in a wide range of forms such as snails, clams and mussels, the cephalopods (squids and octopuses), and chitons.

The snail-like animals are generally relegated to a group called gastropods. This group includes the snails, limpets, abalones, and other forms generally having a single shell which may often be spiraled into a turban-like structure. The gastropods occupy a wide range of ecological niches. Some forms, for instance, the limpets have a tongue-like structure which can be used to scrape algae off the surface of rocks and other hard structures. This is ingested as food. The cone snails have a long tongue-like structure that can be suddenly extruded and which contains a small dart or harpoon-like structure can penetrate the tissues of a fish and even a man's finger. A toxic substance associated with the cones many even be lethal to man. These snails are often colorful and common in tropical reefs. They crawl over the surface of the reef feeding upon worms, fish and other large prey. Sometimes the prey is two or three times as large as the snail, and the snail's mouth can be extended and expanded to envelope the very large prey which is slowly ingested and digested as it is moving into the animal's mouth.

The bivalve mollusc is characterized by having two shells which are attached to a hinge and can be opened and closed. These include mussels, clams, oysters, and scallops. Among the shellfish, bivavles are the most important commercially. Oysters are widely harvested and eaten in the United States and mussels and cockles are widely consumed in Europe, especially in the Mediterranean countries.

Generally, bivalves are suspension feeders. Some, however, are deposit feeders and these include animals belonging to the genus Macoma. The Macoma clams use their siphons as vacuum cleaners and the tip of the siphon is applied to the sediment surface where through ciliary action water and the detritus from the surface are drawn into the body or mantle cavity and carried to the mouth. Another interesting group of bivalves found in northern Europe and in certain tropical environments includes the genus Lima. These bivalves have tissues that look like the tentacles of the sea anemone.

The tentacles are sticky and have cilia to entrap materials suspended in the water.

Some groups of bivalves spend their life in burrows in the sediment, while other forms such as the oysters are attached to solid surfaces, oyster or clam shells. A few bivalves are quite active including the scallops. In their early life history, scallops, like mussels, are attached to pebbles and hard substrates by fine threads called byssal threads. While the mussels remain so attached throughout their lives, scallops are capable of limited motion above the sediment by rapidly opening and closing the shells, thus seeming to swim throught the water.

Cephalopods

The octopus and squid are among the more highly developed of the invertebrates. They have a complex camera-type eye similar to fish and vertebrates and a very highly developed central nervous system which allowed them to swim rapidly and to pursue aggressively their prey whether it be at the sediment-water interface or the water column.

Chitons

This group of molluscs is commonly found in intertidal environments, especially on hard rocky surfaces, on the west coast of the United States and along certain portions of the eastern seaboard. On the west coast, one species grows to be over a half meter in length. The chitons on the east coast grow only a few millimeters in length and are often quite inconspicuous. Chitons are characterized by having a series of plates or valves arranged linearly along the dorsal surface.

Crustaceans

The crustaceans range from small planktonic forms such as the copepods which are rarely over a millimeter or two in length to the large lobsters characteristic of the coastline off Maine and southward to the Carolinas. There are several forms of lobsters. The North American lobster commonly known to people living in New England and the middle Atlantic states has powerful crushing claws capable of breaking open the hardest of shells and thus allowing them to feed on clams, snails, and other shelled organisms. Tropical lobsters lack claws and have long whip-like antennae. These antennae are often spined and can inflict serious injury to the unsuspecting collector or to prey such as finfish on which it feeds.

Crustaceans are organisms having an exoskeleton. By undergoing periodic growth moults, the animal sheds its outer shell and increases rapidly in size. The new shell is finally rehardened due to the deposition of calcareous materials.

Copepods are tiny crustaceans which feed upon single-celled plants and phytoplankton. Many species of copepods live in association with the benthic environment. In some cases, they may become parasitic, that is, they live upon or in the tissues of their organisms or they may become commensal and simply so-exist with another species of marine organism.

Amphipods and isopods are found in association with bottom sediments in almost all ecological situations. Certain amphipods are adapted to the wave swept sandy coastline of the Rockaways, Sandy Hook and the New Jersey beaches. Others live in tubes and feed in ways similar to the tube-dwelling worms or other sessile organisms. Shrimp-like in appearance, amphipods tend to be flattened sideways whereas the isopods which are less abundant are flattened dorso-ventrally. The so-called sowbug, a terrestrial isopod, is one of the few crustaceans found living outside an aquatic environment.

Both amphipods and isopods are extremely important as food for marine fish, especially the early developmental stages of demersal bottom-dwelling species. Amphipods are also sensitive to petroleum and other forms of pollution, hence, they are good indicators of water quality.

Most of us have only seen the large tail or abdomen of shrimp that we find in our shrimp cocktails. Actually shrimps resemble lobsters with their weakly developed claws used for grasping items. Often occurring in dense populations, they are harvested by commercial fishermen by trawling nets over the surface of the sea bottom. Coming in a variety of sizes, they are regarded as a tasty, luxury food for human consumption. Obviously, they are also important in the food chain of other marine organisms.

Crabs, a type of crustacean, range from tiny commensal or parasitic forms which live inside clams, tunicates, and other marine organisms to the large cancroid crabs such as the Dungeness crab found on the west coast of the U.S. A peculiar type, called box crabs, has a large carapace which covers the crabs appendages and looks like a simple rock or outcropping of a flat surface. The hermit crab, which lives inside the shells of dead snails, is not a true crab. It has only four paired walking appendages including the large claws. True crabs always have a total of five paired appendages.

On the west coast, crabs are extremely important for commercial use and on the east coast, the blue crab is paramount among seafoods. The blue crab belongs to the group called swimming or portunid crabs. It is extremely active and aggressive, and developes from the larva to the full adult size in two years. On the east coast, the blue crab populations vary from extremely dense, providing good commercial and recreational harvesting to low density and low yields to commercial or recreational harvesters.

Crabs are extremely important in the marine food chain for larger species of fish and the small dogfish or bottom-feeding sharks. In turn, they prey on shellfish and worms and thus are important to the total food chain. The reproductive behavior of the hermit crab, and fiddler crab, is being studied to understand how lower animals locate each other, reproduce and carry out other functions.

Students of marine biology during their first field trips to the shoreline are often surprised to find that barnacles are actually crustaceans. When they reproduce, the eggs hatch into small larvae like other crustaceans such as shrimp, crabs, and certain lobsters. This naupiler larval stage identifies barnacles as true crustaceans. As the larvae moult into progressively larger individuals, they finally settle to the bottom, attach themselves by a pair of adhesive glands, and develop a hard outer calcareous shell.

Barnacles are important economically for their tendency to attach themselves to hard objects, including piers and hulls of vessels. When this occurs in large numbers, they weigh down the vessels and interfere with the smooth flow of the hull through the water. The scraping of barnacles from vessel hulls is a well known exercise to individuals who have pursued a nautical life.

The echinoderms are the spiny skinned animals such as seastars, sea urchins, brittle stars, and sea cucumbers. In many environments, their pigmentation and vivid colors make them more conspicuous than other marine life. On the west coast of the U.S., there are over a dozen species of seastars, some over a meter in diameter, and some highly pigmented with reds, oranges, and yellows.

Seastars are voracious predators which move about on a series of tube feet. These tube feet can extend themselves, attach to a surface and contract, thus drawing the seastar over the sea floor. They can also attach themselves to the shells of certain clams and other invertebrates and open the shell by continuous contractions. The seastar's stomach averts through the mouth and digests the clam tissues with its powerful enzymes.

Sea urchins are the round or disc shaped organisms common in intertidal environments throughout the world. Certain species are also found in the very deep waters of the abyssal zone. Sea urchins have long spiny attachments for protection and locomotion. The spines, manipulated in unison, move the urchins over the sea floor. For food, urchins scrape algae and other organisms off of rock surfaces. Their eggs and larvae are frequently used in embryological research because temperature changes or the injection of certain chemicals can induce urchins to spawn eggs and sperm artificially.

Brittle stars are very fragile, small, marine animals with long arms or rays. When picked up or otherwise handled, the tips or even an entire arm breaks free, and the remaining part of the animal scurries off to try and protect itself in a crevice or hole. The brittle stars are foragers which eat organic debris found on the sediment surface.

Sea cucumbers, recognized as echinoderms, look like large worms. The sea cucumbers of the Pacific are harvested by Chinese and Japanese for their long edible muscle bands. Soft bodied, they are often found nestled in cracks or crevices in intertidal and sublittoral environments. Although they are less colorful than seastars or sea urchins, they frequently have long tentacles which can be extended from the mouth and used to collect suspended materials from the water.

Other species are extremely important to the ecology of the marine environment. Bryozoans are small colonial organisms which form dense sheets on rocky surfaces, pilings, or other wooden structures. The bryozoans occupy a similar ecological niche to the corals and hydroids. Usually their colonies are not branching, but form a single layer of calcified or uncalcified individual polyps. Like the barnacles, the bryozoans often encrust the hulls of vessels, thus interferring with their speed and navigability. Although they are protected by their little armor encasements, they can still be fed upon by seastars and organisms capable of rasping them off hard surfaces.

Tunicates exist as solitary individuals or as complex social or colonial assemblages. Each tunicate consists of a body with two holes to a sac-like stomach. One hole is the incurrent hole or siphon into which water flows. A screen-like structure filters out food and cilia then carry the food to the stomach. The water then flows out of the second opening of the body called the excurrent siphon. Tunicates are fouling organisms frequently found on hard rocky outcroppings, ship hulls, piers and other structures which man is interested in for economic reasons.

Bottom-living fish such as the flounders, cod and certain sea bass are extremely important in the functioning of the benthic community. Fishery biologists study demersal fish of themselves with little concern for the associated benthic forms, while benthic ecologists study only the invertebrate animals that form the so-called benthic community. But, it is most important to recognize the complex feeding interactions between the various benthic invertebrates and demersal fish.

Demersal fish include not only the bony fish just mentioned, but also bottom-feeding sharks such as the angel shark and the dogfish. Most bottom-feeding fish are capable of directly ingestomg bottom organisms such as worms; and those species which have complex jaw formations can crush shelled organisms such as barnacles and mussels and ingest the soft parts.

Algae include a wide range of plant-like organisms. Algal cells contain chlorophyll which makes photosynthesis, the single biological function that allows life to exist, possible. In photosynthesis, plant cells utilize sunlight, carbon dioxide and water to produce sugar like materials which form the nutrients of the plant cells themselves. Plants, in turn, are fed upon by animal life, and thus we have the beginning of a food chain. Animals which feed on algae are called herbivores, while those animals which feed upon animal life are called carnivores. In some cases, however, it is hard to draw clear lines between these various feeding types. For instance, some marine animals are omnivores, that is, they feed on both plants and animals, while other species feed on single-celled plants and zooplankton during their early stages and on animal life during later life stages.

Aquatic plants are important to benthic communities. Kelp, classified as an algae, may grow up to 20 or 30 meters in length off of the southern California coast. There, they form dense forests which provide habitats for specialized fish life as well as for associated benthic organisms. Thus, algae can range from single-celled plants forming the phytoplankton to large and in providing habitats for benthic organisms.

Symbiotic Realtions

Many different kinds of relationships exist between benthic organisms. These range from the parasitic relationships of worms that live within the bodies of other organisms, to complex interrelationships in which single-celled algae live in association with other organisms. A group of worms referred to as the nematodes may be either free-living or parasitic within the body tissues of fish and various invertebrates. Pea crabs have a peculiar life cycle in which the adult crab lives within a mussel or tunicate and produces a larval stage which lives freely in the water. Eventually, the zooea larvae moults into a true crab which must find a host in which to live. The crab picks off food from the gill tissues of clams and mussels and uses this for food. The giant Tridacna clam found in the South Pacific has algae associated with its mantle. These algae exist within the tissue of the clam but are exposed to sunlight in tropical waters when the clam is opened. The algae carry on photosynthesis, and the foodstuffs produced by the algae are used in the nutrition of these giant clams.

There are also complex associations between corals and other species of single-celled algae. Some algae produce calcareous exoskeletons which become intermingled with coral animals, thus adding to the solidification of tropical reefs. In many instances, the corals and algae cannot exist independent of one another. There are literally hundreds of symbiotic relations in the marine environment, and fore-going represent only a few.

Throughout the world there are different types of benthic community structure. on the shores of Denmark, you would find certain species characteristic of muddy bottoms of Denmark. Similar type communities could be found in parts of Australia or off the east coast of North America and Puget Sound. We call these parallel communities. Within each of these similar communities, there seem to be certain ecological niches which are filled by a particular species. In almost all of these environments, there would be crab species which act as carnivores and predators on certain species of small clams which live inside the sediment. There would also be worms in each of the communities.

When soft mud communities are compared with sandy hard bottom communities, there are differences in community structures.

Off of New Jersey, for example, where the sand bottoms undergo considerable stress due to wave action, animal species are quite different from those found in mud bottom communities in offshore waters of 30 to several hundred meters in depth. However, the species of the New Jersey shoreline are similar to those off the California coastline on the west coast of the U.S.

In recent years, scientists have combined the numbers of individuals of each species by mathematical formula to arrive at an index of diversity. When the average index of diversity changes, it indicates an environmental change. In temperate waters, such environmental changes can be seasonal, that is, when water temperatures drop during the winter certain species common in the summer become relatively inconspicuous. Other changes are of a longer term. For instance, in recent decades water temperatures have been declining somewhat each year. Thus, the reproduction and survival of lobsters in more northern waters off of North America have been affected and the lobster populations seem to be shifting to the more southern waters as temperatures decline. Such temporal and spatial shifts in the relative abundance of various benthic species can be identified by using these diversity indices.

The Benthos as Indicators of Environmental Pollution Degradation

Just as diversity indices can be used to note changes in the "natural" environment, so can changes in diversity and other characteristics of benthic community structure be used to indicate the effects of pollution due to man's activities. Planktonic communities change constantly, and are swept from one are to another by water currents. A population sample today may not be at all the same the following day because the entire population of plankton or pelagic species has changed due to water currents carrying them away or new fish species moving in. On the other hand, benthic communities tend to "stay in place". Thus, it is possible to measure the benthic community structure as well as physiological responses of benthic organisms in a particular area and to use the resulting data as "baselines". If these baselines are measured with sufficient frequency throughout long periods, then these baseline changes can be used as indicators of environmental change. If changes in benthic community structure are associated with increases in pollutants such as petroleum, PCBs, increased temperatures, then such changes can be attributed to man-induced pollution and stressful activities.

Measurements of the effects of pollution have been carried out increasingly for two or three decades. Initially, such measurements involve counting the number of species and individuals present. This data is then used to calculate diversity indices and other statistical parameters. In recent years, many new shampling techniques have been introduced to determine the well-being of benthic organisms.

Sampling the Environment

The early benthic ecologist simply used dredges or grab samplers (small devices much like steam shovels) that could be lowered into the water to obtain a sample of the sea bottom.

The mud from the sea bottom is brought to the surface and washed through screens. Then the animals were collected, examined alive or placed into containers and relaxed with some anesthetic, and then permanently preserved in formalin or alcohol. Such bottled samples could be returned to the laboratory where they were counted, measured and analyzed for a variety of environmental variables.

Today study methods of benthic communities have changed greatly. In many cases, physiologists accompany the benthic ecologist. They place the animal samples in special chambers which measure their respiration or metabolism. Other scientists remove blood and tissue samples for complex analyses involving the activity of enzymes. The enzyme levels generally indicate the degree of stress due to man's activities or pollutant released into the waters.

Other scientists study the genetic make up of the eggs and larvae of marine benthic organisms. If changes in environmental quality affect the chromosomes within the eggs, these changes can be identified by studying the eggs under conventional light and electron microscopes. Thus, to study the entire field of benthic ecology, there is a need for scientists trained in physiology, chemistry, behavior, genetics and many other fields other than ecology and general biology. Undoubtedly, in the future even more sophisticated techniques well be developed which will enable greater understanding of benthic communities.

POLLUTION AND MARINE RESOURCES

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Introduction

The impact of man on the marine environment has received ever increasing attention during the past few years. As the quality and quantity of various marine resources dwindle, this trend will probably continue. The technical journals are full of reports of various studies on the effects of pollutants on marine resources. Despite all of these studies and the increased awareness of the general public, it seems like we are still losing ground. Indeed, after spending many millions to clean up the Hudson, it is now closed to some fisheries. 1979 saw the world's largest oil spill in the Gulf of Mexico which caused economic disaster to the tourist trade in that area, half of San Francisco Bay is now being closed to fishing and swimming because of sewage treatment plant malfunctions, and the list could go on. With more efficient ways to harvest various marine resources and more people using the shore areas for recreational purposes, it is imperative that we take a more vigilant attitude in protecting these habitats. We will look at the various types and sources of pollution and then the effects of these pollutants on marine resources.

Types and Sources

Pollution sources can be regarded from two points of view: one, the volume and the other, the concentration or amount of pollutants contained in that volume. One way to measure the strength of organic wastes is the biological oxygen demand tests (BOD). This test measures the amount of oxygen used by bacteria in oxidizing the organic material in the waste. Tests to measure the concentration of toxic wastes, such as metals and pesticides, are often done by the bioassay method. Various dilutions of the wastes are used and their effects on certain aquatic organisms are observed. By doing the same tests with standard solutions, an estimate can be made for the concentration in the waste sample.

Until about 10-15 years ago, the main source of aquatic pollution was sanitary or domestic wastes. These are wastes generated by our daily activities and originate in our kitchens, bathrooms, and office buildings. These wastes are organic in nature, very dilute (high volume, low strength) and often containing only about 300 mg of pollutants per liter of wastes. Sanitary wastes are rather easy to treat. Most modern treatment plants can remove about 80 to 90 per cent of the pollutants if the plant is run properly and not overloaded. The latter effect is quite common. As more homes and apartment buildings are built and are hooked into the system, the design capacity of the plant can be exceeded. A further problem in treating sanitary wastes is the disposal of the sewage sludge. Disposal at sea is common but has created biological deserts around the disposal site. By law, this type of disposal should end over the next few years.

In the last 10 years or so, wastes, originating from various industrial processes are getting more attention. Many of them have been around for a long time but were neglected. Most of them can be considered as low volume, high concentration sources. Industrial wastes are very diverse in composition and most are difficult and expensive to treat. An approach to dealing with industrial pollution is first to try to change the in-plant process to reduce the amount or concentration of the pollutants. The metal finishing industry contributes various metals, such as silver, gold, chromium and copper as well as organic solvents of which many are highly toxic. The effluents are sometimes discharged directly into receiving waters or are hooked up into sanitary sewer lines. In the latter case, they often interfere with the treatment of the wastes the sewer lines carry. A further difficulty with plating wastes is that they often originate from one man operations, as in the jewelry and clothing industry. These operations are often very small and it is more expedient to dump a spent plating solution into a sink than to send it to a treatment plant.

Food processing is still another source of a low volume, high concentration (BOD) waste. The wastes come from spillage and clean-up in the brewing, canning and bottling operations of various foods. Treatment of these wastes is somewhat like the treatment of sanitary wastes, that is by biological methods. Problems do arise in many plants in that the flows are very variable during the course of a day as most plants are not a 24-hour operation. The pollutants removed can often be used as animal feeds. The petroleum industry has had an ever increasing impact during recent times on many coastal areas. Malfunctioning of drilling wells, mishaps to tankers and discharges from processing plants are the main sources of these pollutants. As we build larger and larger tankers and erect more and more wells, pollution from the petroleum industry seems to be getting worse. Indeed, as mentioned earlier, 1979 saw the world's largest oil spill in the Gulf of Mexico. Separation of oil from water in process effluents is usually done by skimming or centrifuging. Cleaning up of oil spills is done by: 1) the addition of absorbants and collecting them and the absorbed oil, or 2) by dispersing the oil with chemical dispersants. The latter method may do more harm than good as it does not remove this oil, but only disperses the oil in the water column making it available to many filter-feeding organisms. In any case, the more toxic components of petroleum products are much more soluble than the remaining components which are the materials that are usually cleaned up.

Coastal waters are being used more as a cooling agent for power plants. Water is pumped through power plants and its temperature is increased by about 10 degrees before being discharged into receiving waters. The volume is sometimes enormous;

1.5 million gallons per minute are pumped by some plants. Cooling towers can be used but are very expensive and pose aesthetic problems. As we pave more of our coastal areas for roads and parking fields, we provide less area for infiltration, and thus surface runoff is increased. Runoff contains all kinds of pollutants, including relatively large amounts of lead, petroleum and sediments. Filtration through marsh areas or recharge basins does help in lessening the amount of pollutants that reach the receiving waters.

Dredging may not only destroy the area dredged, but also the area where the spoil is deposited. Most dredging projects are designed to deepen shipping channels into harbors of large cities. These sediments act as a trap for many kinds of pollutants which are prevalent around highly urbanized areas. Dredging often agitates the sediments releasing pollutants to the water column. Placing of such sediments in biological productive areas can make the area uninhabitable for many species of organisms. While man is trying to solve one problem, he sometimes creates others. Such is the case of trying to control mosquitos and other insects which inhabit our salt marshes. Long-lived pesticides such as DDT were spread by airplane over many of our beaches and marshes. These pesticides have half-lives of about 10 to 15 years and have caused biological problems to many kinds of organisms other than the ones intended.

Effects

The effects of the above pollutants on marine resources can easily be seen in endless ways. They can, however, be classified into three categories: health, biological and aesthetic. The bottom line on all three is economic with millions of dollars lost each year because of the degradation of marine habitats. Some pollutants may fall into more than one category, while others may in one case cause degradation and in another could be tolerable. For example, a large nutrient input could cause excessive algal growths which in turn cause biological problems. However, excessive algal growths could be considered beneficial in systems where herbivorous fish are grown. Small amounts of raw sewage may not be acceptable in small estuaries, but discharge into the ocean would be because of dilution.

Discharging raw sewage or effluents from sewage treatment plants that do not chlorinate can release large numbers of many species of bacteria into the receiving waters. Most species are harmless but others can cause various health problems. The group of bacteria used to detect sewage pollution are know as the coliform group. They themselves are harmless but are easily tested for and are found in association with raw sewage. An assumption is made that there is a ratio between the coliforms present to disease-causing organisms present. Therefore, coliform concentrations can be used as a criterion to close areas for shellfishing or water contact sports. The economic loss of such actions are obvious. Hotels, restaurants and various vendors all do a reduced business around resort areas when beaches become fouled. Shellfish are filter-feeding animals and can concentrate large amounts of bacteria from the surrounding waters. Shellfish from bacterially polluted areas can be transplanted into clean water and after 30 days can be harvested. This does entail an added cost for manpower and operational boats. Areas where sewage sludge is dumped may also be subject to the above conditions as well as others. Finfish caught in sludge dump areas often suffer from finrot. Fins develop sores and sometimes parts of a fin may fall off. Energy is expended by the affected fish in combating the disease instead of going into growth or gonad production. Needless to say no one would buy or eat a fish suffering from finrot.

Nutrients, such as compounds of nitrogen and phosphorus, are needed in any body of water to support plant (algae) growth which in turn provides food for the grazing animals. Problems arise where the nutrients are of such a quantity that excessive plant growth occurs. A body of water in such a state is said to be eutrophic. Nutrients can come from sewage treatment plant effluents, dumping of sewage sludge and surface runoff, amongst others. Dredging can supply nutrients to the water column in the area of dredging or by runoff if the material dredged is placed along the shore of a body of water. No one likes to go swimming in water that has a pea soup appearance. Similarly, fishermen quickly abandon an area where their lines get fouled by filamentous algae. Both of these activities while recreational in nature are actually a multi-million dollar business. Many charter boats have never left the dock and motel rooms have remained empty because of excessive algae growths. Eutrophic bodies of water often have conditions that directly affect the organisms that live in it. When the nutrients present are not in the correct ratio, species of algae may grow that can not be or are poorly metabolized by the grazing animals. This results in poor growth or their filtering apparatus can get clogged which can result in death to some filter-feeding animals. The dissovled oxygen balance is often upset in waters with large plant growths. Aquatic plants like land plants produce oxygen as they grow (photosynthesis). Eutrophic waters often have very high oxygen concentrations during daylight hours. However, as these plants die, bacteria quickly consume the oxygen during the decaying process and cause oxygen levels to fall to such low levels that fish, crabs, shellfish, etc. suffocate and die.

When hydrocarbons (crude oil, gasoline, tars, etc.) find their way into the marine environment, several things can happen. Being lighter than sea water most hydrocarbons float, while some dissolve and others volatilize into the air. Wave action can cause an oil-sediment emulsion which may be heavier than the surrounding water and therefore would sink. Lastly, the hydrocarbons due to tidal or wind action can be deposited along the shore. Wherever deposited, certain species of bacteria will degrade and metabolize the material. This is a very slow process.

Many sea and shore birds have been lost because of oil spills. The mechanism is by either ingesting oil particles or by getting their feathers fouled. Apparently, some fish-eating birds mistake small particles of oil for fish or crustaceans and ingest the particles while feeding. Landing in an oil slick disrupts the functions of the feathers in protecting the bird from cold and water. Cleaning oiled birds with various solvents is a very costly and laborious task with the rate of success being very low. The dissolved fraction, which is usually the more toxic fraction, finds its way into many pelagic and benthic organisms. At worst, the organism can be poisoned or their gills can become clogged, and they die. Lower concentrations can produce an off-taste flavor or color to shellfish and finfish, making them less desirable at the market place. Unfortunately, such contaminated organisms retain their off-flavor for years after the oil has disappeared.

Slicks deposited along the shore smother and kill most of the organisms beneath it. The various sea grasses, which provide the base of many food chains, can easily be wiped out by deposited petroleum products. Such deposits have half-lives of many years. Therefore recolonization of such areas is a long term process. Oil deposited on beaches located in resort areas has obvious detrimental economic effects. Clean-up of such areas is by physical means such as by bulldozing and hand labor which is very costly.

Lastly, man has impinged upon the marine environment in many ways that at first glance may not be apparent. Such acts are often committed for the convenience of man. Industrial effluents even when treated are allowed to be discharged into surface waters. Concentrations in these effluents may be small, but certain pollutants such as metals do build up over the years. Copper is toxic to lobsters in concentrations of only a few mg/l and such concentrations are easily attained in many areas receiving industrial effluents. It is very convenient to have pipes to carry storm waters from highways and parking fields to our shore areas. Such runoff contains large amounts of lead, detergents from washing cars and assorted debris that wind up on our highways. Such sources are many times very localized and may affect organisms in a small area. However, as we build larger parking fields and roadways around our shores, the problem may get worse.

The use of pesticides to control mosquitos and other insects on our marshlands proved to be a disaster in the past. Most pesticides are broad-based, that is they kill many non-target organisms. Many pesticides do magnify as they progress through the food chain. At the upper levels of the food chain, various biological effects occur. For example, ospreys (fish hawks) after eating DDT-contaminated fish lay eggs with very thin shells that break during incubation. Fortunately, many of the pesticides used in the past have now been replaced by ones that have very short half-lives. Also, new pesticide regulations provide for stricter control of uses and types of pesticides.

Summary

Because the coastal areas of the U.S. are getting increased usage by man, it is imperative that we impose stricter control on the types and number of activities allowed. Uncontrolled use will not only ruin such habitats for wildlife but for man himself. The use of our marshlands and shore areas for dumping grounds for solid wastes or sewage sludge, bulkheading for larger marinas, paving for parking fields, etc., must be phased out over the next few years. If not, our beaches will be continuously fouled and our wildlife will gradually disappear with concurrent high economic losses. Fortunately, recent tidal wetland laws and management programs for marine areas at several levels of government should go a long way in protection of the very valuable resources located in our marine ecosystems.

You and the New York City Waterfront Revival

by Linda O'Dierno, Sea Grant Specialist in New York City

Historically, the waterfront has been the key to New York City's growth and prosperity. Our city boasts 578 miles of coastline which includes 14 bays, five rivers, two straits, and a large sound. The construction of the Erie Canal in the 1820's joined the city's magnificent harbor to the heartland of the country, and the economy skyrocketed.

History and the Waterfront

Although time and technology have made rapid advances, New York's port has lagged behind. Piers were designed for break bulk shipping, but what was feasible in the 1940's and '50s no longer works today, and so facilities are now in desrepair. Jobs have moved away from the waterfront and into the inner city. With the advent of containerization, shipping has moved out of the hub of the city to fringe areas, namely Brooklyn, Staten Island, Hoboken, Port Newark, Jersey City and Elizabeth, which are less congested and closer to rail lines and highways, and where overhead costs are lower.

As the cost of break bulk shipping from New York has increased, piers have been abandoned only to become popular sites for arson. Gone are the days of luxury liners when public figures and Hollywood stars, returning from European holidays, added a feeling of glamour and romance to New York's waterfront. Now people are preoccupied with getting from here to there in a hurry, and transatlantic travel has become mundane.

Although Manhattan has only two working finger-piers, 160,000 jobs depend directly on shipping. These include occupations such as insurance agent and freight forwarder. The 60 million long tons of cargo that pass through the Port of New York/New Jersey constitute 16 percent, an estimate $32 billion in revenue per year, of all commercial activity in the city.

Not only are New Yorkers confronted with a series of deteriorating piers, but they also cut off from their waterfront by a ribbon of highways that line 30 percent of the shoreline. Twenty-four bridges and four tunnels link the archipelago that makes up New York City to the mainland of North America.

In 1933, New York City had one mile of public beach. Today, there are 18 miles of public beach, and 64 waterfront parks that cover 84 miles of coast. Twelve miles of beach are currently swimmable. This rapid expansion far outstrips the city's ability to maintain facilities, and so many have fallen into despair. Some sites have been adopted and restored by local citizen's groups. The East River Park Ampitheatre Restoration Committee, for example, has succeeded in securing city funds for a design study of the East River Park area and private funds for a feasibility study to investigate the possibility of a food concession in the park.

In recent decades, many undesirable activities have been assigned to the waterfront. The city's two major airports take up 11 percent of the waterfront. Twenty electric power generating plants are located at the waters edge because of the ready supply of water so necessary for cooling operations. Thirteen water pollution control plants, nine refuse landfills, 10 marine transfer stations, 80 tank farms, and four incinerators line the waterfront. In the mid-sixties when the Port Authority adapted its facilities for containerization, the city continued to invest in break bulk piers. Now abandoned, these piers serve as parking lots, heliports, and indoor tennis courts. If a car is towed away by the police department, it goes to Pier 76. And even though many piers stand as potential fire hazards, New Yorkers, craving a little sun on a summer day, flock to them, complete with lawn chairs, sun reflectors, and the New York Times.

Over the years, the building of piers, airports, power plants etc. has meant one thing: the city's wetlands which originally served as natural filters and allowed the environment to cleanse itself gradually were filled. Plants which normally took up pollutants from the water and used them as nutrients disappeared.

Today, some wetlands are slowly reverting back to their natural condition. The Gateway National Recreation Area, a wetland in Brooklyn, Queens and Staten Island, is a good example of this effort to set aside an area for protection as well as public education and recreation. Without such an effort, the area would have become a dumping ground. A group of students from John Dewey High School began an erosion control project which included the planting of beach grass and the strategic placement of old Christmas trees to stabilize the dunes at one of Gateway's Brooklyn sites. Their work has had a remarkable impact in the environment.

Impact of the Federal Coastal Zone Management Act on New York's Waterfront

The Federal Coastal Zone Management Act of 1972 encourages all government levels to work towards protecting land and water resources while promoting economic development at the same time. General issues to be addressed under this act include: aesthetics, air quality, economic development, energy development, fish and wildlife, flooding and erosion, impacts of Outer Continental Shelf development, public access, recreation, solid waste and water quality.

Because of this and other similar legislation, many New Yorkers now see the development of the waterfront as the city's greatest resource. Recognizing this potential, Mayor Koch aims toward becoming the mayor who brought the waterfront back to the people. According to Koch and others, waterfront redevelopment will pay off in many ways. It will provide revenue for the city and jobs for its residents. The overall effect will be an improvement in the quality of life for the city.

Another important waterfront issue is the development of industry in the Outer Continental Shelf. New York's deep water access strategically located between the Baltimore Canyon and George's Bank make it a natural commercial center for the offshore oil and gas exploration taking place. Furthermore, its already established corporate headquarters, transportation, housing and schools, marine and energy industries make an increase in commercial activity less of a risk to its social, economic and environmental structure.

The City's 208 Plan

A second piece of legislation that is affecting the redevelopment of New York's waterfront is Section 208 of the Federal Clean Water Act of 1977 which brought about the city's 208 Plan. This plan is designed to improve the quality of water in New York Harbor and adjacent waterways by the year 2000. Because New York has a combined sewer system that handles both domestic wastes and storm runoff, water quality is an especially acute problem. During periods of heavy rainfall when the amount of water in the sewer system increases, flood gates are opened to allow both treated and untreated sewage to empty into surrounding waters. This discharge of both treated and untreated sewage is a major pollution problem in the city. However, other pollution problems such as industrial discharges, oil spills, and leachate runoff from landfill sites must not be ignored.

In order to deal with these problems, the city's 208 Plan calls for: the upgrading of the Coney Island and Owl's Head Water Pollution Control Plants to a secondary treatment level; the completion of construction of the Red Hook and North River Water Pollution Control Plants; the rehabilitation of the Newtown Creek Water Pollution Control Plant; the disinfection of all water pollution control plant discharges during the summer, and year-round where shellfishing is to be protected; and improvements in sewer maintenance.

To carry out this plan, it will be necessary to provide for secondary sewage treatment. This process includes aeration of organic matter to allow bacteria to build up around the matter and to combine individual particles into clusters. Once the bacteria either consumes or converts the organic matter into simpler, stable compounds, the remains are then moved to a final settling tank where most of the suspended solids settle and form a sludge which is removed from the tank for disposal. The plan also proposes the need to control industrial wastes discharged into the sewer system by developing a pretreatment program for heavy metals and toxic substances.

The Federal Clean Water Act allows a state to allocate four percent of its construction funds for innovative waste treatment methods. In some cities, treated sludge is being composted for use as a soil conditioner or fertilizer. In Chicago, for example, sludge is barged to strip-mined land where it is used as a fertilizer in the growth of corn, soy beans, and wheat. Heat-dried sludge is being marketed by the Milwaukee Sewerage Commission under the trade name "Milorganite" for use as a soil conditioner. Presently, because of the high concentration of industrial contaminants in New York City's sludge, composting is not a suitable method of disposal.

Governmental Agencies

Responsibility for the waterfront is shared by a number of governmental agencies. The Department of Ports and Terminals has primary responsibility for 500 parcels of land and receives an estimated revenue of $50 million per year. As New York's largest waterfront landlord, Ports and Terminals is responsible for issuing land use permits and enforcing these regulations. The Department of Environmental Protection handles the 208 Water Quality Management Program, and City Planning Department deals with engineering and planning aspects of waterfront redevelopment.

When a piece of waterfront property undergoes development, a number of issues must be considered, namely, public access, the amount of revenue returned to the city, and other economic benefits. When a property is marketed, criteria for the project is first developed. Private investors may seek technical assistance from governmental agencies. The River Cafe under the Brooklyn Bridge at Fulton Ferry, for example, is an excellent use of private investment for the general good of the city. Avoiding the necessity for landfill, underwater land is rented to a private concession. Public access is provided through a public park which the concessioner has agreed to maintain. The result has been increased traffic to the area, making the waterfront safer at night. The restaurant provides 144 jobs and $100,000 in revenue to the city yearly. Such usage allows for redevelopment of the waterfront without strapping the $3 million that has been set aside in the city's capital budget for waterfront improvement.

Sites for Future Redevelopment

A tour of the Manhattan waterfront includes a number of sites that have been and will be developed in the future. Some of these are:

- Battery Park at the southern tip of Manhattan Island. This area provides a noonday respite from the hectic pace of the financial district for thousands of New Yorkers. There are plans to develop a promenade that will link the Battery Maritime Building with South Street Seaport on the East River just south of the Brooklyn Bridge. Here, shops, restaurants, and exhibits help New Yorkers relive the history of sailing days. Federal and state grants will help this area develop to an even greater extent. Plans also call for landfill to open up a mile of waterfront for housing, offices, and shops.

- Fulton Fish Market area. Traveling north, we come to the Fulton Fish Market. To fully appreciate the market, it must be visited at 6 or 7 a.m. when activity is at its height. The market which has been situated here since the 1820's sells about 3.5 million pounds of fish and seafood every week. Most of the fish now arrives by truck, as trucks are faster and cheaper than boats. The only seafood delivered by water is salmon, which arrives by trawler from Long Island. Nearby is an area between the Brooklyn and Manhattan Bridges where the city is considering proposals for a marina development. Presently, this prime waterfront land is being used as a parking lot.

- Thirtieth Street. This site will soon become the home of Manhattan's first waterfront restaurant.

- Manhattan's Upper East Side. Now we come to Carl Schurz Park, the site of Gracie Mansion. Several years ago, a group of concerned citizens felt something should be done to help city children appreciate New York's maritime heritage. The group secured an old fireboathouse at 90th Street on the East River and converted it into a marine education center.

- Manhattan's West Side. Traveling to the west side of Manhattan, we come to the 79th Street Boat Basin, a public marina on the Hudson River. At 47th Street, a market is planned. Also on the west is the Port Authority's Passenger Ship Terminal leased from the city where there are berths for six ships. Further south, a private group, Odysseys in Flight, is hoping to convert the World War II carrier, Intrepid, into an aerospace and naval memorial museum.

- West Way Project. Another major project for the Hudson is Westway, a highway that would replace the old Westside Highway. The road would be built on 183 acres of landfill which would include 93 acres of waterfront park and 60 acres for housing and local services. It is hoped that the highway will boost the economy of westside businesses.

- Brooklyn Bridge area. On the Brooklyn side of the bridge is another old fireboathouse, now the home of the Maritime Historical Society Museum. Just north of this site is the Empire Stores, a 15-acre complex owned by New York State. The site boasts a landmark building that was constructed during the Civil War. Future plans include a maritime museum and hotel.

- Staten Island. Plans are underway to convert Staten Island's Sailor's Snug Harbor into a cultural center. The harbor was built as a home for retired seamen in 1833 by Robert Richard Randall, a sea captain and New York merchant. As costs have escalated, the city has assumed responsibility for this property which houses a series of Greek revival buildings.

Throughout the city, there are hundreds of sites, maybe not as splendid as Snug Harbor or as well situated as the East River fireboathouse, that would make excellent parks and waterfront facilities.

How to Get Involved?

The best way to become involved in your waterfront is to contact your local community planning board. There are 59 boards in the city, each assigned with the responsibility of studying waterfront development and securing funds from the city. Neighborhood organizations can also effect changes by developing community action plans and working with local industry.

Throughout the city, numerous streetends that border the waterfront offer the possibility of redevelopment. One, the Grand Street Streetend Park, was an experiment by the New York Parks Council to determine the feasibility of community-developed waterfront parks. The Williamsburg section of Brooklyn was chosen for the site of this experiment since the need for waterfront access in this crowded community was so urgent, and community organizations and schools were so eager to be involved. School children, community volunteers and Youth Corps workers started the neighborhood park that would meet the needs of the community and provide access to the river. Local industry pitched in with cash contributions. Governmental agencies assisted in the planning process. The finished product boasts several paths and a road that leads to the former Manhattan/Brooklyn ferry landing. An observation deck and a platform to view the harbor traffic also doubles as a stage for neighborhood concerts and shows. Seating provided by old barrels filled with concrete and a garden complete the landscape.

Throughout the city there are waterfront sites that are nc used for washing cars and dumping garbage. With a little community spirit, these sites could be come showplaces and morale boosters for the surrounding neighborhoods.

Remember its your waterfront and the time to get involved is now!

Barrier Island Dune Ecology: The Fragile Edge

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Barrier beaches, to those of us who live near the Atlantic shore, are the source of two clear and contrasting memories. The first comes from calm seas and sunny, warm days when it seemed as though everyone within 100 miles was crowded onto the ocean beach. The second is of the violent and destructive impact of a hurricane on the shore. Between these two beach images, lies a full range of experiences as diverse as those who go to the edge of the sea. Barrier beaches stand amid both our experiences and our attempts to develop a rational policy toward them.

In an effort to get closer to the joys of summer, people have built houses, cottages, beach clubs and condominiums at the water's edge, while hoping for an infrequent storm pattern. Although they have convinced the government to issue low-cost insurance, Mother Nature still strikes, as witnessed in 1938 (before the practice of naming hurricanes became fashionable) when a record hurricane brought death and distruction to Long Island and New England. Near the eye of the storm at Westhampton Beach, for example, 175 houses were destroyed within a five-mile stretch of barrier beach.

Today, barrier beaches are the subject of a growing contro-versy, Spurred by the attraction of both summer-time fun and profit, developers are eager to build on these thin strips of land. But the high cost of disaster aid (Frederick, the most ex-pensive hurricane in history caused $700 million in damages on the Gulf Coast near Mobile in 1979), has cautioned others about future development. Caught between the contestants is the barrier beach and its flora and fauna.

Two hundred and eighty-two barrier islands exist along the Atlantic and Gulf Coasts. Created along the Continental shelf during the last Ice Age, these shifting ribbons of sand support a fascinating and highly adaptive community. A growing understanding of barrier beaches and their wildlife has raised some serious questions about continued development on their shifting sands.

Barrier beaches form where sediments, usually sand, wash into the edge of the sea. Carried down by rivers as on the west coast or eroded by waves from cliffs and headlands along Long Island the sediments are shaped and moved by the tides.

Waves striking parallel to the beach can move or remove sand onto or off the beach face depending on the size of the waves. Summer waves which are gentle and good for bathers tend to move sand onto the beach. Winter waves which can be much larger re-move sand from the beach. And so the sand is removed during the winter, temporarily washed into the sea, and returned during the summer, cleansed for another assault by beach goers.

But more often than not, waves hit the beach at an angle usually from the southeast especially during winter northeasters. They carry sand along the beach as well as up and back. Hence, there is a longshore transport of sand along the beach face, which on Long Island moves sand to the west. Sand eroded from the cliffs at Montauk, for example, moves westward along the south shore and is deposited in New York Harbor where a sizeable amount of sand is mined.

If the volume of sand in the longshore transport is constant, and if the sea level remains unchanged, the sands of barrier beaches and the forces of the sea strike an equilibrium, a turbulent standoff, and the position of the shoreline remains constant except for seasonal variations. But if the sea is rising, sand is removed by the longshore transport. It has been estimated that the sea level was about 120 meters, or 400 feet lower, 12,000 years ago following the melting of the glacier of the last Ice Age. In the last 100 years, the sea level has risen a little more than an inch a year or nearly 20 feet. A rising sea slowly inundates the beach and during storms washes over the dunes. And so the beach face sand carried over the dune crest contributes to the northward movement of Long Island's barrier beaches.

Some washovers become inlets, and some large flood tide deltas of sand form in the quiet bay waters inside the inlet. Inlets thereby siphon off large volumes of sand from the longshore transport adding to the net movement of sand northward. While Long Island's barrier beaches are amply covered with beach grass which tends to anchor the sand, wind is often sufficiently strong to move sand over the dune crest where it is trapped by dense stands of vegetation. Aeolian forces contribute to this northward migration of the barrier beaches as well. Thus, strong evidence suggests that Long Island's barrier islands are moving out from under man-made structures and northward toward the coast.

To survive, the flora and fauna of the barrier beach must be mobile. The forces of natural selection have produced some creative responses to this dynamic and, sometimes harsh, world.

Although the beach itself is not rich in wildlife, it is nevertheless a lee shore by virtue of both wind and currents, and therefore exposed to striking creatures that are washed ashore. Right whales used to come close to our shores until whaling nearly exterminated them. But in the later winter of 1979, a dead right whale came ashore at Easthampton. This leviathan which required two huge technological contraptions to move it but a few feet onto dry sand, displayed its long baleen plates used in filtering plankton from the sea. Astride its upper jaw and snout were large circular eruptions called callosities, each providing a home for numerous half-inch long marine lice. In the South Atlantic along the Argentine coast, the callosity patterns allow scientists to recognize individual whales as they try to decipher the nature of their social structure. Even in death this grand beast granted important insights into the submarine world that brushes our barrier beaches.

With the exception of small crustaceans, few organisms have adapted to the shifting sands of the beach's surfline. Crustaceans spend a lifetime digging in the moving sands and provide food for alert sanderlings which spend their lives first catching a burrowing shrimp, then dodging a rushing wave.

Beneath the sand in the surfline, a less discernible struggle goes on. Arctic wedge clams, a little more than an inch in length burrow in the sand and filter food from the waters above. Where they concentrate, moon snails can occasionally be found searching for a meal. Crawling just under the surface of the sand, the moon snail searches for a clam, seizes it, and drills a hole in the shell. Evidence of this struggle is seen where the shells of dead wedge clams have washed ashore.

At the high tide line, the beach sand is somewhat more stable especially during the summer but few organisms live there. One exception is the sea rocket which unfolds its tiny blue four-petaled flowers. A bite of the branch confirms its relationship with the mustards. Beach buggies and an occasional summer storm make life difficult for the sea rocket, but they have developed a clever strategy of wandering. Its fruit is two-seeded; one held loosely at the tip of the branch in a bulbous, spongy, floatable case; and the other held firmly by the stem attached to the plant. So when a ripe outer seed breaks away from its parent and is washed away during a storm or spring high tide, the other stays home to replace its parent. Thus the sea rocket risks half of its offspring in adventure in hopes of a new settlement, and plows the remaining half into a proven location, the place where it grew up. Behind the dune crest, beach grass is the dominant species. Sending roots deep into the sandy soil, it seeks an adequate water supply and in the process prevents sand from eroding away. When sand has drifted over it during the winter, it can also send new shoots up, thus helping the dunes grow higher and northward. Because beach grass grows densely, the barrier beaches of the northeast are different from their southeastern counterparts where sea oats forms clumps, and where wash-over and wind erosion are dominant. But whichever plant species lives on the dunes, it must cope with shifting sands, hot temperatures in the summer and disappearing water which percolates rapidly through the sand into an underground aquifer.

Infrequently, artificial water holes in the beach alter near-by plant growth. Where artesian wells have been constructed in the clay lens, ground water is released. Unlike the classical artesian systems of the midwest, these barrier island wells create an oasis of plants in contrast to the dryness surrounding desert wells.

Further down the dune slope, there is a moist more diversely vegetated area called the swale. Here, poison ivy, bayberry, and rugosa rose form inpenetrable clumps, negotiable only by rabbits. Here, the soil holds more moisture and the fresh water table occasionally breaks the surface. Between the clumps of bushes, there are many varieties of flowering plants. In an occasional clearing, a fox den can be found while deer are known to browse and sleep in the dense but less impenetrable thickets.

If the mosquito commission has not drained away the few remaining fresh water ponds, Fowler's toads, hog nosed snakes and tadpoles can be found. These animals which make up a small food chain depend totally upon these small packets of fresh water for survival.

One of the most spectacular natural events of the barrier beach occurs usually in late September or early October. After a spell of bad weather followed by a clear day with strong northwest winds, large numbers of hawks come out of New England, cross the Long Island Sound, continue across Long Island, and turn west over the barrier beach. On Eastern Long Island, as many as 500 or more hawks can be seen in a few hours. Further west, as the hawks from the east join those that come from the west, the numbers swell to the thousands in the early morning. Indeed, they go by so fast that identification is not always possible. Such flights are invariably punctuated with a peregrine falcon or two, numerous marsh hawks and an occasional Coopers hawk or osprey. The main stream, however, is composed of kestrels, sharp shinned hawks and merlins, truly and awesome sight.

North of the swale, the Spartina marshes are found. This area of salt marshes has gone from wasteland to hallowed ground in less than 20 years. Normally covered during high tides, they were rapidly destroyed after World War II when the building boom hit western Long Island. Flat and easily filled with dredged spoil, these wetlands were converted into waterfront property before their natural value came to be appreciated. A strong effort is now being made to preserve the remaining few.

Among the more fascinating stretches of Long Island's barrier islands is the Sunken Forest on Fire Island. Nowhere is one more surprised at Nature's creativity than here. Here, behind a second dune line there is what appears to be a well-sheared green carpet. In reality, the carpet is a green canopy consisting of a moist, cool, calm forest dominated by sassafras, shadblow and holly. Here where the boggy floor nurtures a calm, sheltered, complex forest, one is struck by the contrast to the nearby shifting, harsh, world of sand.

But surprises from the natural world are not infrequent. Even educators are startled to learn from year-round baymen that the bottom of the bay is often frozen after a long cold spell during the late winter. Since ice usually forms on the water surface, an explanation was needed. Present theory suggests that when fresh water from the barrier beach or the mainland seeps underground into the bay bottom, it makes contact with salt water. The temperature of the salt water is below 32^{0}F. Since the fresh water freezes at about 32^{O}F, the salt water is cold enough to freeze the water entering the bay from underground aquifers. The effect of this freezing phenomenon on organisms living in the bay bottom has not been fully assessed.

In the deltas behind the barrier islands where flooding tides drop sediments, it's a common practice to dump sand dredged up from intracoastal waterways. These sites are often a better place for spoil than valuable marshland since the added sand provides nesting sites for terns and skimmers. Isolated from predators such as racoons, foxes and rats, these birds persist in one of the few available breeding areas along a rapidly developing coastline.

Although barrier beaches are fragile, they can also be resilient. Evolution has created species whose abilities are well adapted to a shifting, sandy environment. In this sense, barrier beach life is resilient. If left undisturbed, barrier beach inhabitants can, as long as the sea level doesn't change too rapidly, survive for a long time.

But the greatest threat to the barrier beaches is man's activity. Beach buggies crush plants and disturb nesting birds; oil spills kill bird life; dredge spoil covers over and eliminates Spartina marshes. Dominated by an engineering ethic, we try to stabilize, immobolize and constrain barrier beaches so they can accommodate our structures safely.

But the forces of the sea are immense. As we understand beach processes better, we are struck by the fact that barrier beaches may serve us best if left to struggle with the sea like they have been doing successfully for thousands of years. Whatever the outcome, the wildlife will continue to adapt and search for a place in the sun alongside of man's creations.

AQUACULTURE: FOOD FOR OUR FUTURE

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We tend to look upon the sea as a vast and relatively untapped reservoir of food. So, as the world's population increases, our fears of a world-wide nutritional crisis are softened somewhat by our belief that the mighty oceans that we view with such awe must have a limitless capacity to support us. But, of course, even the sea is not limitless. Our estimates of the sea's ultimate food producing capacity have been clouded by our relative ignorance of the basic systems taht determine the sea's productivity. The current average annual yield from the sea is about 60 million metric tons. One estimate has suggested that about 36 grams of protein are required per person per day for proper nutrition. Thus, our harvest from the sea could now provide about 30 percent of the protein requirement for the earth's four billion people if all of the harvest were used for human consumption. Since by the year 2000 the world population is expected to increase to about six billion people, the yield from the sea will have to increase by two-thirds just to keep pace.

Experts have had difficulty estimating just what the sea's food producing capacity might be. Estimates range from about 100 million metric tons to almost two billion metric tons annually. In any case, it is generally accepted that in order to increase our harvest significantly over 100 million metric tons, we will have to harvest species that are now wasted, and our harvest will have to include many species that are low in the food chain. Even now efforts are being made by Russia and Japan to harvest and use some of the estimated 100 million metric tons of krill, a small shrimp-like animal, made available to us in part because of our reduction of the Antarctic whales that once used krill as their main food source.

Not a very encouraging picture, but the facts speak for themselves. Even utilization of untapped protein sources in the sea can only be expected to increase total yields to about 150 million metric tons annually. This figure could be much lower if unchecked pollution or mismanagement reduces catches from the more traditional fisheries.

This relatively pessimistic appraisal of the food producing capacity of the sea is based on our continuing to harvest its resources as hunters and gatherers of untended stocks. But thousands of years ago the Romans knew that the yield from their oyster grounds could be greatly increased through the use of simple forms of animal husbandry, caring for their crop of oysters in much the same way that they did for their crops on land. The relatively simple forms of oyster culture now used in

Japan have been able to produce up to 40,000 lbs. of shucked oyster meats per acre of sea surface. If these same methods, involving the use of rafts, produced similar yields, the entire Maryland oyster crop now grown on 500 square miles of bay bottom could be grown in one square mile. Moreover, at this rate of productivity, Long Island Sound could produce three times the total tonnage from all the world's fisheries. Estimates such as these can be very misleading because they assume that perfect culture conditions exist over very large areas. They also assume the existence of an unrealistic rate of phytoplankton growth to serve as food for millions of cultured organisms. However, these estimates do serve to emphasize the enormous productivity that could theoretically be realized from the sea through the application of culture concepts that we take for granted on land.

Aquaculture, the sea's counter part to agriculture, involves the control of all or part of the life cycle of an organism. Sometimes called mariculture, when applied to organisms living strictly in salt water, aquaculture is quite simply the farming of the sea. In practice, the degree of control exercised and the fraction of the life cycle controlled vary considerably. The term <u>extensive</u> aquaculture is generally applied to culture practices that require relatively little investment per animal, are relatively simple, even primative, and exercise little control over the animals. <u>Intensive</u> aquaculture, on the other hand, makes use of more sophisticated techniques and equipment, requires more investment per animal, and may involve control over most of the animal's life cycle.

Oyster culture as it is practiced in Delaware Bay involves moving the young "seed" oysters from the state controlled areas that best produce them to leased grounds that best support their growth. This is aquaculture in its most extensive form. It requires little investment in each animal, and the degree of control over the animals is minimal. At the other end of the intensity scale, researchers at the University of Delaware have constructed a very sophisticated system that allows them to hold oysters and to grow them from egg to market size totally within the walls of the laboratory. The complex system, functioning within right of the old Delaware Bay oyster boats, produces the planktonic algae required as food for the oysters. This "closed system" is perhaps the most intensive form of aquaculture. It requires considerable investment in each animal eventually harvested. In fact, at this point, closed system production of oysters has not been economically feasible. The system is, nonetheless, an amazing technological achievement that holds promise for the future.

Between these two extremes of intensity of aquaculture, there is an entire spectrum of methods and approaches involving varying degrees of control and sophistication. For example, F.M. Flower and Sons Oyster Co. in Oyster Bay, L.I. began using a laboratory like oyster hatchery to supplement faultering natural reproduction on their oyster beds. The hatchery proved successful, and for a number of years very small seed oysters were released onto the bay bottom without protection.

More recently, the company has increased the intensity of their aqaculture efforts by maintaining the seed oysters on rafted trays to protect them from predators. In this way they have been able to obtain much higher yields from their hatchery produced seed. However, the use of rafts also requires that they invest more time and money in each animal.

The Pacific salmon, members of the genus Oncorhynchus, are the mainstay of aqaculture in the Pacific Northwest. Again, as with Eastern oysters, extremes in culture intensity are employed. Some culturist, such as Dr.William McNeil of the giant Weyerhauser Co., believe that the future of salmon aquaculture lies with its most extensive form, "ocean ranching". Ocean ranching involves the removal of eggs from mature females and maintaining the young fish hatched from those eggs until they are ready to return to the sea. This requires anywhere from five months to two years, depending on the species of salmon used. When the fish are ready to return to the sea as "smolt", they are simply released. Two to four years later, again depending on the species, a small percentage of the fish will return to the point of release and become, at that time, the property of the company that released them. Weyerhauser, which has invested over $10 million in ocean ranching, must get back about 2% of the fish that they release in order to make a profit. While this percentage may seem small, the mortality rate of Pacific salmon is very high, and the economic feasibility of the ocean ranching concept remains to be proven.

At the other end of the intensity scale, many salmon culturists prefer to maintain the fish under carefully controlled conditions until they are ready for market. These so called "raceway systems" require that fish be protected from disease and provided with prepared foods for at least two years. Although very costly per fish, intensive salmon culture is reliable and can be expected to result in high percentage of marketable fish from the eggs taken.

Whatever the species cultured, clearly there are advantages and disadvantages associated with the degrees of intensity utilized in culture. With salmon or oysters, there are clear trade-offs, gains and losses, realized from sophisticated culture systems such as closed systems or raceways that avoid reliance upon the whims of nature for the growth and survival of the crop. On the other hand, these systems require considerable energy and are expensive, and because they tend to push existing technology to the limit, they require more skill and specialized training to operate. Selection of the appropriate level of intensity for a given species and location is one of the most basic and important decisions that an aquaculturist must make. It is not possible to generalize. The choice depends on the specific conditions, the economics, available technology, and the social and legal problems encountered.

Perhaps even a more basic decision is the choice of species to be cultured. Most often the species chosen is one that has already been cultured successfully or exists naturally at that location. Thus, oysters are cultured with varying degrees of intensity all along the Atlantic and Gulf coasts, but salmon are cultured successfully only in the Pacific Northwest. The Draft National Aquaculture Plan published by the Department of Commerce in May of 1980 listed species that were judged to be viable candidates for freshwater and marine aquaculture with existing technology. The list is based on existing aquaculture and on the opinions of a panel of experts, aquaculturists and researchers, that met in September of 1979 to draft the plan. The list is as follows:

Freshwater	Saltwater
catfish	oysters
crawfish	hard clams
trout	shrimp
freshwater prawn	salmon
baitfish	striped bass
largemouth bass	

In addition, a list was included of other species that are being cultured now in this country, but which seem to require additional research and development before they are likely to be cultured on a large scale. Included among these were: lobsters, scallops, abalone, eels, and baitworms.

Not just any plant or animal is suitable for aquaculture. Many species such as the blue crab are highly prized, but have proven difficult if not impossible to culture in an economically sound system. Organisms that have been successfully cultured possess characteristics in common that offer important advantages to the culturists. Some of these characteristics are:

1. a relatively high price, necessary to justify the risk and investment now associated with aquaculture;

2. sufficient market volume and demand to warrant a larger supply;

3. a good growth rate;

4. efficient food conversion;

5. relative hardiness, resistence to disease, tolerance of crowding;

6. food availability or existing technology to produce the food required for them to grow;

7. a relatively simple life cycle that can be controlled; and

8. an indigenous population in the area chosen as a site.

It is likely that any of the species now successfully cultured score high in all of the eight characteristics listed above. However, it is very unlikely that any species can be successfully cultured if it does not meet most of the required criteria.

The potential and the need for aquaculture is clear. But, somehow the reality seems to lag behind the potential in the U.S. On a world wide average, aquaculture produces about 10 percent of the total of all fisheries products. But in the U.S., only about 3 percent of our fisheries products come from aquaculture. However, the percentages are much higher for certain species. For example, it is estimated that at least 30 percent of the landings of Pacific salmon and about 40 percent of the Nation's oysters are produced through aquaculture. Aquaculture success stories with salmon and oysters show the contribution that aquaculture can make to food production in this country and elsewhere. There is clearly a potential for greatly increased production of food that has yet to be realized.

Identifying the reasons for the generally disappointing status of U.S. aquaculture was one of the major goals of the authors of the National Aquaculture Plan. They found that there are several obvious constraints to the development of aquaculture in this country. Specific difficulties encountered by individual culturists may vary, but there are common characteristics to their most serious problems that must be dealt with before U.S. aquaculture can reach its potential. The problems most often encountered include inadequate basic information on the biology of the cultured organism, marketing problems, legal difficulties, and social/political problems. The specific biological problems encountered usually involve the juvenile stages of the cultured organism. Most culture systems can obtain sufficient "seed" animals from larvae, and most have little difficulty handling the adults. However, handling the very small juveniles usually proves to be the weak link in the culture system.

Legal problems mentioned by aquaculturists include conflicting regulations, and the lack of a single government agency responsible for aquaculture. One California abalone culturist reported having to deal with 45 government agencies in his frustrating, but eventually successful effort to establish an abalone culture system. Land use regulations, zoning problems, failure to distinguish between wild harvest and cultured organisms in application of minimum legal size limits, and lack of avialable areas for leasing are among the most serious problems encountered by aquaculturists. Most have reported that, although the public supports the concept of aquaculture in general, people tend to oppose leasing of bay bottom to private individuals or companies and do not support the presence of rafts or other structures in their particular area. Public opposition to any type of development on coastal areas and to private control over portions of the water have effectively prevented the expanision of aquaculture in the U.S. The problem is compounded by the lack of a coordinated government effort to support aquaculture and by the high risk nature of the business in a tight money market.

Despite the problems, aquaculture is growing, and efforts in the U.S. Congress and Senate to pass a National Aquaculture Bill can only spur that growth. Government agencies recognize the problems and are now making a real effort to improve the bureaucracy that deals with aquaculture at all levels. The food producing capacity of aquaculture is not a theory; the enormous productivity of systems in existence in this country and particularly in Asia attest to aquaculture's ability to produce food. With an improving social, political and legal climate combined with continuing technological advancements, the future of aquaculture is indeed bright. In a world where food can no longer be taken for granted, even in the wealthiest of nations, aquaculture may hold the key to survival for millions of people

WHALES AND MAN

by

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Whales have had wide public attention for the last 10 years or so. This concern has been brought about by several events: the slaughter by whalers of several species in succession, so that their numbers were reduced to very low levels; a great interest in marine mammals generally, which brought about federal legislation prohibiting killing by Americans; and a kinship with whales that was stimulated by TV and other media.

This concern came a bit too late to have any major effect, however. We would have welcomed it in 1960 or earlier when we were trying desperately, with little effect at first, to make the Whaling Commission take a more serious view of its responsibilities. By 1970 when, for the first time, an organized conservation campaign began on behalf of whales, the Whaling Commission was already on its way up from its low point of 1964. The continuance of this campaign, when much of the work has already been accomplished, threatens to wreck a carefully put together scheme of control. The accomplishments of the Commission, although far too slow in coming, have not been fully recognized. The proponents of a moratorium are clearly sincere and well-introduced, but their extreme position at this late stage might well lead to disaster.

Over the years the villains have changed also. In the 17th and early 18th century it was the Basques and the Dutch. In the later 18th and early 19th century it was the Americans, and in the later 19th and early 20th the British and Norwegians, and finally the Japanese and Soviets. These last two countries, now the major whaling nations, have come under criticism largely because they were increasing their share of an ever-decreasing catch at a time when a large part of the world's population was saying no. But equally responsible, in fact probably much more so, because they whaled without any restrictions art all, were the British, Norwegians, Americans, and the Dutch and the Basques, plus at least 18 other countries which at one time or another over the past 450 years, contributed to the decline.

The Major Species of Whale

In the early days the major species were the right whales: the black right whale, and the Greenland or bowhead whale. These were the "right" whales to kill because they swam slowly, stayed close to shore, at least in winter, had thick blubber and thus usually did not sink when killed, and had very long and valuable baleen plates. For these reasons they could be approached closely with rowboats or even canoes, and were valuable for their baleen alone.

As the whalers became able to move farther offshore, the sperm whale became valuable because it contained high quality oil, especially in the head, which made excellent smokeless candles and oil for lamps. It was also a more tropical whale, which reduced the need to go into the Arctic for bowheads, at best a dangerous and uncomfortable life. Then, when the breeding grounds of the gray whales became known, this became an easy whale to kill, because it bred in the shallow lagoons of the Baja California coast.

The right whales were heavily exploited first in the North Atlantic by whalers who gradually worked their way across the ocean and reduced their numbers everywhere. They soon found the even more valuable bowhead in the ice of the Arctic, and quickly reduced them to low numbers. By the early 19th century they had penetrated the North Pacific and southern hemisphere where whales were still abundant, but these were soon reduced to small numbers. The humpback, a relatively slow swimming and fat whale, was also reduced at this time.

These were not the only whales in the world ocean, however. There were large numbers of rorquals, especially around the Antarctic continent, but these were relatively safe from serious harvesting in the early days because they were too fast, and sank when they were killed, so that they usually could not be recovered. Harvesting of these fast whales required development of several new devices and aids: the harpoon gun and explosive harpoon head; a device to pump air into the whale so that it would float; and eventually a ramp on the factory ship so that the whale, especially in the Antarctic, could be hauled aboard for butchering on the relatively stable platform of a large ship. Development of the first two came about 1865 in Norway. The ramp was first put to use in 1925, and this opened up the last and the largest whaling ground in the world ocean , in the Antarctic, and for the first time made all parts of the world ocean available to whalers.

It did not take long for these new developments to be felt. In less than six years, from 1925 to 1931, the world oil market became saturated. In 1931 the blue whale, the greatest animal ever to live on this earth, produced its maximum catch. Despite the respite offered by the decline of whaling after 1931 and the almost complete protection offered during the second world war, the blue whale never reached close to that population level again, and was finally placed on the prohibited list.

After the blue whale reached its peak, it was followed by the humpback (easy to kill, and relatively valuable), the fin, the sei and Bryde's, and finally the minke, each one, with the exception of the humpback smaller than the previous one. These 10 species were the most sought after, and the ones most affected by whaling.

Life Histories

Black right whale

This whale was abundant in the Bay of Biscay in the early days of whaling, where it was easily available to the early Basques. As demand grew, and local supplies were depleted, whalers worked their way across the Atlantic, first to Iceland, then to Greenland, and finally to Newfoundland, Nova Scotia, and New England. By the time they arrived in the western part of the Atlantic they soon found the Greenland right whale or bowhead in Davis Strait and farther north.

The black right whale had a large head, an arched mouth, with callosities on the head (the bonnet) and elsewhere. There were no dorsal fin and no grooves on the throat, and the flippers were short and broad. It reached maturity at 40 to 60 feet in length and 25 or 30 to 80 tons. At birth the calf was about 20 feet long, weighed about a ton, and one was born about every three years. Oil yield was as high as 8,700 gallons, the blubber averaged 10 inches thick, and the baleen was 5 to 8 feet long. Its food consisted of copepods and other such crustaceans, euphausiids, and fishes up to 6 inches long. When baleen was in great demand, it sold for 5 to 7 dollars per pound, and one or two right whales, each yielding 1,000 to 2,000 pounds, could pay for a whaling voyage. Often the baleen was the only part kept, the rest was discarded and wasted. These whales had become scarce in all parts of the world ocean by the mid-19th century.

Greenland right or bowhead whales

The bowhead was confined to the Arctic Ocean and probably was never very abundant, possibly not more than 18,000 before whaling began. It was the most valuable of all whales at the time, having very long and fine baleen and a large store of oil.

The head of this whale was extremely large, about 1/3 of the total body length, relatively free of callosities, and with a very high, arched mouth. It also lacked a dorsal fin and a grooves on the throat. Sexual maturity was reached at about 38 feet in the male, 40 feet in the female, at an age of four years. Calves at birth were 10 to 15 feet long, weighed about 1,000 pounds, and one was born about every two years. Oil yield of a large bowhead was a ton and a half, blubber averaged 10 inches thick, and the baleen was 12 to 15 feet long. Its food was benthic crustaceans, euphausiids, copepods, pteropods, and amphipods. As with the black right whale, the baleen, when in great demand, was even more valuable, and from one or two whales the baleen could pay for a voyage.

The bowhead lived among the ice, thus could not escape the whalers, and its slow swimming speed of 2 to 6 miles per hour, and its relatively small numbers, quickly brought it close to extinction. The bowhead and the black right whales have been protected since 1935 except for subsistence hunting by Eskimos. The numbers of bowheads, however, have not increased, and it is believed that inefficient whaling methods, which ensure that relatively large numbers are struck but lost, plus the gradual increase in numbers of Eskimos, have held the stocks down. In some parts of the world ocean black right whales are increasing.

Gray whale

This is strictly a North Pacific whale, in recent years probably mostly confined to the North American side. A closely-related species once inhabited the North Atlantic Ocean also. It became extinct perhaps 500 years ago or more, and it is not clear whether man had a hand in this or not.

On the North American side of the Pacific the gray whale probably never exceeded 15,000 animals. It was vulnerable, once its breeding area was discovered, for it usually stays close to shore during its north-south migrations, breeding in the lagoons of the Baja California coast. The dorsal fin is reduced to a series of humps on the back, and there are only two or three grooves on the throat.

The gray whale reaches maturity at about 36 feet long and about 16 tons. At birth the calf is 16 feet long and weighs 1,000 pounds. About one is born every two years. The calf is weaned at about 28 feet long. The baleen is short and dark in color. This whale feeds on the bottom, and its principal food is amphipods.

This is a fairly slow swimming whale. It spends the summer in the Gulf of Alaska and Bering Sea, begins to migrate south in October, and begins to show up along the Baja California coast about the middle of November. They fast during most of the southward migration and lose considerable weight in doing so. By the time they begin their northward migration again in February, their weight and oil yield are down. When the breeding grounds were found in 1846, gray whales were killed in large numbers, and by the end of the century were reduced almost to extinction. The species was placed on the prohibited list by the Convention of 1935. In the interim, however, despite the lack of effective controls on killing, it has come back slowly, and now numbers at least 12,000 animals.

Sperm whale

This is the largest and the most valuable of the toothed whales. In contrast to the baleen whales, which feed upon some of the smallest zooplankton in the sea, the sperm whale feeds mostly on squids, some of which are very large, and to a lesser extent upon deep-sea fishes. Also in contrast to the baleen whales, the male sperm whale grows much larger than the female, 60 feet as compared with 37 feet for the female. This is also a tropical whale, which lives mostly between about 45° N. Latitude and 45°S. Latitude. Only the larger males penetrate farther north. Another important difference is that sperm whales are strongly polygamous, and one large male can maintain a harem of 20 or more females. This has been suggested as one way in which sperm whales can be managed, by killing only the smaller bulls, which are excess to the reproductive process.

Sperm whales mature sexually at 8 or 9 years of age. The gestation period is about 15 months, and births take place only every 4 or 5 years. Some sperm whales dive very deep, and can stay down for over an hour. The deepest known dive is over 10,000 feet. The virgin population may have been as great as 1.5 million.

Sperm whales sometimes produce ambergris, once a valuable by-product used in making perfume.

Humpback whale

This whale is fairly easy to identify. It has a heavy body and long flippers, with strong tubercles over much of the body. At times it leaps clear of the water, landing on its side or even on its back. Its blubber is second only to the blue whale in absolute thickness. It averages about 5 inches, and the humpback yields 3 to 6 tons of oil. It is a middle sized whale, 45 to 51 feet long, weight 35 to 40 tons.

The humpback has baleen plates about 2 1/2 feet long, and 12 to 26 grooves on the throat. The food is mostly euphausiids, but it also feeds upon anchovy, herring, sardines, cod, and salmon. In the winter the stomach is usually empty. Humpbacks have an unusual method of feeding at times. They blow a "bubble net" which is coil shaped, then rise through the center and capture the organisms inside the barrier.

The gestation period is about 12 months, and one young is born about every two years. The newborn calf measures up to 16 feet and weighs about 2 tons. The average cruising speed is less than 4 knots.

The rorquals

The rest of the commercial whales, except for the smaller toothed whales, are called rorquals, characterized by their corrugated or pleated throats. They are fast swimmers, with maximum speed of 20 knots, although only for short bursts. The cruising speed probably is 8 to 12 knots.

Blue whale

The blue whale is the largest animal that has ever lived upon this earth. The largest authenticated animal was 98 feet long, but they probably exceed that length somewhat. The heaviest blue whale was an 89 foot animal, which weighed 320,000 pounds or 160 tons. The size of these whales can also be imagined by knowing that an 82 foot whale weighed 203,000 pounds and produced 52,500 pounds of meat. At birth the calf is 23 to 26 feet long and weighs 5,500 pounds. While she is nursing, the mother must supply over 50 gallons of milk per day, and the milk is 35% to 50% fat. The calf gains weight at over 200 pounds per day. The food requirements of an adult are about 1.5 million calories per day. It fasts for most of the winter, so must consume about 3 million calories per day in summer. The food is almost exclusively <u>Euphausia pacifica</u> in the north, and one pound of that euphausiid supplies about 400 calories. Thus an adult blue whale must consume 4 tons of krill per day. The stomach holds about one ton, so it must eat four meals per day.

Sexual maturity is reached in about 10 years, the gestation period is about one year, one young is born every two or three years. The virgin population probably was about 200,000 whales.

Fin whale

The fin whale has an interesting asymmetrical pigmentation on the two sides of the head. The lower jaw on the right side is completely white, and about one-third of the baleen in the front on the right side is also white. This is the second largest of all the whales, reaching about 80 feet maximum. Average adult males are 62 feet, females 67 feet. Breeding takes place in winter, the gestation period is about 11 months, and the calf is about 20 feet long at birth. There is at least one resting year, sometimes more, between pregnancies. The calf nurses for about 6 months and is weaned at about 36 to 40 feet.

The food is principally euphausiids, but small fishes are sometimes taken when in concentrated groups. Fin whales in the southern hemisphere are somewhat larger than in the northern. There are grooves along the throat, and a dorsal fin.

Sei whale

The name comes from the coal fish or sei (Gadus virens), which appears off the Finmark coast at the same time as the sei whale. This is a slender whale, males about 45 to 48 feet, females 49 to 50 feet, and the extreme length about 60 feet. It is less boreal than the fin whale, but does not go so far south, either.

The sei whale is about 10 years old at sexual maturity. Its pregnancy rate in the North Pacific is about 40%. Its food is mainly small invertebrates such as euphausiids and copepods. It also has a dorsal fin and grooves on the throat.

Bryde's whale

This whale is very similar in appearance to the sei whale and even whalers have difficulty telling them apart in the water. It is a more tropical species than the sei, has three ridges on the head instead of one, and is not as migratory. Its maximum length is about 42 feet for a male, 44 feet for a female.

The diet is more restrictive, and it generally feeds at a higher trophic level. Small sharks and even penguins have been found in the stomach, although they are most likely swallowed with fishes.

Minke whale

The minke whale is the smallest of the rorquals, seldom exceeding 30 feet long. It was not harvested in great numbers until the larger whales were reduced, and never was included within the blue whale quota limits in the Antarctic. The flippers have a distinctive white patch or band. The minke ranges broadly over the ocean in summer, but in winter is mostly at 20° to 25° North or South Latitude. It is the most likely of the rorquals to breach. It arches more gracefully and the splash is smaller than that of the humpback.

Other toothed whales

Various other toothed whales are taken, the most interesting of which are the killer whale, the beluga, and the narwhal. The killer whale is the second largest, next to the sperm. The male is about 32 feet and weighs 9 or 10 tons, the female is about 28 feet and weighs 5 to 6 tons. The calf is about 8 feet at birth and weighs 400 pounds. These are fast whales; the top speed about 30 miles per hour. Their food consists of fishes, squids, octopus, dolphins, porpoises, whales, and seals.

The beluga is a white whale which lives in the Arctic. The adult male is 11 to 15 feet long and weighs about 3,300 pounds; the female is 10 to 13 feet long, and weighs about 3,000 pounds; the largest males are about 22 feet and weigh 2½ tons. Birth takes place in relatively warm water in estuaries, therefore these are migratory, coming south in summer and north in winter. Occasionally, one may be seen as far south as Long Island. At birth the calves are gray and remain dark until 2 years old, then a lighter gray for the next three or four years.

The narwhal is perhaps the most curious of all whales. It has the single tooth which grows to a tusk 6 to 9 feet long. The tusk spirals counterclockwise from the animal's point of view, and new growth constantly compensates for wear. Most people believe it is a secondary sexual characteristic like a beard or horns. The adult male is 15 feet long and weighs about 3,500 pounds, the female is 13 feet and 2,000 pounds. It is found only in the Arctic, within the drift ice. Birth takes place in mid-July, conception is about 15 months earlier, and calves are born only about once every three years. The newborn calf is 5 feet long and weighs about 180 pounds. It is adequately protected by a one inch layer of blubber.

The Numbers of Whales

The numbers of whales are difficult to determine, but estimates can be made from a variety of sources. Most of them depend to a considerable extent on catch and effort data. Catch records are reasonably reliable and have been collected for a relatively long time. Effort data are less reliable for two reasons. Measurement of effort in a mixed fishery is difficult, and effort tends to increase with time as the stocks become less. Adjustments can be made, however, which at least partly compensate. Many methods also require estimates of recruitment rate and mortality rate. From these have come stock assessments which are the most reliable available.

Estimates of virgin stock sizes vary with species. Some are fairly good, others are largely guesswork. They are given in table 1. Present stock sizes are somewhat more accurate. They are given in the second column in table 1. It can be seen that while some species are seriously overharvested, others are in reasonably good condition still, and with careful observance of the quotas and closures, there is hope that the whales will come back.

It will be noted that of this list only sei and fin whales

Table 1. - Estimates of the numbers of whales in the world ocean before whaling began and at the present. Data from Gambell (1976) modified by subsequent developments, in thousands of whales.

Species	Initial number	Present number	Present quota*
Right whale	100,000	4,000	0
Bowhead	18,000	1,000	26
Gray whale	15,000	12,000	179
Humpback	101,000	5,000	10
Blue whale	186,000	10,000	0
Fin whale	448,000	100,000	604
Sei whale	197,000	70,000	100
Bryde's whale	?	?	743
Pygmy blue	10,000	4,000	0
Minke	360,000	300,000	12,006
Sperm whale	1,000,000	700,000	2,203
	2,435,000	1,206,000	15,871

* Most of these quota apply only in specified parts of the ocean.

in the North Atlantic, Bryde's whales in parts of the Antarctic and North Pacific, and sperm whales in parts of the Antarctic, North Pacific, and North Atlantic can be taken. Bowheads and gray whales can be taken only in limited quantities by aborigines for their own use, and the 10 humpbacks only off Greenland. The others are completely protected.

Conservation

The International Whaling Commission had its first beginnings in the early 1930s, when biologists were aware that some kinds of whale were already in need of protection. Right whales, gray whales, and to a lesser degree the humpback were already seriously affected. The first international agreement placed right and gray whales on the prohibited list, world ide, and the gray, at least, has increased in abundance as a result. Today the gray whale is almost as abundant as it was before whaling began. The right whales have not noticeably increased, except in a few places. The Greenland right whale has been kept down by its specialized habits. It lives only in the Arctic, close to the ice, and it apparently has been held to low numbers by Eskimo hunting, which is not a very efficient way of harvesting. The black right whale is more abundant and less restricted in its movements, and in some parts of the world, in northern and southern hemispheres, it may be slowly recovering.

The chief incentive that led to formation of an international body was the harvesting of rorquals, which began in a small way in the late 1800s, after the harpoon gun and the explosive harpoon head were invented about 1865. Major harvesting of rorquals began about 1925, however, when ramps were first fitted to factory ships, so that whales could be hauled on board for cutting up. Once this was possible, the whole of the stormy Antarctic was opened up to whaling. Instead of lying in the drift ice or anchored in harbors, where catcher boats were limited to their cruising range of about 150 miles from home, the fleets could now go anywhere that whales were abundant. The reaction was so quick that in six years more whales were taken than could be used, and in 1932 whaling declined substantially because the oil could not be sold. Already the largest whale, the blue whale, was seriously overharvested.

This respite, gained at first by overproduction and in part by the world recession, was further helped by the second world war, which reduced whaling to low levels for another six years or so. The first whaling convention was not ratified until 1935, and it contained relatively few constraints upon whalers. Its demise was assured by the war, and nothing was done again until 1946.

The 1946 whaling convention, which entered into force in 1949 after the required number of nations had signed it, was more comprehensive and inclusive than the earlier one, but it had several serious weaknesses. Perhaps the worst was the blue whale unit, which rated whales according to their oil production, so that one blue whale equalled 2 fin whales, 2½ humpbacks, and 6 sei whales. This did not include all rorquals, and it also left out the toothed whales, but the quotas on which it was based did not separate individual species. Thus, after the blue whales were almost gone (in fact they were already reduced before the blue whale unit became effective), whalers could turn to fins, or humpbacks, or sei or Bryde's whales in turn, or to all together, until all were overharvested. The only way in which it could have worked would have been if the quota had been set at a low level, in fact, at the level of the blue whale population at that time. Thus, even though the quota was considerably reduced compared with catches before the war and was about the total allowable catch of the four species combined, 16,000 BWU as compared with about 36,000 in the best year before the war, it was really no quota at all. Despite this great weakness, nothing effective was done until more than 20 years later, when the blue whale unit was abolished in 1972.

The Protectionists

Great public concern about whaling did not begin until 1966, when Scott McVay published an eloquent article in Scientific American. It was five years later before this became a real movement, however. Its beginnings were reflected in the size of the United States delegation, which up to and including 1970 was five persons, but in 1971 it grew to 19. In fact, the Whaling Commission began to act in response to the growing concern as early as 1965, and from that year on was responding slowly but surely to the growing set of problems.

This slow growth and then sudden explosion of interest in whales was an interesting phenomenon in itself. Why did it occur when it did, and what has been the result? The first and most obvious fact is that whales were indeed seriously overexploited, so much so that the Commission had placed blue and humpbacks under a moratorium by 1966, and was trying to place rational quotas on the other whales. This probably would not have stirred wide public interest in the problem. But when the public had been awakened by a series of TV programs and articles that developed a great interest in the porpoise "Flipper," a wide belief in the high degree of intelligence of whales developed. This belief in an unusual intelligence was stimulated by the work of Lilly (1961). Another development at about the same time was the publication of a book by Farley Mowat (1972) which told, very eloquently, the story of a fin whale, trapped in a bay in Newfoundland and the animal-like actions of the local people, as they hounded the whale to its death.

At about the same time, the plight of the whales was brought to the attention of the whole world at a United Nations meeting in Stockholm, Sweden, entitled the Conference on the Human Environment. Among many things discussed was the plight of the whales. The conference also called for a moratorium on killing whales. Most people expected the International Whaling Commission, which met about a month later, to listen and to obey. It came as somewhat of a shock that the Commission did listen, but took no action. This was an unfortunate confrontation between two groups with entirely distinct objectives, the one dominated by idealists with an extreme postion, the other made up of practical men with narrower objectives. The International Whaling Commission was unable to afford the luxury of total abstinence, when indeed such an extreme position was not necessary. It was also complicated by the unfortunate fact that, as whales became scarcer, the best strategy for industry would be to take all the whales they could, then get out, rather than act conservatively and wait for 50 or 100 years to begin again. Industry's obvious strategy was short-term; the Commission was doing its best to compromise between a moratorium and an open season; and the United Nations, backed by most of the people, was calling for an abrupt and total closure.

Despite the inaction of the Commission on the moratorium issue at the 1972 meeting, it did take some important steps. Just prior to the meeting, an agreement on an international observer scheme for the Antarctic had been agreed upon. The agreement was signed in London during the meeting and completed action on the four major unsolved problems that still faced it:

1) implementation of an international observer scheme;

2) for whale stocks that are clearly overexploited, catch quotas that are sufficiently below the best estimates of present sustainable yield to ensure that the stocks will be rebuilt to maximum yields;

3) for whale stocks that are not overexploited, catch quotas no higher than the best estimates of maximum sustainable yields;

4) elimination of the blue whale unit as a management unit.

These were not the only remaining problems, but they were the major ones, and others have been solved one by one since that time. At present the Commission has the following restrictions, in effect, which appear to be responsove: in the Antarctic 8,102 minke and 264 Bryde's whales, broken down into six subquotas by area; in the North Pacific 1,361 minke, 479 Bryde's, and 179 gray whales; in the North Atlantic 100 sei, 2,543 minke, and 604 fin whales; in the southern hemisphere 580 sperm whales, 1,350 in the North Pacific, and 273 in the North America. This total of 15,835 whales, plus a small number for aborigines, appears to be consistent with present views of the commission and should continue to build up the stocks.

Under the circumstances, it appears unnecessary to have a complete moratorium on killing whales. In fact, a moratorium would be counterproductive, for some countries and some people see a need to continue killing whales. Moral issues notwithstanding, this is a far better compromise than a total moratorium with no means of enforcing it. After much hard work on the part of the nations belonging to the Whaling Commission, with considerable short term sacrifice on the part of some, the commission now appears to be able to control whaling around the world.

What About the Future?

Despite the poor performance of the Whaling Commission until 1965, and its slow progress thereafter, I am optimistic about the future. Instead of criticizing the commission for its failures, let us look at it positively to see what it has accomplished. Let us also remember that this has been accomplished in a remarkably short time.

If we operate on the assumption that organized whaling began in 1001, less than a thousand years ago, and compress the whole history of that period into a single day, IWC began its work only 41 minutes ago. The first substantial steps toward successful management are less than 18 minutes old. Perhaps we should be impressed with what has been accomplished in that short period, rather than take the totally negative attitude of bewailing the failures and slow action.

First of all, we should recognize that, despite the failure to stop overharvesting completely, it has been clearly demonstrated that the harvest would have been greater if we had not had the imperfect constraints that the commission imposed (Gulland, 1966). Remember also that before the Whaling Commission was established, there were no limitations on whaling at all. Whales of any size were killed, even nursing young, to make it that much easier to kill the protective mother. Whales were used as fenders between mother ship and catcher boat, then discarded when they deteriorated too much. Whales were marked with flags, once killed, to be picked up later at a more convenient time, but many were lost. Whales were killed for their baleen only, or for the baleen and the blubber, and the rest discarded. All of this was most wasteful and destructive, but all was at least partially halted by the convention. Indefinite moratoria, not just for an arbitrary period of 10 years, were placed upon right, bowhead and gray whales. The recovery of the gray and some signs that right whales are becoming more abundant demonstrates that these measures were successful. Since those beginnings, many other things have happened such as the prohibitions on killing blue and humpback whales. Elimination of the blue whale unit, rational quotas upon fin, sei, and sperm whales, with complete prohibition in some areas, and implementation of an international observer scheme, all have contributed.

Unfortunately these measures were not enough to prevent severe overharvesting of some species, and although the situation is improving, it is not yet certain that all whales will return to their former abundance. The story of the gray whale, however, is encouraging, and there is hope for all the rest. It is now time to stop efforts to interfere with regulated whaling, as some brave but misguided persons have tried to do, and to drop the public clamor for a total moratorium, which could well be counterproductive. If utopia were around the corner, perhaps we could afford the luxury of leaving whales alone, but it is not yet an acceptable substitute for wise thinking and compromise.

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Coastal Resources: Exploring Our Continental Shelf

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SOME BACKGROUND

Continental shelves are submerged margins of the continental blocks. They range in width from almost nothing off southeast France and Algeria to more than 1,000 km off Norway and the USSR. Usually they are wide with gentle slopes off old and stable coasts with low relief such as the east coast of the United States, and are narrow and steep off young and active mountainous coasts such as the west coasts of North and South America. The continental shelf off New York and New Jersey is approximately 180km wide and has a slope of only about 03'; a change in elevation of less than 1 m in every 1,000 m, a slope gentler than that required of a billiard table for championship play.

Continental shelves are submerged beneath the sea now, but they have not always been. As recently as 15,000 years ago they were exposed to the atmosphere--high and dry. Where fish and plankton now swim in our own shelf waters off New York and New Jersey, only 15,000 years ago bison, ancient elephants, mastadons, tapirs, horses, and other large mammals roamed. At that time the shelf was covered with climax forests of northern hardwoods and boreal conifers, with meadows, and with fresh water wetlands. The Hudson River made its way across the broad, gentle plain for 180 km before it finally reached the sea that lay beyond the edge of the continental shelf. The estuary of the Hudson was small, confined to the head of the canyon the Hudson had carved into the outer edge of the continental shelf as it cascaded over the edge of the gentle shelf and down the much steeper continental slope. There was no Great South Bay, and no Long Island Sound.

Fifteen thousand years ago it was the last glacial maximum. For most of the previous 80,000 years, sea level had been falling. Water evaporated from the ocean and carried by warm air masses over the continents was precipitated as snow as the air was cooled by the colder continents. Year-by-year, for nearly 80,000 years, the glacier had grown and advanced. By 15,000 years ago it extended from the Arctic Circle all the way down into what is now coastal New York. At its maximum extent it covered Long Island Sound and most of Long Island, Fig. 1. Winters were long, wet and harsh. Summers short and cool. Mean annual temperatures were 8 to 10°C cooler than today. Sea level stood nearly 125 m below its present level, Fig. 2.

Fifteen thousand years ago the scene was set for a change. The climate began to warm up. The glaciers still grew each winter, but they lost more to melting in the other seasons than they had gained the winter before. Their long retreat had begun.

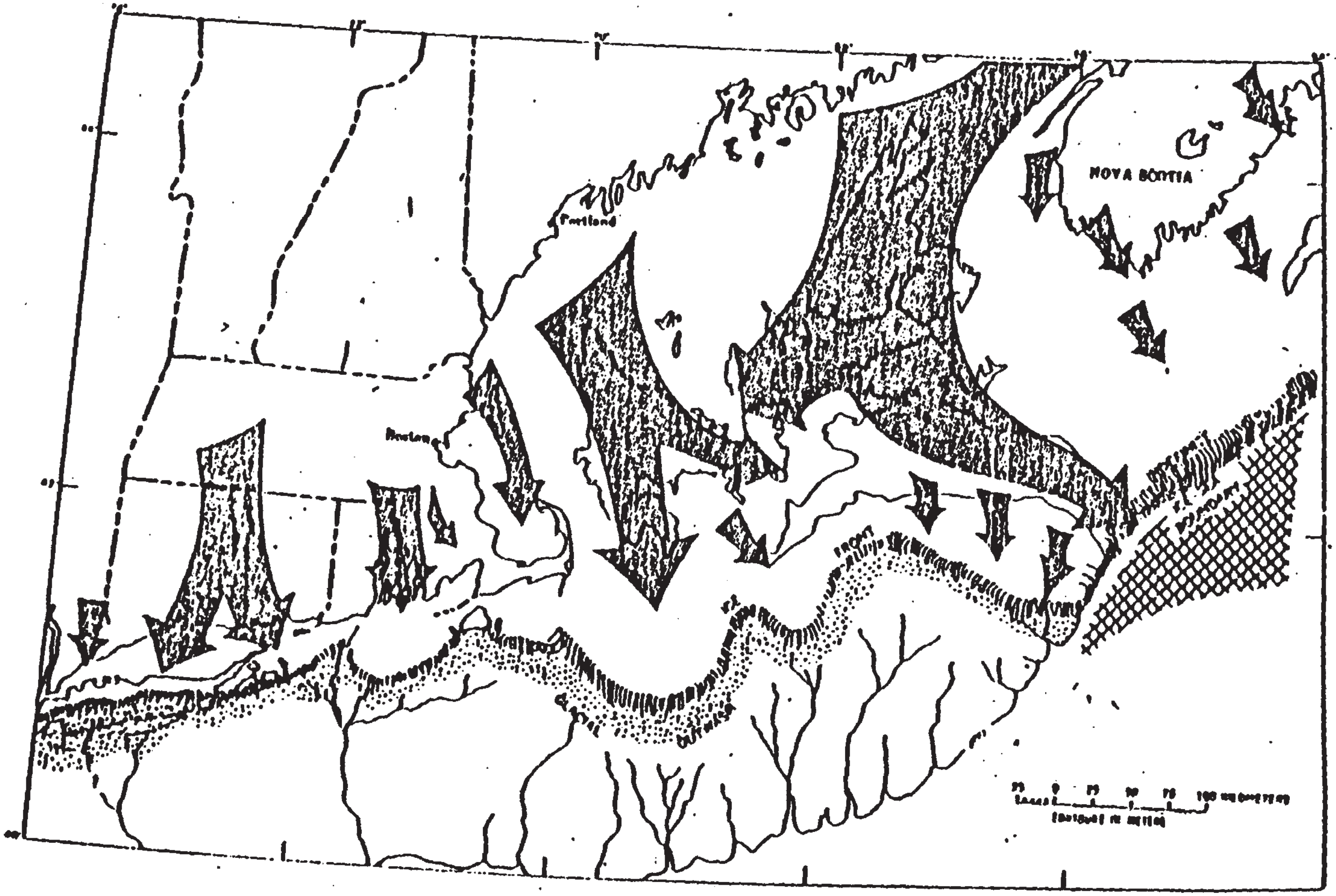

FIGURE 1. SCHEMATIC MAP SHOWING MAXIMUM GLACIAL ADVANCE OFF NEW ENGLAND-NEW YORK.
(From Schlee and Pratt, 1970).

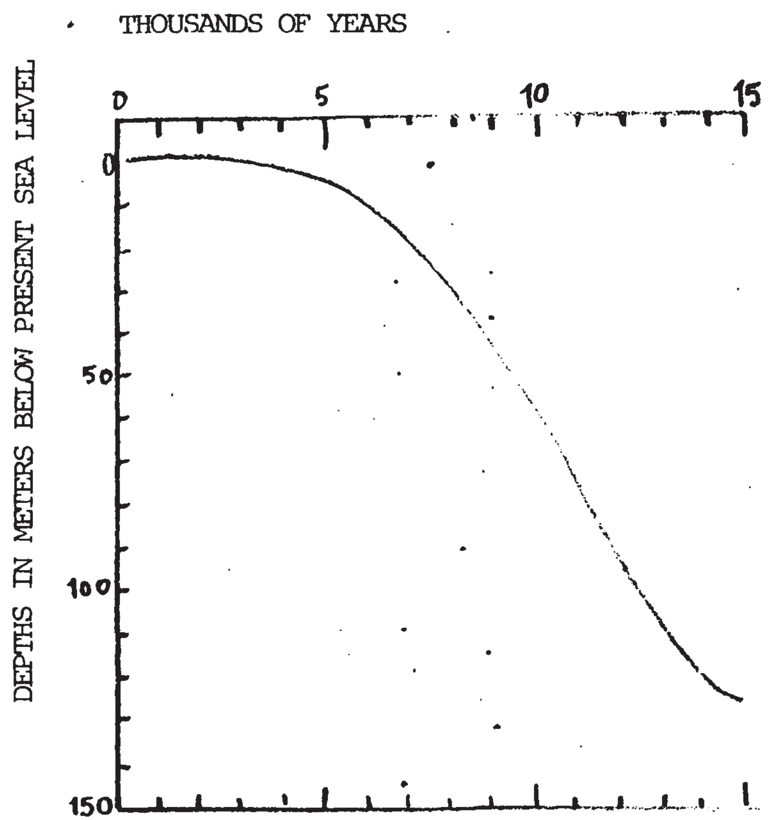

FIGURE 2. Sea level over the past 15,000 years

It would not end until the great North American ice sheet had retreated all the way to the pole. By 14,000 years ago the ice had retreated to Connecticut; the Long Island Sound Basin was free of glacial ice, near its eastern end was a glacial lake. The glaciers continued to melt and retreat.

What the glaciers lost, the sea gained. Meltwater ran from the glaciers, first in countless rivulets then into streams, and finally in rivers that raced to the sea. Getting back its own the sea responded. It began to rise. The rise was rapid at first, averaging more than one meter per century from about 15,000 years ago to 5,000 years ago, Fig. 2. For every meter it rose, it advanced laterally more than 1,000 meters--an advance across the shelf of more than 10 meters per year. By 8,000 years ago the sea had risen high enough to spill over the Mattituck Sill near the eastern end of Long Island Sound and into the sound, converting it from a glacial lake into an estuary--the Long Island Sound estuary. By 3,000 years ago the sea was within a few meters of its present position. At that time its rate of rise slowed appreciably. The barrier islands along the south shore of Long Island had been formed, enclosing a series of coastal lagoons behind them. The configuration of the coastline was similar to what we observe today, at least in its gross features.

The advancing sea had drowned the continental shelf. The rampaging rivers and the glacial outwash had blanketed the shelf with sand and gravel. The only reminders of the shelf's recent dry past are the elephant teeth occasionally dredged up in fishermen's nets, and the peat deposits now buried beneath the shelf's surface.

Geologists call such attacks of the sea or the land, "transgressions", as if the suggest that the sea had an obligation to stay within its own basin. In fact, the sea has resided peacefully within its oceanic basin for most of the past one million years, and perhaps longer. The available data suggest that we have had interglacial periods as warm as the present Holocene Interglacial, with sea levels as high as today, only about 10 percent of the time over at least the past one million years. Interglacials, and accompanying highstands of the sea have occurred on the average once in every 100,000 years and each has lasted about 10,000 years. Our present interglacial has already lasted much longer than that--half again as long. Are we due for another glacial period? Perhaps. But there are those who argue just as convincingly that people's activities have warmed the earth's climate and that the remaining glacial ice may melt causing a further rise of sea level.

An estimate 26 million cubic meters of glacial ice now cover about 10 percent of the land surface of the earth. This ice is concentrated in the Antarctic ice sheet, and in small glaciers in the Arctic and in the Alps. Nearly 90 percent is contained in the huge Antarctic ice sheet centered roughly on the South Pole. If this ice sheet were to melt entirely, sea level would rise nearly 60 meters. New York, Philadelphia, Baltimore, Washington, Richmond, and all of Long Island would be submerged. The Hudson River estuary would be joined with Long Island Sound and with the Delaware Bay and Chesapeake Bay to the south. But don't rush to unload your present waterfront property or to invest in land in the Peekskill's or the Catskill's that would become waterfront. To melt the entire Antarctic ice cap would take thousands of years. However, partial melting could cause appreciable changes in sea level in a much shorter time.

Substantial world-wide changes in sea level within a few decades could occur only if large quantities of glacial ice were calved--split off-from the Antarctic ice sheet into the Southern Ocean. A surge of ice from Wilkes Land could raise sea level by more than 15 meters in less than a century.

It isn't clear which way sea level will swing next, but change is the order of nature and almost any change is bound to be bad for society. A rise of only a few meters would drown most of our coastal areas. A fall of the same amount would drain large areas of our estuaries and nearshore environments. Many shipping channels would be useless; dredging problems would be exacerbated beyond anything we have dreamed of. Our coastal areas literally live under the Sword of Damocles.

Our present coastal environments are young geologically; none is older than 15,000 years old, and all of our estuaries are less than 10,000 years old. There is tremendous pressure on these areas by society; pressure to take as much from them as we can, and in return to burden them with our waste products. Despite their youth, some already show signs of old age.

In the remainder of this paper we will examine briefly some of the mineral resources and the living marine resources of our continental shelf, and a strategy to help ensure that the dredging required to maintain the Port of New York and New Jersey can be carried out with acceptable risk to the environment and the living resources that depend upon it, including people.

MINERAL RESOURCES

Sand and Gravel

Most of the continental shelf off the east coast of the United States is blanketed with sand and gravel deposits that range in thickness from a few meters to a few tens of meters, Fig. 3. These are relict deposits; deposits laid down by rivers and glacial outwash during the last lowstand of sea level and the succeeding period of rising sea level. The sedimentary particles are generally angular to sub-rounded, and predominantly quartz. They will become an increasingly important natural resource in the near future.

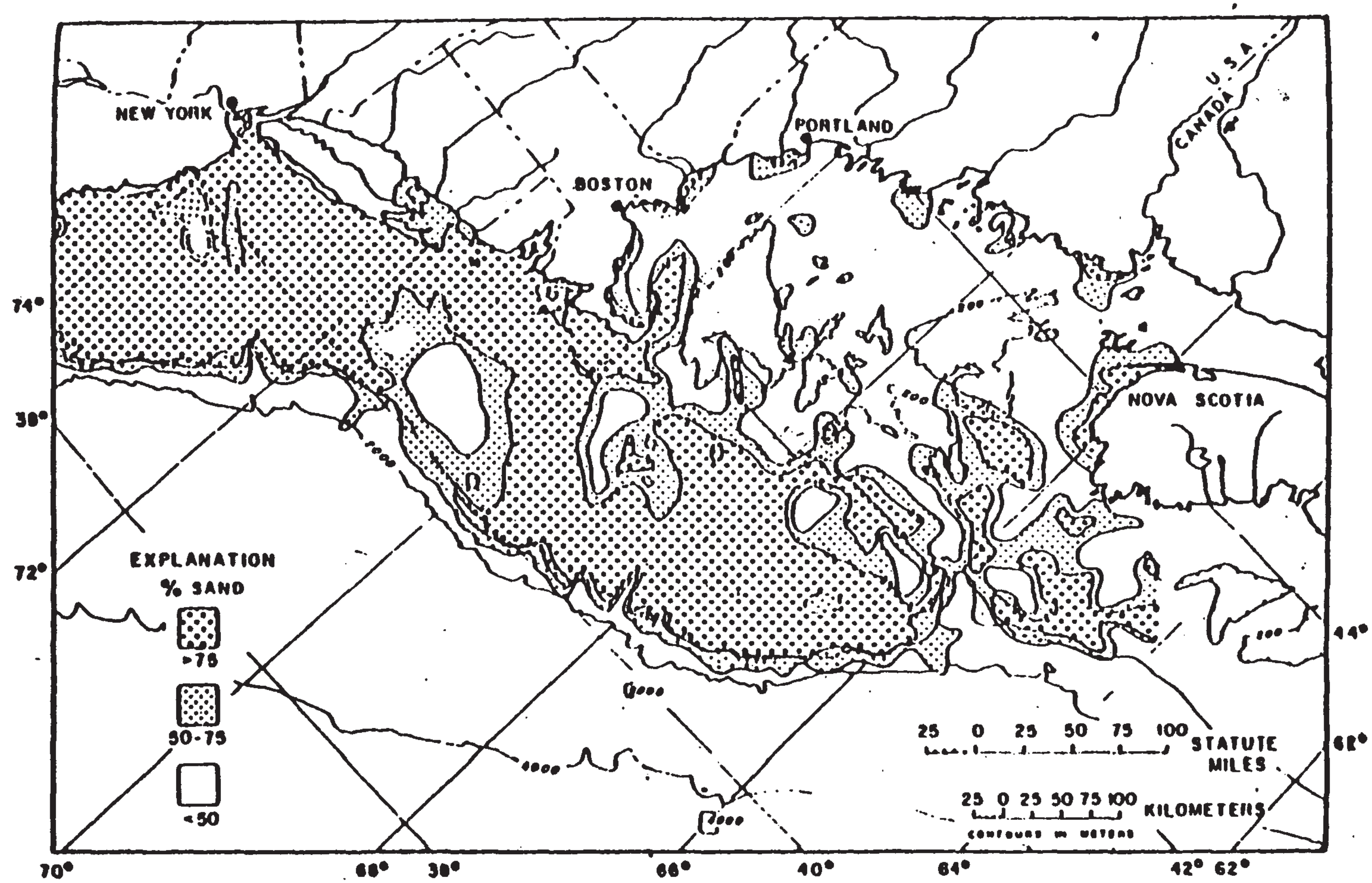

FIGURE 3. DISTRIBUTION OF SAND ON NORTHEASTERN ATLANTIC SHELF AND SLOPE.

Future demands for sand and gravel by the United States have been projected at nearly two billion metric tons per year by the 1980's. The metropolitan New York area alone will need an estimated 65 to 80 million metric tons (25 to 30 million cubic meters) for construction aggregate and for fill over the next five years. Much of this will have to come from submarine sources. Creeping urbanization and suburbanization have fore-closed many terrestrial sources of sand and gravel within an economic distance of the metropolitan region including those sources on Long Island.

A recent study carried out for the New York Sea Grant Institute examined the present and future demands for sand and gravel in the metropolitan New York area and assessed the capacity of terrestrial supplies to meet these demands. The investigators concluded that regional shortages of construction aggregate could be expected by the year 2000 and that even before then transportation costs would cause suppliers to look to offshore sources.

To date, sand deposits on our continental shelf have been exploited only for beach nourishment. Sand and gravel resources of the Lower Bay of New York Harbor, however, have been an important sources of material for construction aggregate and for fill. Since about 1963 the Lower Bay has displaced Long Island as the principal source of sand to the Metropolitan Region. Between 1950 and 1975 the rate of removal of sand from the Lower Bay ranged from 230,000 cubic meters to nearly 15 million cubic meters per year, and averaged about 2.8 million cubic meters per year. Because of conflicting uses within the harbor, we will soon see a move to deposits on the inner continental shelf. Not only can these deposits be mined without adversely affecting the living marine resources, but coupling their removal with disposal of contaminated solid wastes in the excavated pits could lead to improved environmental quality. This is discussed more fully in a later section.

Oil and Gas

The geological requirement for development of an economically exploitable reservoir of petroleum is the presence of several kinds of rock, each in a particular relation to the others. Such an association of rocks is called a formation, and it is the presence of particular formations that petroleum geologists seek in their search for oil and gas.

A good petroleum-bearing formation contains a source rock, a deposit rich in organic matter which can decompose to form oil; a reservoir rock, a deposit highly porous and permeable where petroleum can accumulate and from which it can be pumped; and a trap rock, a rock which encases the reservoir rock and confines liquid petroleum within it. Traps may be either structural of stratigraphic, or a combination of the two. A structural trap is often a concave-shaped rock sheet that has been deformed by tectonic processes. A stratigraphic trap is formed sometimes by layers of impermeable sedimentary rock, or by ancient coral reefs firmly cemented by deposition of additional calcium carbonate in the interstices.

The Atlantic continental shelf of the United States is the seaward extension of the exposed Atlantic Coastal Plain, a thick wedge of gently sloping sedimentary strata deposited over the past 75 to 150 million years. The thin edge of the wedge is onshore; the thick edge, offshore. The wedge of sedimentary deposits overlies crystalline basement rocks. The surface of this basement is creased with a long, deep depression that runs roughly parallel to the edge of the continental shelf and stretches from south of Long Island (NY) to Cape Hatteras (NC). The depression is filled with several tens of thousands of meters of sedimentary rocks produced over millions of years by erosion of the continent and by additions pf organic matter from biological activity (primary productivity) in the shallow overlying shelf waters. This depression is called the Baltimore Canyon Trough, and it is this trough that is thought to hold rich petroleum reserves, Fig. 4. A similar feature is found under Georges Banks off Maine and Nova Scotia.

One theory of the origin of this trough is that during the initial formation of the Atlantic Ocean some 300 million years ago, a large segment of rock slipped down as a result of tensional forces in the earth's crust. Later, as large masses of sediment filled the trough, their weight depressed it still further allowing additional sediments to accumulate. On the seaward side of the trough an extensive ridge of coral reef grew upward to remain in the sunlit near-surface waters as the bottom sank beneath it. The sediments that fill the trough are thought to constitute both a good source rock and a good reservoir rock, Having been deposited in near-shore water, they should be rich in organic matter derived from high primary productivity of nutrient-rich waters. Their rapid rate of deposition should have buried considerable amounts of this organic matter to depths great enough where temperature and pressure were high enough to produce petroleum. They appear to meet the criteria for good source rocks. The texture of the materials should provide porous and permeable sedimentary rocks, making them good reservoir rocks. The crystalline basement below and the impermeable coral reef to the seaward side should act as good trap rocks, completing the potentially favorable formation. Favorable geological conditions do not, of course, guarantee economical deposits or petroleum, and the results of preliminary exploratory drilling in the Baltimore Canyon Trough have been disappointing. But the jury is still out. If extensive petroleum reserves are found, there is no reason why their exploitation need interfere with other uses of our continental shelf waters.

Other Mineral Deposits

Because of the recent history of our continental shelf, one might expect to find valuable placer deposits. Placer deposits are deposits of minerals such as gold, diamonds and rutile which have been concentrated by flowing waters because of their great density. To date, no valuable placer deposits have been found on our continental shelf and none are likely.

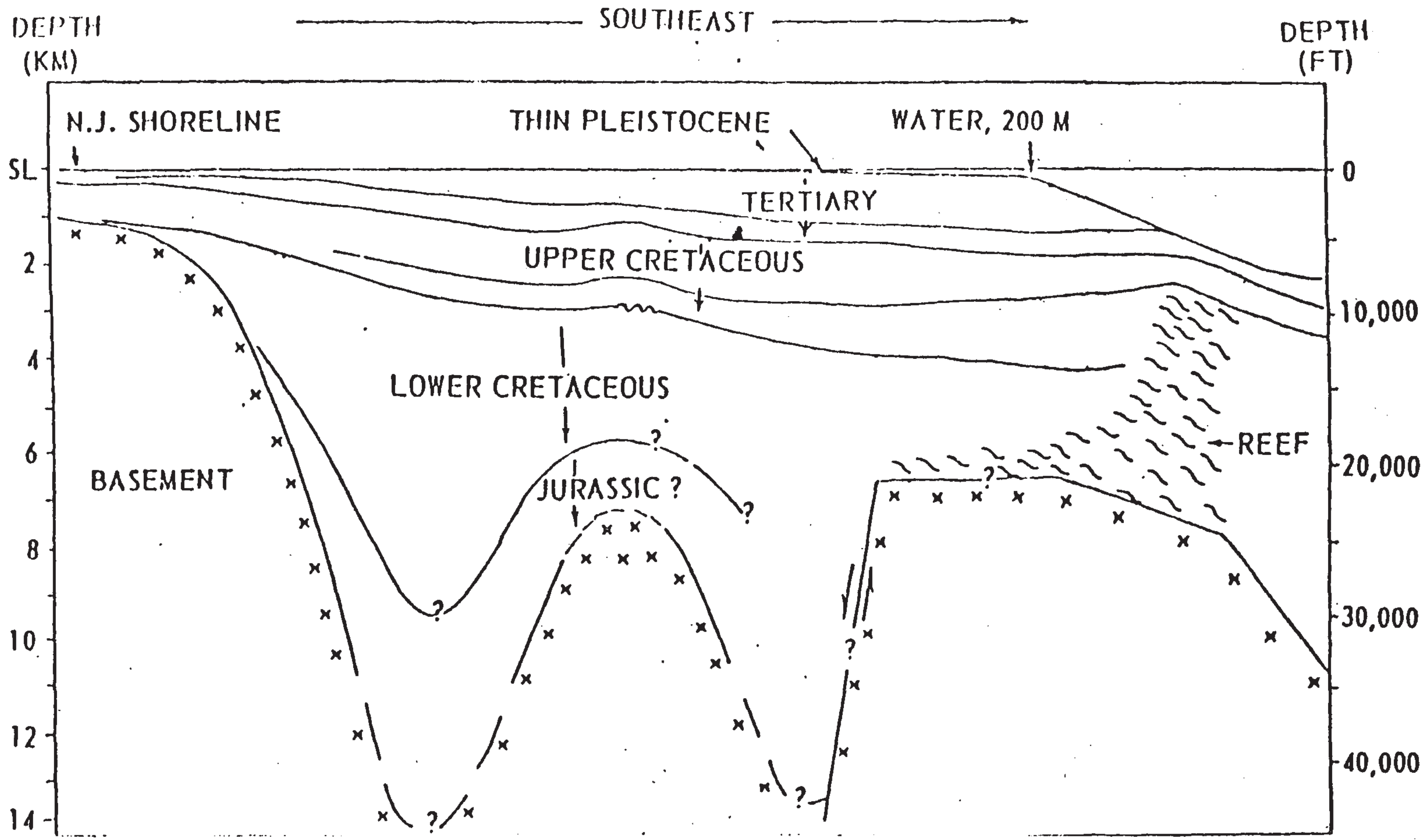

FIGURE 4. Diagrammatic Section Across Baltimore Canyon Trough Illustrating Regional Structures and the General Geology. Figure is based on a common depth point seismic reflection profile shot for the U.S. Geological Survey offshore of New Jersey. The basement intrusion located near the center of the diagram is a local feature in the Baltimore Canyon trough. The ridge structure beneath the shelf-slope break parallels the Continental Slope along the entire Mid-Atlantic area. From USGS (1975).

LIVING MARINE RESOURCES

Our continental shelf waters have been an important fishing ground since colonial days. The first whaling by New World colonists began on Long Island about 1640, and long before that time Indians had learned to harvest shellfish and finfish that abounded in local waters. Early settlers not only harvested fish for food, but used trash fish such as menhaden for fertilizer, plowing them into the ground to nourish the soil. Today, commercial and recreational fisheries still are very important to the economy of the region.

Total domestic catches of all species from New York continental shelf waters have fluctuated widely over the past century. Professor J.L. McHugh of the State University of New York's Marine Science Research Center has identified three distinct periods: 1880-1926; 1929-1962; and 1962-1975 (Fig. 5.).

1880-1926. Although there are numerous years for which no data are available, two features stand out. First, landings fluctuated widely and second, the general trend in landings was downward. According to McHugh, low landings probably reflect economic conditions and not declines in supply. Each low point coincided with a recession.

1929-1962. There was a sharp recovery in fish landings following the great depression. The rise was stimulated by meat rationing in the 1940's, but had its beginnings in the late 1920's when enterprising fishermen found wintering grounds of many coastal species on the outer shelf. There was a sharp rise in landings in 1945 because of the industrial fishery for menhaden for production of fish oil and meal. The stimulus for development of the east coast menhaden fishery was the collapse of the Pacific sardine industry in the 1940's.

The greatest total domestic commercial catch on record was 314,000 metric tons in 1951. Eighty-seven percent by weight was menhaden.

1962-1965. There was a precipitous decline in total landings because of the collapse of the menhaden industry in New York and New Jersey. The rise after 1971 resulted from the local and temporary resurgence of menhaden, supplemented by additional catches of striped bass, scup, blue crab, hard clams, weakfish, bluefish and summer flounder.

Total catch statistics are dominated by industrial fish, particularly menhaden. Food fish have a different history. Food fish have been declining since 1939; shellfish have been rising irregularly since 1942, principally because of the surf clam industry. The principal food fishes caught in our continental shelf and inshore waters include: flounders, scup, weakfish, bluefish, striped bass and butterfish. Others that are important include: croaker, black sea bass, haddock, shad, and mackerel.

According to Professor McHugh, the decline in food fish

Figure 5, Total commercial landings of marine fishes and shellfishes in the New York Bight area, 1880-1975 catches can not be attributed primarily to foreign fishing. Catches had dropped substantially even before the post-war expansion of foreign fishing began. Foreign fishing was an added burden at a time when many segments of domestic fisheries were already in trouble. Adoption of the 200-mile-limit on 1 March 1977 under Public Law 94-265, The Fishery Conservation and Management Act of 1976, will not eliminate the fundamental need to develop and implement effective strategies to manage our domestic fisheries.

Our estuaries are important finfish and shellfish areas. Great South Bay alone produces more hard clams than all the rest of the United States' east coast estuaries combined, and more than half of the total United States harvest. The total value of this one fishery is estimated to be in excess of one hundred million dollars when all the appropriate multipliers are applied.

Clearly, our continental shelf and nearshore waters are tremendously bountiful and important "fishing holes", important economically and recreationally.

A PROBLEM AND AN OPPORTUNITY

One of the major problems that must be resolved for effective operation of the Port of New York and New Jersey is to secure suitable sites for disposal of dredged materials that fail to meet the bioassay and bioaccumulation criteria for ocean disposal. It has been estimated that with enforcement of these criteria 10 to 20 percent of the material dredged from the Port will be unacceptable for ocean disposal. Historically, most of these materials have been dumped in the New York Bight. Ten to 20 percent of the total is equivalent to a volume of one to two million cubic meters per year for which an alternative disposal site, or sites, must be found--an alternative to continued disposal in the New York Bight. Sites must be secured if the port is to be operated without interruption and without serious economic perturbations to the region. On superficial examination, the range of alternative sites appears to be large and includes: upland areas, fringing areas, artificial islands, overboard within the harbor and in other coastal waters, and confined subaqueous disposal behind barriers. It also has been suggested that these waste materials should be put to constructive uses such as the manufacture of bricks and building blocks. For New York and for many other metropolitan regions, the number of practical alternatives--both practically and environmentally--is much smaller and dwindling.

One potentially attractive alternative for disposal of contaminated dredged materials and other contaminated solid wastes is to bury these materials beneath the sea floor and cover them over with clean sediments. This is a procedure that is only now being tested. It differs from previous capping operations in which materials to be capped were dumped on the ambient sea floor. The proposed strategy call for the excavation of deep pits in the sea floor, back-filling with contaminated wastes, and covering over with a relatively thick cap of clean sediment that matches the texture of surface sediments in undisturbed surrounding areas. The disposal strategy makes sense economically only if there is a competitive market for the sand and gravel that is extracted. There is.

We believe this combination of strategies could solve two of the region's problems. It could provide much needed sand and gravel at competitive prices, and it could provide suitable sites for disposal of contaminated dredged materials. Burial of contaminated dredged materials beneath the sea floor probably provides the safest method of disposal for these materials. It removes them from contact with human beings more effectively than disposal on islands, in upland areas, or in fringing areas, and isolates them from contact with the water and marine organisms.

A CONCLUDING REMARK

Our continental shelf and nearshore coastal environments are vitally important to this region because of the variety of uses they serve. Many of our activities depend directly or indirectly upon these environments. We use them for shipping and transportation; for their extractable resources--organic and inorganic; for cooling the condensers of power plants; for recreation and aesthetic enjoyment; and we use them as repositories for many of our waste products. All of these uses are legitimate, but they sometimes make conflicting demands on the environment. To ensure maximum benefit to society from these resources over the longer term we must develop effective management plans. Economic pressures to use the Bight and other continental shelf areas for waste disposal will intensify. This will be true in spite of the Ocean Dumping Act; more stringent criteria for the disposal of dredged materials in the ocean; and a variety of other actions taken recently to safeguard the ocean and its living resources. These pressures need not lead to further degradation of our environment and its living resources. But without proper planning and management they surely will. The enactment of well-intentioned environmental policies, but policies whose implications have not been analyzed rigorously, serve neither society nor the environment well.

Environmental policy should follow a clear statement of the problem. A thoughtful identification of alternatives for dealing with the problem, and a rigorous assessment of the environmental, economic, and socio-political factors associated with each alternative. Our waters should not be considered independently of our land and our air. It is high time that we substituted a multi-medium approach for the single-medium approach to the management of environmental problems.

MARINE TOXINS:

POTENTIAL AIDS TO HUMAN HEALTH

by

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The world's oceans comprise the largest of all biospheres or regions of life on planet earth. It is some 300 times greater by volume than the living space on land. And the range of various environmental conditions is much narrower than those found on land. Temperature, for example, ranges from about - 1.6°C in Antarctica and deep waters to about 30°C at the surface of the Red Sea, as opposed to recorded air extremes of -68 and +58°C. Salinity varies to only slightly in various parts of the open ocean. The ranges are greater, of course, in estuaries and enclosed lagoons. A highly saline, hot brine source has been discovered at the bottom of the Red Sea. But on the whole, the marine environment is remarkably constant over large areas, so much so that the major characteristics of the world's oceans may be measured in terms of relatively minor differences in specific gravity or density.

There is a greater variety of major types of organisms in the sea than on land. Some animal phyla, such as the Echinoderms (sea stars, sea cucumbers, sea urchins, etc.) and the Chaetognaths (arrow worms) are exclusively marine. Many other phyla are predominantly marine with only a few freshwater representatives (cf Table I).

It's impossible to give an exact number of poisonous and venomous marine animals, because the possible toxicity of some marine forms has still to be determined. However, at least 1,000 species of marine animals are known to be toxic. For the most part, the 1,000 or so toxic marine species are widely distributed in all the oceans of the world but are predominantly associated with coral reefs and they represent the full gamut of marine life - from unicellular dinoflagellates to fishes.

There are numerous, though often times erroneous, references in ancient literature to the use of aquatic organisms as aids in various human disorders. In antiquity, for example, the poison from the puffer fish was used to treat sciatica and the poison from the newt and giant salamander was used to cure stupidity - with what success no one knows!

TABLE I

APPROXIMATE NUMBER OF LIVING SPECIES OF INVERTEBRATES

Phylum	No. Species	Phylum	No. Species
PORIFERA*	4,500	SIPUNCULOIDEA	275
CNIDARIA*	11,000	ECHIUROIDEA*	80
CTENOPHORA*	80	ANNELIDA*	8,800
PLATYHELMINTHES	15,000	ONYCHOPHORA	80
RHYNCHOCOELA (=NEMERTEA)*	600	ARTHROPODA	800,000
BRYOZOA (=ENTOPROCTA)*	60	TARTIGRADA	170
ACANTHOCEPHALA	300	CHAETOGNATHA*	60
ROTIFERA	1,500	POGONOPHORA*	100
GASTROTRICHA	150	ECHINODERMATA*	6,000
EKINORHYNCHA*	100		
NEMATOHELMINTHES	80,000		
NEMATOMORPHA	250		
ECTOPROCTA (BRYOZOA)*	4,000		
PHORONIDA*	15		
BRACHIOPODA*	310		
MOLLUSCA*	110,000		

* EXCLUSIVELY OR PRIMARILY MARINE SPECIES.

Pliny the Elder, who lived around 50 A.D., recounts the often bizarre effects attributed to the use of marine animals in human medicine. He suggested that the spine of the stingray, when burned and mixed with vinegar, will alleviate the pain of toothaches. And if the intact stingray spine is attached to the navel of a pregnant woman, it will enable her to have easy childbirth, provided the spine is taken from a living ray which is then returned alive to the sea. Pliny also commented on the toxicity of a nudibranch, or sea slug. The poison from this animal, he reports, is so deadly that if a pregnant woman even looks at it, she will immediately feel pain, become nauseous and abort. The above examples from Pliny's "Naturalis Historia," if they were efficacious at all, would seem to be more in support of psychotherapy than as potential drugs from the sea. But scientists have made some interesting discoveries based on clues received from folklore of primitive cultures.

Although the terms venomous and poisonous are often used interchangeably, most biotoxicologists prefer to restrict the use of the word venomous to those animals which have a gland or group of highly specialized secretory cells, a venom duct (although this is not a constant feature), and a structure for delivering the venom. Venomous animals are phanerotoxic (Gk phanero = obvious). Poisonous animals are cryptotoxic (Gk crypto = hidden). The toxic nature of poisonous animals is not obvious without detailed examinations that often involve sophisticated bioassays. These animals do not have an apparatus to deliver the poison. Poisoning by these forms usually takes place through ingestion rather than injection. Animals such as snakes, stingrays and zebrafish are venomous while certain porcupine and puffer fishes are poisonous animals.

Research dealing with toxins from marine animals may lead to the development of drugs useful in human medicine. Marine organisms have already contributed significantly in the search for useful drugs: extracts from sea weeds are used in the pharmaceutical, cosmetic, food and industrial fields as emulsifiers, absorbents, stabilizers and thickeners. Marine algae have also been shown to contain substances with broad spectrum antibiotic, antiviral and anticoagulant properties, and have been used to heal experimentally-induced ulcers. Seaweed extracts are effective in treating parasitic roundworm (Ascaris lumbricoides); whipworm (Trichurus trichura) and tapeworm (Taenia spp.) infestations. And biologically active substances have been obtained from a variety of marine animals (for detailed reviews, cf Selected Readings).

Toxicity is a useful indicator of biological activity and, as such, provides important leads to other pharmacological properties of value. Marine biotoxins offer a variety of new or little-known molecular structures which chemists may ultimately synthesize and manipulate into useful products. Extracts of sponges, crabs, corals, sea anemones, annelids, molluscs, echinoderms and other marine invertebrates have been tested for anticarcinogenic, antibiotic, hemolytic, analgesic and hypo - and hypertensive activities.

Halitoxin, extracted from the sponge Haliclona viridis, extended the life of mice inoculated with Ehrlich ascites tumor cells, and the administration of an extract from the sponge Chondrilla nucula extended the survival time of mice with lymphocytic leukemia. Broad spectrum antibiotics have been extracted from a number of sponge species.

Antimicrobial substances have also been found in various cnidaria and palytoxin, a toxic principle, extracted from Palythoa toxica, was effective against Ehrlich ascites tumors in mice. Prostaglandins were found in the gorgonian, Plexaura homomalla. Prostaglandins are hormones that exhibit powerful physiological activities in mammals; they stimulate smooth muscle, depress blood pressure and exert tranquillizing effects on the central nervous system. The jellyfish, Aequorea aequorea, has a bioluminescent protein that glows in the presence of calcium or strontium. Aequorin, the bioluminescent protein in this jellyfish, can record minor changes in calcium content in biological fluids; such calcium changes are often reflective of cellular dysfunction which may signal the onset of certain cardiac irregularities. The sea anemone, Rhodactis howesi, widely distributed on coral reefs in the tropical Indo-Pacific, contains a powerful neurotoxin. It also has an anti-coagulant factor that appears to be distinct from the lethal toxin.

A tube-dwelling polychaete worm, Thelepus setosus, has yielded an extract that has antifungal activity. And extracts of the tentacles of two tropical marine polychaetes (Lanice conchilega and Reteterebella queenslandia) prevented the growth of Ehrlich ascites tumors in mice.

A novel insecticide was developed from a toxin from a marine worm found in Japanese waters. The toxic constituent was first isolated from the annelid, Lumbrinereis brevicirra, in 1934. Scientists in Japan worked on this toxin for more than 30 years and were successful in developing a new insecticide. This synthesized insecticide (PADAN) is effective against the rice-stem borer and other insect pests. It is not toxic to warm-blooded animals and it is biodegradable. It is also effective against insects that had developed a resistance to organophosphates or chlorinated hydrocarbons.

Antibacterial and antiviral substances have been extracted from a variety of molluscs, including abalone, clam, sea snail, queen conch and squid. Eledoisin, found in the posterior salivary gland of the octopus Eledone, was 50 times more potent than acetylcholine, histamine or bradykinin in provoking hypotension in dogs. Eledoisin acts peripherally, affecting smooth muscle and/or postganglionic pathways to blood vessels.

Many species of echinoderms (notably sea cucumbers and sea stars) contain highly toxic substances. Holothurin, a steroid saponin from the Bahamian sea cucumber, Actinopyga agassizi, suppressed the growth of Krebs-2 ascites tumors and Sarcoma-180 in mice. Holothurin also inhibited the growth of a variety of protozoans, interfered with regeneration in planaria, modified developmental patterns in sea urchin eggs, and increased the phagocytic activity and affected the amoeboid movement of leucocytes. It also is a potent hemolytic agent and interferes with nerve conduction and modifies both excitation and conduction phenomena of myocardial cells. Similar saponins have been obtained from other sea cucumbers and sea stars. These toxic substances elicit a variety of pharmacological effects on mammals. Holotoxin, a steroid glycoside extracted from the sea cucumber, Stichopus japonicus, exhibited strong antifungal activity.

Other toxins, such as saxitoxin and tetrodotoxin have been extensively studied. Saxitoxin is found in certain toxin-producing dinoflagellates ("Red Tide") and because they are concentrated by certain molluscs (clams, mussels) without any deleterious effects to the molluscs, they are responsible for poisonings in humans who unknowingly eat the affected clams or mussels. Tetrodotoxin also known as puffer or fugu poison is found in certain puffers, ocean sunfishes and porcupinefishes. The poison is concentrated in the ovaries and liver with lesser amounts in the intestine and skin. The amount of toxin in the fish is related to the reproductive cycle and appears to be greatest just prior to spawning. Tetrodotoxin is also found in a California salamander, a goby fish, certain Costa Rican frogs and a species of octopus. Saxitoxin and tetrodotoxin have different chemical structures. But both toxins exhibit the same clinical symptoms when humans become poisoned and both elicit identical effects on excitable membranes. They both block action potentials in nerve and muscle by preventing, in a very specific way, an increase in the permeability to sodium ions, without affecting the outward potassium flow. These toxins are extremely useful for an understanding of excitation phenomena at the ultrastructural level. Scientists contrasting the effects of tetrodotoxin with other toxins have concluded that the sodium channel is located between 5 and 15 Å from the potassium channel on the membrane of the muscle fiber.

There is a fantastic array of powerfully toxic substances present throughout the phylogenetic series of marine animals. Several of these biotoxins are more toxic than some of the well-known synthetic poisons.

Toxins and other biologically active substances extracted from phytoplankton, coelenterates, annelids, molluscs, crustaceans, echinoderms, fishes and other marine animals show a wide range of toxicological and pharmacological activity on nerve, heart, muscle and other organs and tissues. Several of these toxins, some of which have recently been purified and chemically characterized, are used by physiologists as novel potent tools for analyzing the physical and chemical events associated with nerve activity; some, because of their very specific effects on certain target organs, may make their way into Materia Medica and others will serve as the basis for new synthethic drugs to combat human diseases.

Selected Readings

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Sharks: Facts and Fantasies

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Introduction:

Over the ages, man has learned to fear, hate and worship the shark, and even today great auras of terror and excitement surround this magnificent creature.

This paper will discuss sharks and their relatives, the skates and rays, from their early beginnings as primitive, heavily armored, and jawless fishes to the modern forms inhabiting the seas today. It will also discuss their internal design and explore the wide diversity of body form and behaviors (feeding and reproductive habits, etc.) in sharks today.

Evolution:

Modern fish are divided into two main classes: the Osteichthyes or bony fish; and the Chondricthyes or Cartilaginous fish, more commonly known as sharks, skates, rays, and their allies. These groups have a common ancestor in the Ostracoderms, the early jawless vertebrates of the Silurian and Devonian ages.

The jawless Ostracoderms had a bony skeleton and a vacuum cleaner type mouth--a hole into which food was drawn. These fish were mainly bottom-dwellers who fed on bottom-dwelling prey. Some of them, similar to the modern lamprey adopted a parasitic existence to avoid the problem of catching food, while others developed moveable plates around the mouth which served as a primitive kind of jaw. Their absence of a hinged jaw greatly hindered these fishes' abilities to capture and eat food.

Then came a great event in the history of vertebrate animals. Through evolution, jaws were derived from a pair of gill arches. This was not really so radical or magical a shift as it sounds. In the jawless vertebrates, each gill arch was supported by several bones which formed a V-Shape. There were several of these arch supports arranged in series. You can easily imagine how a slight forward shift of that first arch, coupled with a hinging mechanism at the point of the "V" could form the beginnings of a primitive jaw. (Very often in evolution, structures evolved from other structures which were originally designed for very different functions.).

From here, the aquatic vertebrates evolved extremely quickly. The advent of jaws opened up thousands of new ecological opportunities and the fishes took advantage of them all. Sometime soon after the development of jaws, the early aquatic vertebrates split into two main stocks: the bony fishes and the cartilaginous fishes or the sharks, skates, rays, and their allies.

The development of a cartilaginous skeleton, then, is a secondary, characteristic, and although sharks are generally considered to be "primitive" animals, there is good evidence that the bony condition is truly the more primitive one. However, sharks are "primitive" in the sense that they have changed little since they split off from the stock of bony fish over 350 million years ago.

Today sharks, like the bony fish, can be found in all oceans of the world. They range from the deepest to the shallowest waters, from the frigid seas of the Artic to the warmest tropical waters. Some live close to shore, others live far out at sea. Some species even inhabit freshwater rivers and lakes. There are flat sharks and fat sharks, fast sharks and slow sharks, shy sharks and bold sharks.

Anatomy of a Shark

Let's take a look then, at some of the factors of design and life processes that have made sharks so well adapted to a life in the water.

1) External Anatomy:

The sharks and bony fish are streamlined, as were their jawless ancestors, to help them slice through the dense watery medium in which they live. From an engineering standpoint, the tapering shape of the shark allows it to cleave the water with a minimum amount of effort. A large tail fin (caudal fin) helps drive the animal forward through the water with a back and forth sculling action. Medial fins, located on the dorsal and ventral surface, serve to stabilize the fish and prevent slide-slipping and rolling. Finally, paired fins, consisting of an anterior or pectoral pair and set of pelvic fins which can be anterior or posterior, help steer the animal through the water, assist in making sharp turns to the left or right, and in braking or backing up. The paired fins are more mobile in the bony fishes than in the sharks. Male sharks have a pair of claspers at the base of the pelvic fins to aid in copulation. So with the combination of a streamlined shape, a strong caudal fin, and medial paired fins, the shark is well adapted to an active life in the water.

The sharks' first cousins, the rays (Raiidae), on the other hand have very broad bodies which are flattened dorso-ventrally (top to bottom). The pectoral fins are enormously enlarged and have become fused to the head and trunk to form a circular or quadrangular disc shape. The rays have given up their sleek, streamlined body shape in favor of a form adapted for sluggish bottom living. Rays spend much of their time lying on the sea floor.

They depend to a large extent on resembling their surroundings to escape predation. When the need arises, however, rays can and will swim away very rapidly. An unusual method of locomotion enables them to do this. Their enlarged pectoral fins beat in an up-and-down fashion. Using its fins as wings, the ray seems to "fly" through the water. There has been a transfer of locomotory function from the tail to the pectoral fins, and a corresponding enlargement of the fins and reduction in size of the tail. Some more specialized rays have acquired protective devices other than their coloration, such as the Torpedo ray, with its powerful electric organ, and the Sting ray, with its one or more venomous spines, located on the upper surface of the tail. Sting rays are also equipped with powerful teeth, capable of crushing and grinding bivalves.

The visible lines that run across each side of a fish's body make up the lateral line system. This extraordinary sensory system is delicately attuned to the movements and currents in the water. It is comprised of a series of fluid-filled canals in the head and along each side of the body. The canals lie beneath the surface of the skin and open to the outside by way of small tubules. neuromasts or hairlike projections connected to the nervous system, extend into the canals from their inner walls. Movement of the fluid in the canals, caused by "sound" waves in the water outside, cause the neuromasts to vibrate, thus sending nerve impulses to the brain. This sytem is very sensitive to the frequency vibrations of a wounded or struggling fish, swimmers on the surface, or other potential prey items. Such sounds can be detected by sharks from a distance of over one mile.

2) Internal Anatomy:

The spiney dogfish will serve to illustrate the internal anatomy of typical sharks and rays. (Remember, a ray is really nothing more than a flattened shark).

Sharks have very small brains. The olfactory bulb is enlarged, making sharks very sensitive to odors. Cartilaginous vertebrae protect the nerve cord. The teeth of the shark are actually modified scales. When the shark loses a tooth, another replaces it. In order to conserve calcium, teeth are swallowed. Some sharks have up to 24,00 teeth in a lifetime. Instead of an operculum like the bony fish, sharks have a series of gill slits that open directly to the outside. The intestine is short and has a spiral valve for increasing the surface area. The liver is lighter than water and very large. A 15 foot shark may yield 18 gallons of oil which can be sold as cod liver oil. The oil is extremely high in vitamin A. Because sharks do not have a swim bladder, they must swim continuously or sink.

Reproduction

The breeding habits of sharks and rays differ considerably from those of the bony fishes. Fertilization is internal by copulation. In bony fish the female lays eggs and the male releases sperm into the surrounding water, bringing about external fertilization. In sharks, the male uses a pair of claspers, located at the base of the pelvic fins to stabilize himself and his mate and to guide the sperm into the female. The eggs are large and well-supplied with yolk and, once fertilized, may be shed to the outside (especially in skates and rays). Before an egg is shed, however, a casing is secreted around it for protection. The casing is made of a tough material which hardens on contact with seawater. Egg capsules are usually square or rectangular, and each corner is drawn out to a point. Water entering through a hole in the top of one of the points serves to aerate the egg. These egg cases are the "mermaid's purses" found commonly in the wrack along the high tide lines at the seashore. More often, sharks bear their young alive. The egg may hatch within the mother, who brings the young forth alive (ovoviviparity) or nurtures the embryo in the womb to give birth to a live baby shark (viviparity).

The young shark is hungry and restless. Whether it is hatched from an egg case or born alive, it must be immediately prepared to hold its own in the watery world. There is no playful puppyhood, no nest and no parental care for the newborn shark.

In most sharks and rays, breeding takes place on a seasonal basis. Small sharks bear only a few young at a time, while the large scavengers, like the tiger or hammerhead, may carry 20 or more.

Types of Sharks, Skates, and Rays

Although sharks range throughout all the oceans in the world, they are numerous in tropical and temperate waters and near the poles. There are about 300 different species of sharks and 100 rays, each varying, enormously in size and habit. To illustrate these differences, a variety of sharks, skates, and rays will be described in detail.

Local Sharks:

Spiney Dogfish (*Squalus acanthias*)

- grows to a lenth of about 2 feet;
- common in local waters--also known as the sandshark;
- most prolific shark--27 million of them were caught in one season off Massachusetts;
- name comes from sharp dorsal spines.

Great White Shark (_Carcharodon_ _carcharias_)

Feared the world over as a maneater;
stout bodies, may grow to 35' (15-18' is common);
large triangular, serrated teeth;
found in both warm and cool waters;
roams the seas freely, apparently with no territories;
little or nothing is known of reproductive habits.

Great Blue Shark (_Prionace_ _glauca_)

Sleek form, long graceful pectoral fins, and indigo blue color making them one of the most beautiful sharks;
thought to be a maneater, but there is no positive proof of this;
extremely abundant all over the world;
bears young alive.
a single female, less than 10 feet long may give birth to 50 young each about one foot long.

Mako Shark (_Isurus_ _oxyrinchus_)

Very active, strong swimming;
said to be, pound for pound, the strongest and swiftest shark;
highly prized as a game fish--leaps into the air when hooked.

The above sharks are ones you might see if you went on a shark expedition off Long Island. Now, let's look at other sharks that have unusual methods of feeding:

Thresher Shark (_Alopias_ _vulpinus_)

Unusually long tail--may be as long as the rest of the body;
jaws and teeth relatively weak;
uses tail to thrash at prey (birds, large fish);
herds schools of small fish into a tight crowd and then lunges into them with mouth open;
found in nearshore waters--east and west Atlantic, east and west Pacific.

Sawfish (_pristis_ _pectinatus_)

has a flattened, elongate snout, with rows of sharp teeth like structures on each edge;
to capture prey, the sawfish slices the saw sideways through the water and impales fish on the edge.

Basking Shark (_Cetorhinus_ _Maximus_)

Large to 45 feet long;
weight to 7 tons or more;

harmless plankton feeder;
sluggish;
found in all temperate waters of the Northern Hemisphere.

Whale Shark (Rhincodon typus)

World's largest fish, length to 75 feet;
filter feeder--eats tiny crustaceans and small fish;

The sharks described so far are all free swimming (pelagic) fish. But some sharks are bottom dwellers and have adopted a relatively suggish existence.

Nurse Shark (Ginglymostoma cirratum)

Not related to the dreaded Gray Nurse of Australia;
lies on the bottom often in schools;
most are small;
spend their entire lives in shallow, near shore waters;
feeds quietly on passing squids, shrimps, crabs, or urchins;
divers, aware of their lethargic attitudes are often tempted to approach nurse sharks and handle them. But this practice has, in the past, provoked these otherwise harmless sharks to attack.

Wobblegong (Orectolobus maculatus)

Australian bottom feeder;
beautiful coloring is used for camouflage, blends in with rocks and weeds.

Batoids (after McCormick, Allen, and Young: Shadows in the Sea).

Most Batoids, that is skates, rays, and their relatives have adopted a sluggish, bottom dwelling existence too. As we saw before, they are really nothing more than flattened sharks. They breed like sharks, feed carnivorously like sharks, and have cartilaginous skeletons. They range in size from a few inches across to the huge Giant Devil Ray, which can reach 22 feet across and weight 3,000 pounds.

Batoids do not have razor sharp cutting teeth like many sharks. Rather, their teeth are specialized for grinding up small crustaceans and molluscs that make up a large portion of their diet. The teeth may be prong-like, rounded, or flattened and are arranged in bands or in a mosaic pattern resembling paving stones.

Let's have a look at the five major groups of Batoids:

Electric Rays

Unlike any other group of Batoids, or sharks for that matter, the electric rays have highly developed electric organs. These are used mainly as a defense mechanism. The electric shocks produced are strong enough to stun a person. Electric rays have a shark-like tail although reduced in size.

Rays

Typically, rays are shaped like kites, complete with a tail. In many species, there is a spine used for defense at the base of the tail.

Skates

At first glance, skates resemble rays. In contrast to rays, however, they lack poisonous spines and their tails are heavier, fleshier and lobed. They have fleshy, moveable fins attached to the anterior margin of each pelvic fins, which they use for walking across the bottom. Few grow to a large size.

Sawfishes

Sawfishes have long, narrow, flattened snouts that have a row of sharp teeth-like spines on each edge. Sawfish are not flattened like rays but rather have bodies like sharks. They are classified as Batoids because of certain anatomical details such as gill slits on the underside of their bodies. These slits differentiate them from sharks.

Guitarfishes

Their name describes their shape. These are thought to be links between sharks and rays.

Sharks and Man

In spite of their notoriety, sharks benefit mankind. Their meat is eaten in many countries and, in fact, constitutes the fish in English and Australian "fish 'n chips." Their fins, used in shark fin soup, have long been considered a delicacy in China.

But meat is not the only shark product. Oil is extracted from the liver and used for leather tanning, wood preservation, and as a source of vitamin A. From the gelatinous fibers in the fins comes an ingredient for luxury soap. The skin is made into high quality leather; teeth and jaws are sold as novelties; and fertilizer is made out of virtually everything else that is left.

Shark Attack

Of the 300 or so species of sharks, only about 35 are considered dangerous to man. No one knows what attracts a shark or stimulates it to attack. Neither has anyone developed a sure-fire way of repelling sharks. Experiments using camouflage coloring, waterclouding dyes, noise, bubble curtains, etc. have all met with only moderate success. But, the basic take-home message is to consider all sharks as potentially dangerous, and predictably UNPREDICTABLE. They should be avoided at all costs.

Although your chances of being attacked by a shark are slim, here are some rules to follow:

1) Never swim alone. This is a good safety practice anyway;
2) Leave the water swiftly and calmly if you see a shark;
3) DON'T PANIC or start thrashing about. Sharks may be attracted to your struggling;
4) Never tease or provoke a shark. Even so-called "harmless" ones may turn on you if provoked.

MARINE TRANSPORTATION: AQUAFOIL TO SUBMARINE

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Our own coastal environment is a carefully balanced one. Since Henry Hudson ascended the river which now has his last name, New York Harbor has been considered one of the world's finest ports. The river has been used since 1699 as an important means of transportation.

Today, products which are transported by the marine services of scores of nations represent every type of raw material and manufactured good. During this exploration of marine transportation, we will identify many of the types of craft which are used in merchant fleets and ferry services, as they are used everyday around the world.

GATEWAY TO THE SEA: A CLOSE LOOK AT INTERNATIONAL INTERMODAL CONTAINERIZED CARGO IN THE MARITIME FIELD

The United States is a member, along with many other maritime nations, of the International Standards Organization (ISO) and the Intergovernmental Maritime Consultative Organization (IMCO). The latter has offices in Geneva, Switzerland.

Standardization of cargo container features, to be described in the following pages, has enabled the rapid shipment of cargo worldwide. The key feature is a corner casting which permits lifting, lashing, stacking, stowage and interchange of equipment between ships, port equipment, railroads, trucking firms and even airlines.

UNITED STATES & THE MARITIME UTILIZATION OF I.S.O. CONTAINERS

--- A Look at Intermodal Containerization in Maritime Practice

The following examples of the current utilization of the ISO container represent current practices which provides overseas market delivery of United States products. The wide variety of container types serve almost every shipper. Everything from calculators, communication equipment and cereal grains are regularly containerized. The 'box' may be loaded while on a truck chassis, then 'box' and chassis placed on a railroad flat car for destination to a portside team track, trucked to the gantry crane and loaded aboard a ship. The process is reversed on the receipt side of the marine trip. Thus multi-mode carriage of the unrepacked cargo is achieved.

INTERMODAL TRANSPORTATION OF MARINE CONTAINERS-Selected Uses

1. In recent years, the active U.S. merchant marine included 140 intermodal carriers with a total weight of 2.71 million dwt. This was 19% of the privately owned sector.

2. The Port of New York received 672 ocean going vessels of 6,785,339 net tonnage in a month. Or, almost 22 ships per day, or one every 65 minutes.

3. Portainers (shipside container loading cranes) can handle 20 ft to 40 ft containers. They can lift 30 tons, with a choice of 72 ft or 84 ft outreach. Larger capacities may be used in the more heavily trafficed ports.

4. Railroads, such as Southern Pacific, have carried over 300,000 units piggyback.

5. A 30,000 pound containerized shipment of recyclable aluminum from an estimated 600,000 beverage cans, recently was shipped from Hawaii aboard containership "Hawaiian Monarch" to the West Coast.

6. The Port Authority of New York and New Jersey's designation as "American's Container Capital" has been earned. In its entirety, this world port handled an estimated 12,000,000 tons of containerized freight.

7. Roll-on, Roll-off cargo ships carry a mix of wheeled vehicles, low-profile dolly carriages, and containers, and specialize in outsized cargo such as complete railroad trains, electric turbines, yachts, construction equipment and new autos.

SPECIALIZED CONTAINERS FOR TEMPERATURE CONTROL OF CARGO

1. Free standing all-electric powered air cooled unit, which attaches to the container and the ship's power supply.

2. Integral Unit, which is two pieces (power and compressor) flush mounted, all electric, air or water cooled.

3. Plug-In Units, one piece, recharged, ready for operation or terminal unit which is semi-permanent for use with containers which are on their way through the intermodal network. The cargo is protected during the hours between the arrival/departure of the ship, and the interface with motor carriers.

INTERNATIONAL STANDARDS FACILITATE THE RAPID INTERCHANGE OF CONTAINERS

International container standards have been developed by the International Organization for Standardization (ISO) in Geneva

Switzerland. The ISO Technical Committee #104 has established the following sub-classifications for container boxes:

A. Freight containers (general cargo and some bulks)
B. Perishable (temperature controlled)
C. Tank (one or more compartments for unpressurized liquids)
D. Bulk (fitted to be dump-unloaded)
E. Platform (onto which odd-shaped cargo will be secured)
F. Collapsible (folded flatter for back-haul trip)

ISO Recommendation R668, defines a Freight Container as:

"an article of transportation equipment:

A. of a permanent character and accordingly strong enough to be suitable for repeated use;

B. specially designed to facilitate the carriage of goods by one or more modes of transportation, without intermediate loading;

C. fitted with devices permitting its ready handling, particularly as it is transferred from one mode of transportation to another (corner castings);

D. so designed as to be easy to fill and empty;

E. having an internal volume of 1 meter ^{3}, or 35.3 feet ^{3} or more."

The term 'freight container' includes neither vehicles nor conventional packing.

The ISO Recommendation R1161, Specifications of Corner Fittings for Series 1 freight containers has been adopted by 42 member bodies of the ISO, which accounts for the wide use of containers in international maritime trade.

MARINE CARGO CONTAINERS IN MILITARY SITUATIONS

Container movement has been demonstrated by the Sikorsky S-64 "Skycrane" with a 'troop-pod' used to move military troops to conflict situations.

The U.S. Army Milvan (8x8x20 feet) has a maximum load 40,000 pounds, can be equipped with restraint devices for ammunition shipments with a maximum load of 34,000 pounds. There are 4,500 of these Milvan's in current use.

The Navy of Brazil has developed an ISO Model KA5AL container with a capacity of 5 tons (length 5 ft x 8 ft x 8 ft) with a volume of 7.86 m ^{3}. Fitted with ISO corner castings, it is compatable with the type of transport offered in Brazilian waters.

MARINE CONTAINERS TRAVEL INTO EUROPE VIA T.I.R. MOTOR CARRIERS

The International Road Transport Union (IRU) in Geneva was founded in 1948. It is an international non-governmental organization of national federations for road transport. A customs convention on the international transport of goods via road in 1959 enabled goods to travel in customs-sealed road vehicles (straight frame, tractor-trailer, or marine container trucks) to be carried on road vehicles across one or more national frontiers with a minimum of customs interference. This IRU development greatly stimulated the use of marine containers in intermodal trade. Thirty countries are in IRU.

The TIR vehicles carry removable plates, which enable the entire trailer/container to be customs sealed. The white letters TIR on a light blue background signify these approved shipments. The containers meet special construction requirements which prevent the entry to the cargo, without leaving obvious signs of tampering. The customs seals would have to be violated to gain entry to the cargo space.

These TIR marked containers travel across the frontiers with little difficulty, as long as container and customs seals are undisturbed.

MARINE CONTAINERS ALSO TRAVEL ON EUROPE'S RAILROAD SYSTEM

The company for the international transport called Trans-Containers in Basel, Switzerland is composed of 22 European national railroad administrations. It provides trans-europe container express train services. First utilized in 1970, to provide rapid and regular transport for terminal-to-terminal container movements.

Special rail cars have been designed to only carry containers and avoid the normal formalities at national frontiers. Customs clearance is obtained at the destination terminal.

The containers travel on 'block trains', which are similar to United States' use of unit trains. The entire train is chartered by Inter-Container, and looks much like the U.S. version of container on flat car (COFC). Internationally there are 72 different container manufacturers, who can fabricate containers for this purpose, and comply with ISO standards.

SPECIAL PURPOSE MARINE-MULTIMODE CONTAINERS IN REGULAR SERVICE

To meet shipper requirements, many specialized containers are in regular service, and may be seen today, or on this Maritime Administration orientation. Some of the more popular are:

A. a half-high container (4 ft. high) with a tarp cover fitted and roped into position. These are for use in covered holds.

B. an open-top container, similar to A, but full 8 x 8 x 20 foot or 40 foot in size.

C. ISO 20 x 8 x 8 ft stainless steel tank containers, with a capacity of 4,224 gallons, in a single compartment, with pressure discharge system.

D. Compass Co.'s side door opening container is std. sizes.

E. ISO 30 x 8 x 8 foot stainless steel tank container with heat and insulation and a capacity of 5,895 gallons.

F. Live stock container, with wood floor.

EXTENT OF MARINE CONTAINER CARRIER UTILIZATION

Around the world there are over 204 ship operators who publish regular container service tariffs, excluding non-vessel operating companies.

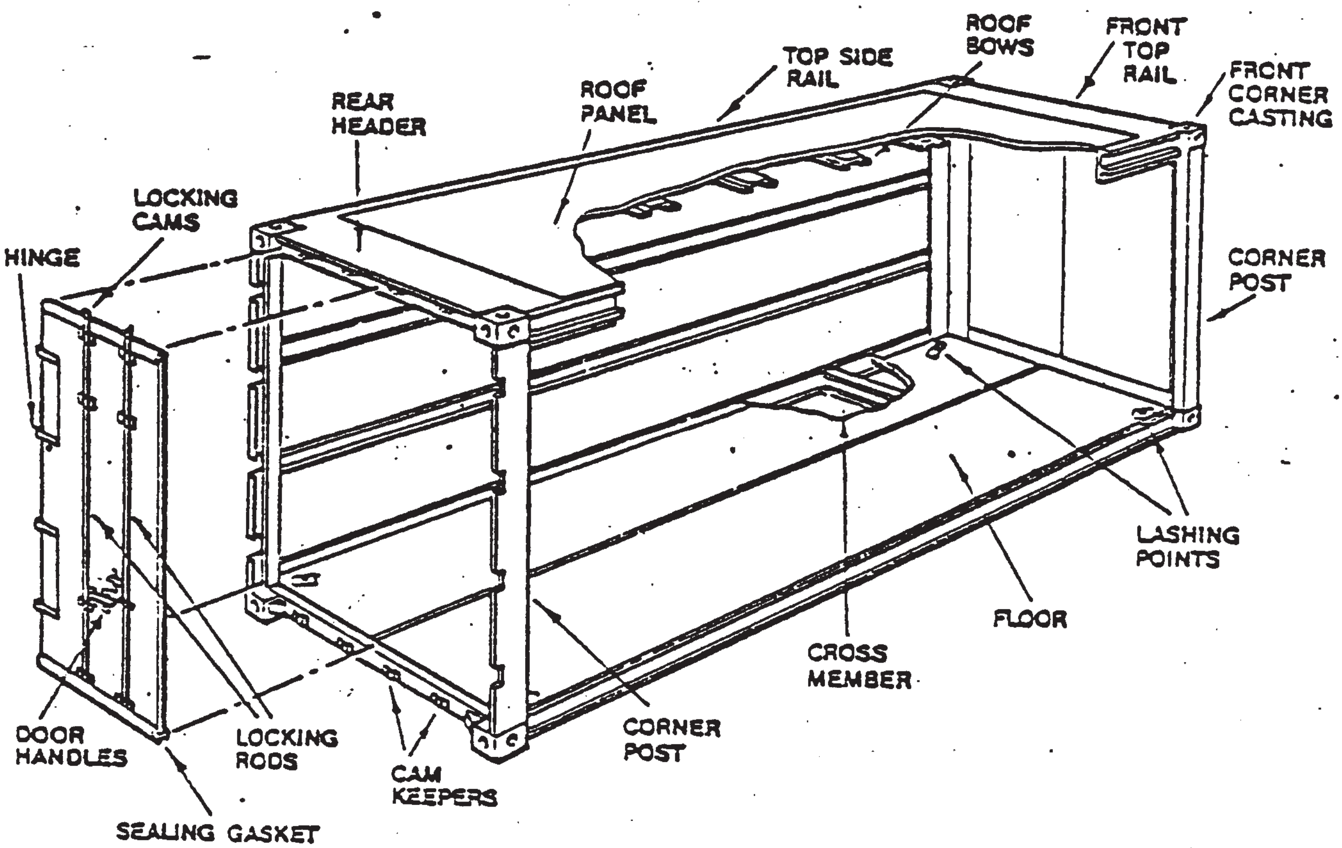
APPENDIX 1

DAMAGE TO CONTAINERS

Containers may have any of the following base materials used in their construction:

Aluminium
Steel
Wood
GRP (Glass Reinforced Plastic)

All are susceptible to some degree to corrosion or damage due to contamination by certain chemicals.



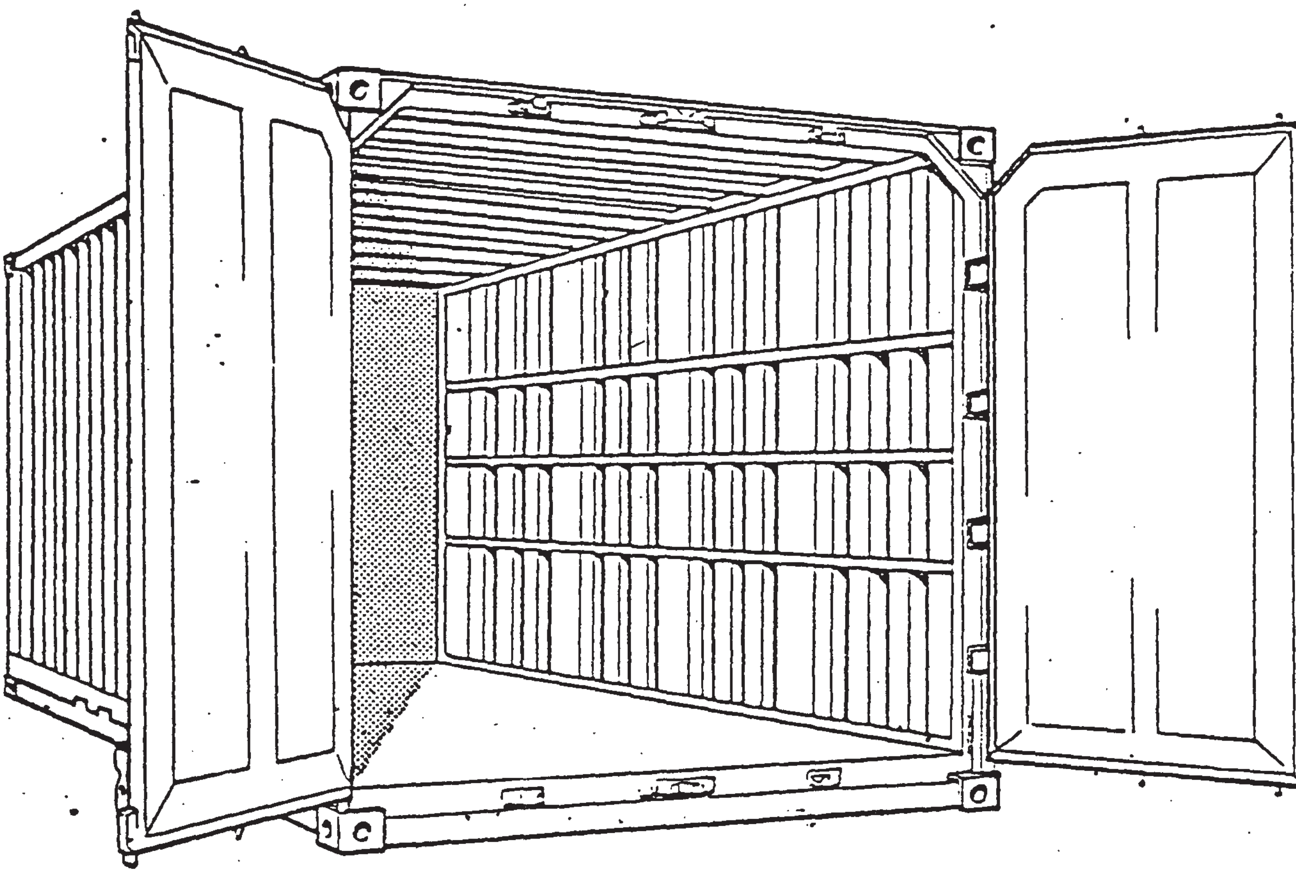
THE PARTS OF A CONTAINER

Any damage is usually as a result of spillage, but in some instances (e.g. certain acids) the escape of fumes can affect the container.

Aluminium, although generally resistant to chemical atack, can be affected with varying rates of corrosion by the following substances:

GENERAL CARGO CONTAINERS

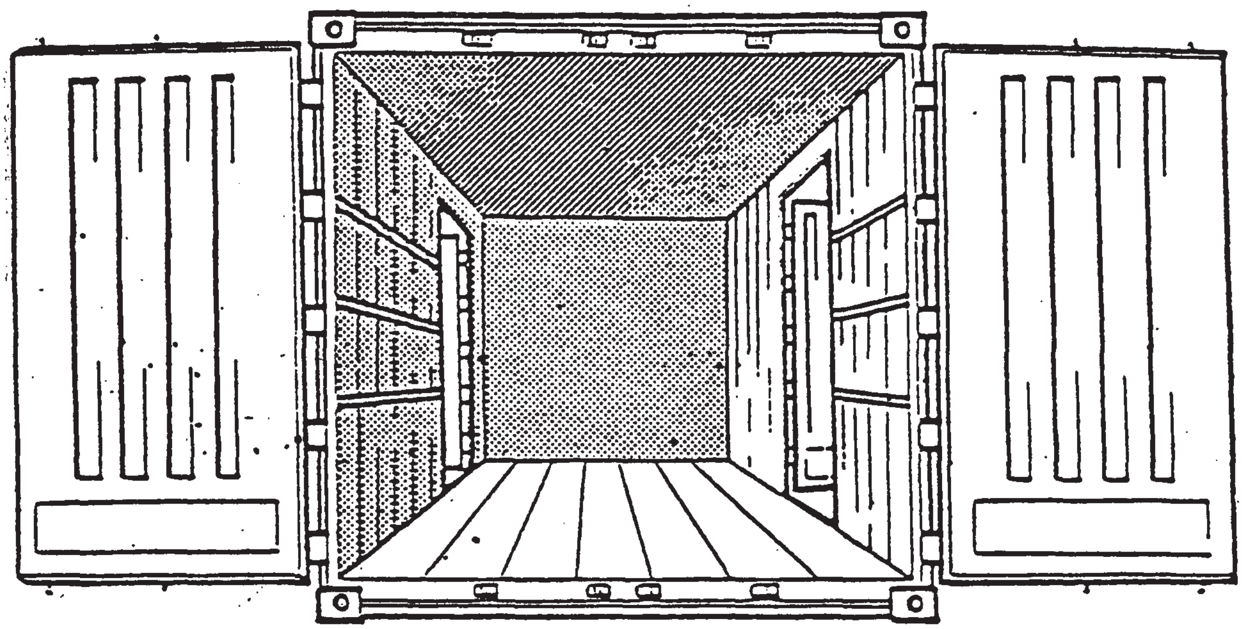
Closed Container



Description;	Completely enclosed but with full width doors at one end. (May sometimes have doors in the sides- see below).
Other names;	Dry Cargo Container Dry Goods Container General Purpose Container
Suitable Cargo;	Most types of dry cargo can be carried in these containers.
Advantages;	Comparatively low construction cost. Little maintenance necessary. Most common type of container, therefore can be easily and quickly made available. Good watertight integrity.
Disadvantages;	Packing and unpacking can only be achieved through the doors in the rear (but see below). The temperature within the container (depending on its construction-e.g. whether lined) will fluctuate in close

response to the ambient conditions (see 'Weather: Temperature').

N.B. (1) The above containers are sometimes constructed with one or more doors in the side walls (Side Door Containers). This gives the advantage of extra access from the side for packing and unpacking, but increase the Tare weight (and therefore reduces the payload), increase the amount of maintenance necessary, increase the chance of moisture dust and fumes gaining entry, and very often reduces the internal width.



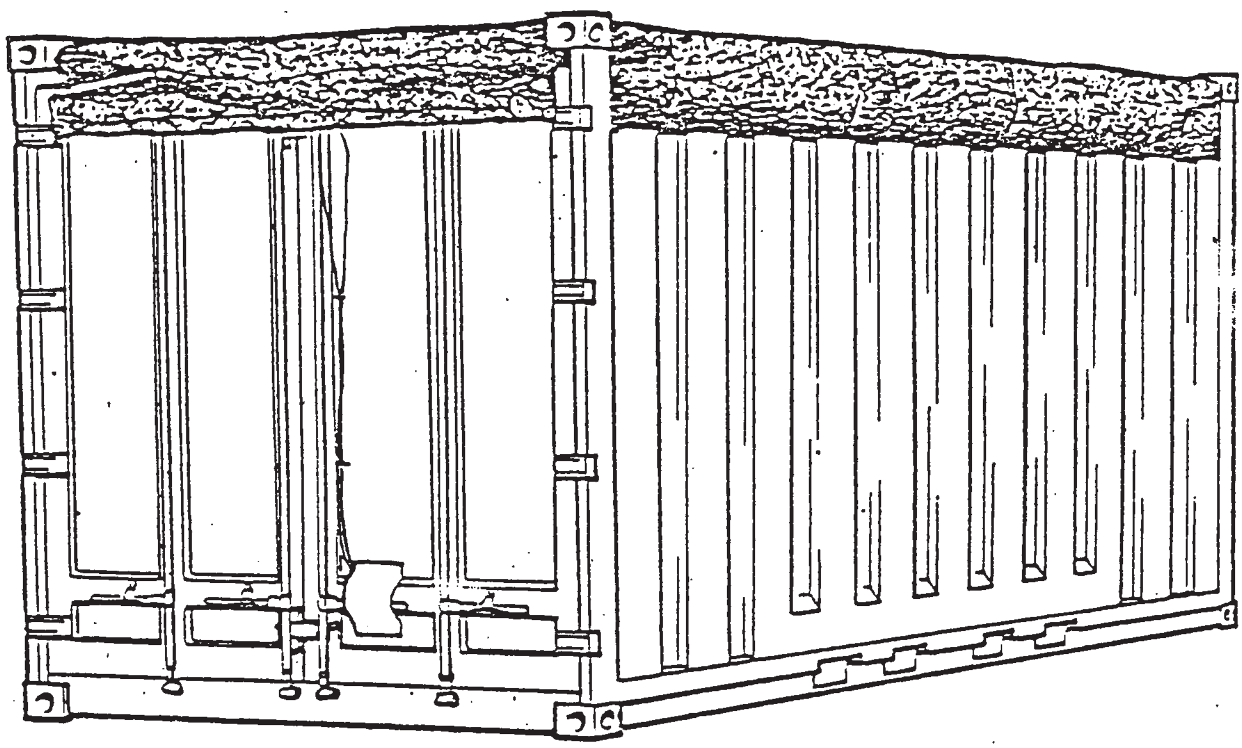
N.B. (2) Dry Goods Containers may, in some cases, have provision for ventilation. These may be used for cargo with excessive moisture, or cargo which gives off gases that need to be dispersed. If the ventilation is by mechanical means (e.g. an electric fan), then power sources have to be provided during all the various stages of transport. Greater maintenance will be required, and careful packing of the cargo to allow a proper through movement of air (see "Packing Patterns"). Non-mechanical ventilation may be ineffective if the container is stacked or loaded so that it is completely and closely surrounded by other containers. Ventilation trunking may be inaccessible and allow dirt to collect, with the associate threat of vermin.

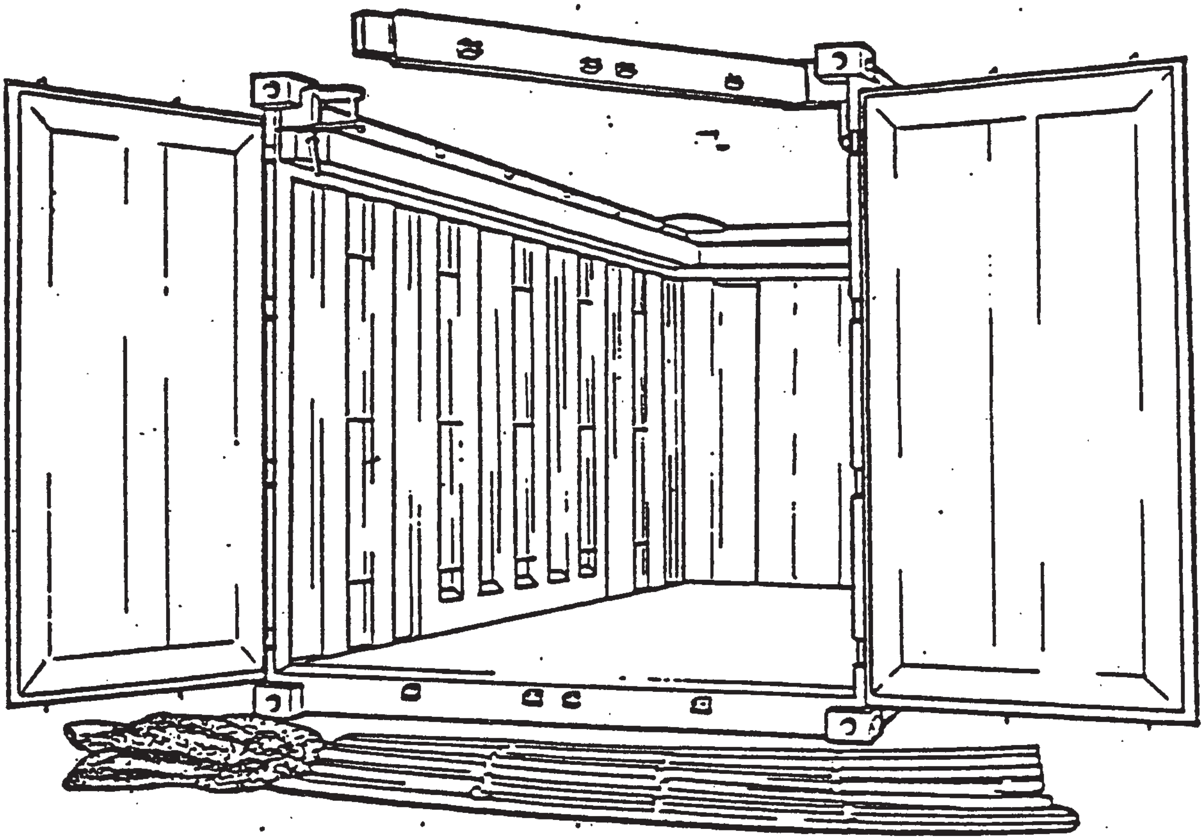
OPEN TOP CONTAINER

Description; Constructed with doors at one end and the top completely open. The interior may be protected from weather by either a solid removable top (Hard Top), (N.B.) or a canvas cover -tilt- (Soft Top).

The Door Header, or main transverse member above the door, may either be swung clear or removed altogether to improve ease of access.

Other names;	Soft-top Container Removable Roof Container Top Loading Container
Suitable cargo;	Items that are too large or too akward to be packed in via the end doors. Over-height cargo (e.g. cargo that will project above the top edges of the container - (see "Oversize, Overheight"). Heavy cargo that requires to be handled by crane. In some instances dry bulk cargo (see "Bulk commodities").
Advantages;	Can be entered (and packed) via either the door and/or the roof. Normally has load bearing sides.

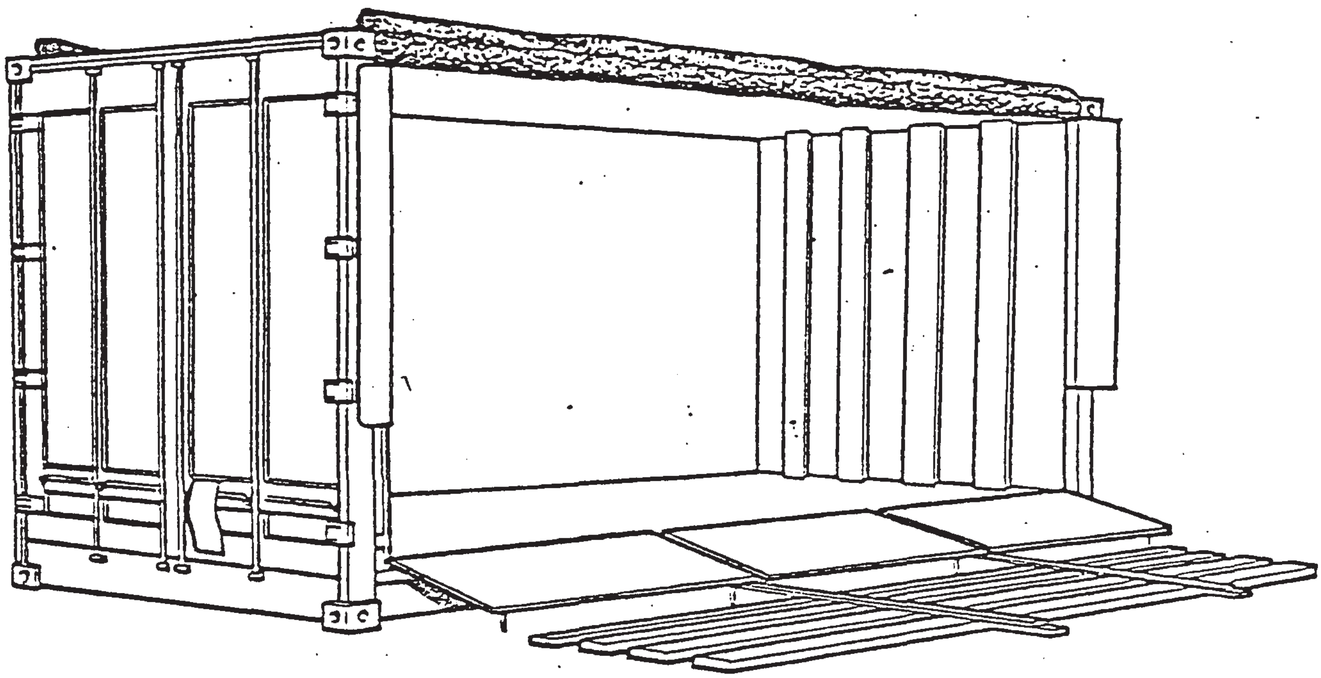




Disadvantages; Greater Tare weight than Dry Freight Container. More maintenance required. Soft Tops susceptible to weather, heat and tear damage. Hard Tops sometimes require special equipment to remove and replace top. Top side rails because of the extra strength required, project further into the container (e.g. cargo space) than they would in a Closed Box Container. Deflection of side walls when packed - or even when stood on slightly uneven ground - sometimes makes the fitting and removal of the roof bows or hard top difficult. Some containers have devices enabling this side wall deflection to be corrected - usually in the form of a wire strop and turnbuckle pulling the top side rails towards one another. Some tilt designs are difficult to fit when the container is empty or only part loaded - e.g. if the container is on a trailer the tilt has to spread and 'buttoned' while working at a dangerous height above the ground.

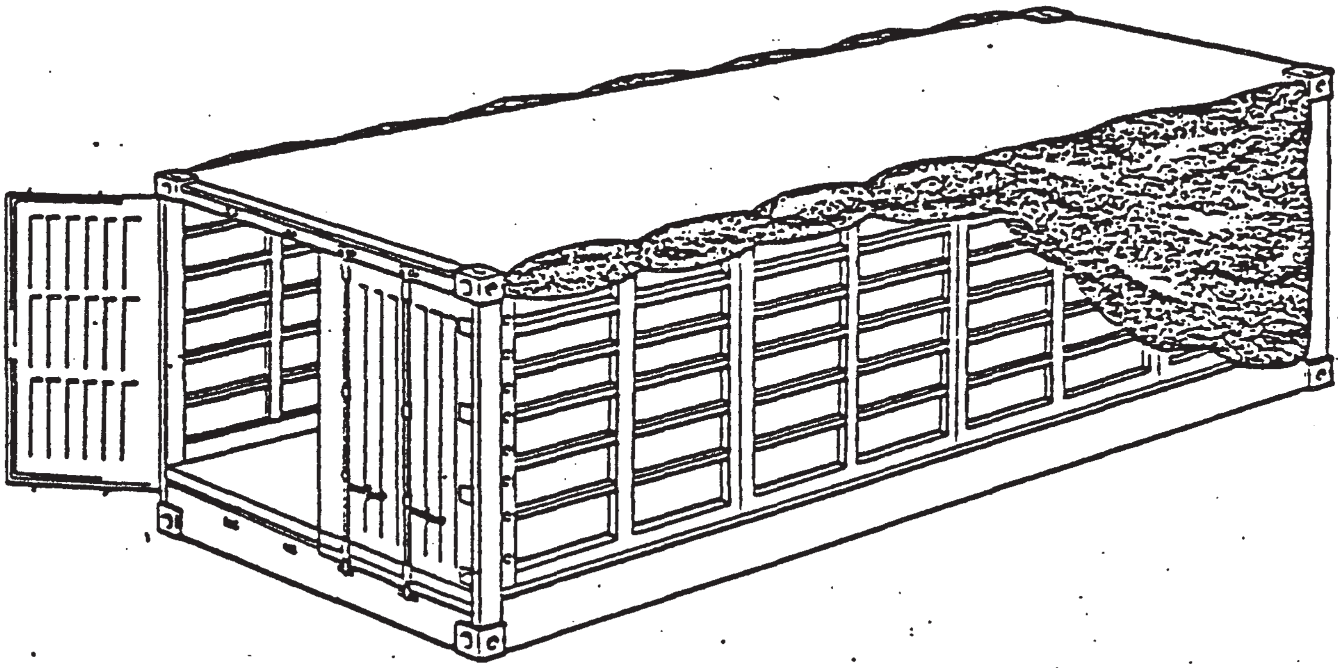
N.B. Containers with solid removable tops are classed by ISO as variants of the Closed Box Container.

OPEN SIDED CONTAINERS

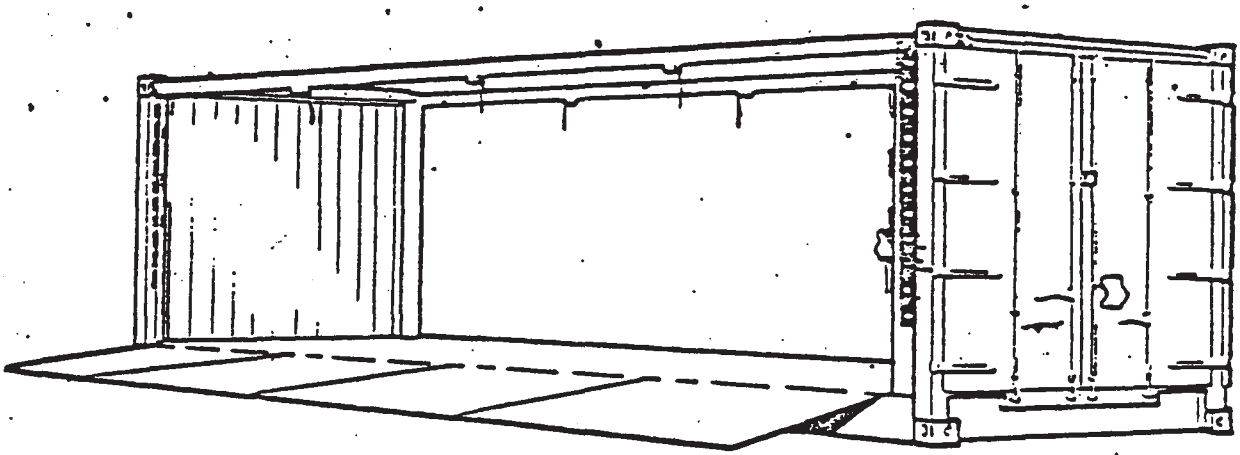


Description;	Has end wall, rood and end doors, and removable sides. The sides are usually covered with a tarpaulin cover or tilt.
Other names;	Side Loading Container. Curtain Sided Container. Open Wall Container.
Suitable Cargo;	Any of such dimensions that it needs to be packed
Advantages;	May be entered from either side of the door end. Solid roof gives good weather protection.
Disadvantages;	High Tare weight* (due to deep floor recessing because of lack of side wall). If the portable sides are not load bearing then the securing of the cargo can prove a problem. Fairly high maintenance costs. If portable sides are removable there is risk of parts becoming lost. If side supports are not being used for a particular cargo, then safe stowage position must be found for them.

N.B. In comparison with closed containers.



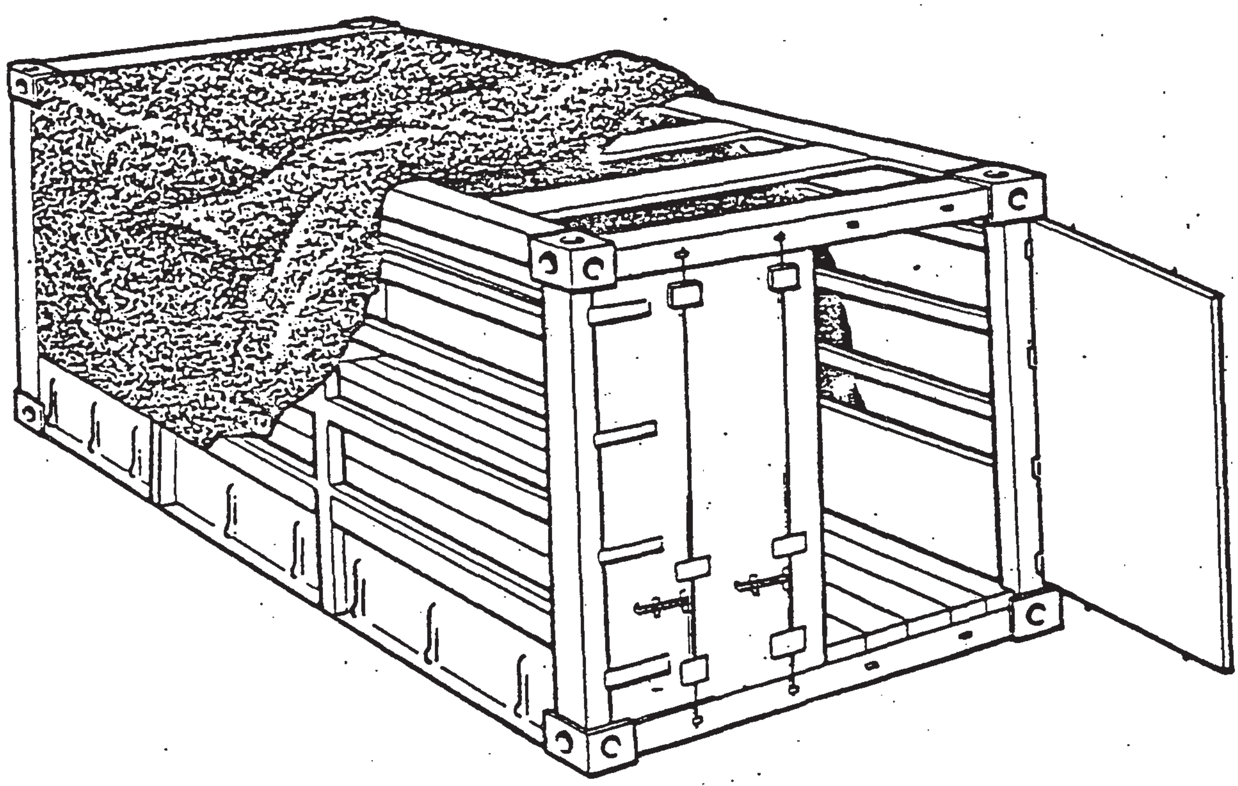
OPEN-TOP OPEN SIDED CONTAINER



Description; Has end walls with top longitudinals - which distinguishes it from the Flatrack. There may be a framework to allow a tarpaulin or tilt to be spread and secured.

Other names; Full Tilt Containers.

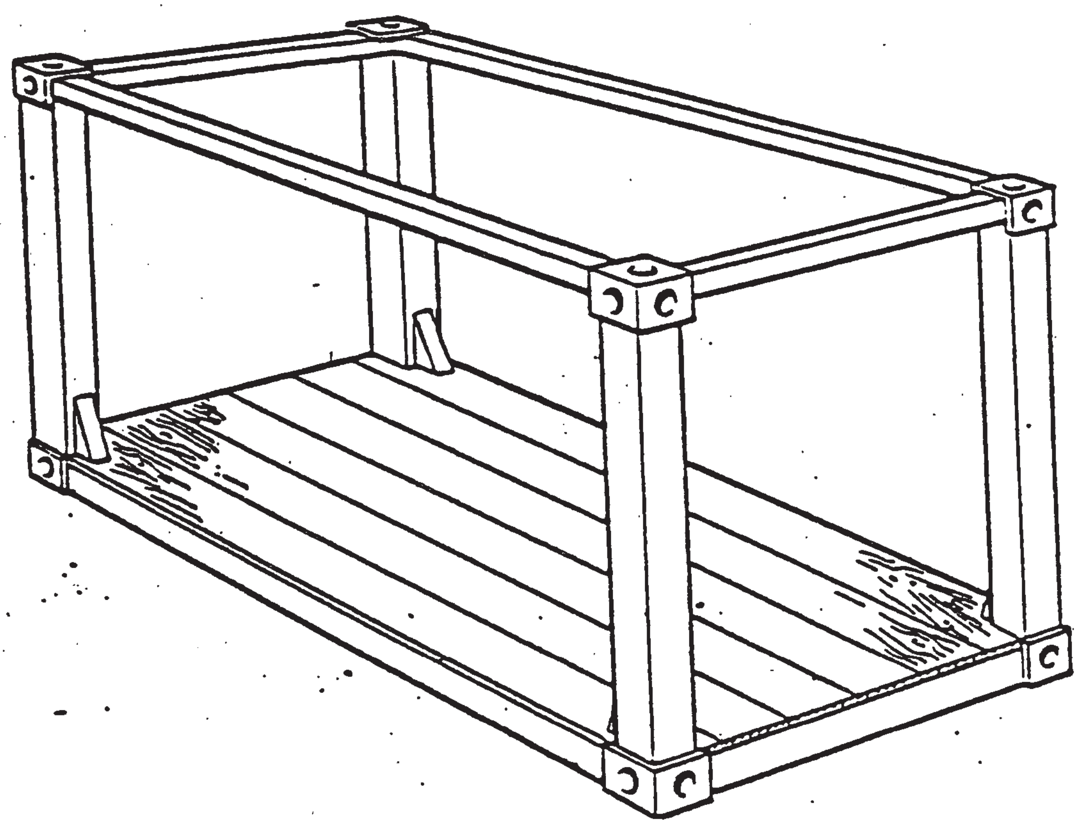
Suitable Cargo;	Awkward units that cannot easily be stowed in via the doors of a Dry Freight Container. Cargo unaffected by the weather or with its own protection.
Advantages;	Easy access - can be packed through the doors (if applicable) or from the sides or overhead.
Disadvantages;	Greater Tare weight than Dry Freight Container (because of extra strength required from lack of side walls). Can be awkward and time consuming fitting tilt - especially when container is empty of cargo. Sides (if framework or battens are fitted), are not load bearing, so special attention has to be given to securing cargo. Not suitable for cargo requiring special protection from the weather. Tilt vulnerable to damage and a stowage problem when not in use.



OPEN-TOP OPEN-SIDED

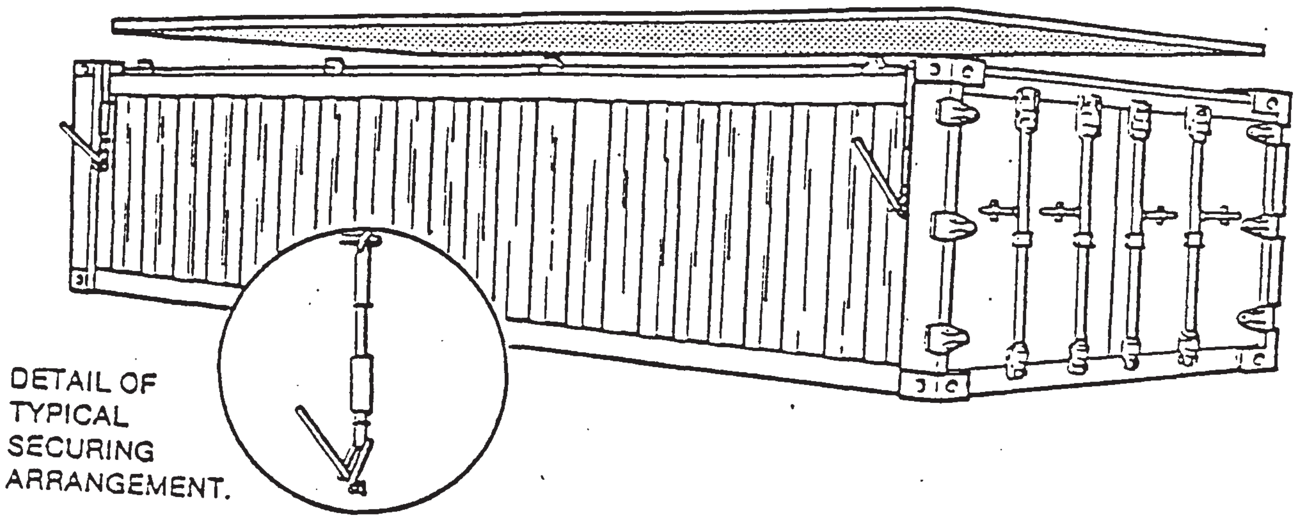
Description;	A base with skeletal superstructure only. May have wire or frame between the corner posts to support a tilt. May also have boards slotting into the ends.
Other names;	Skeletal Container.
Suitable Cargo;	as for Open-Top Open-Sided container.
Advantages;	Can be approached from any direction when packing with cargo. May take oversize cargo (see "Oversize and Overweight").

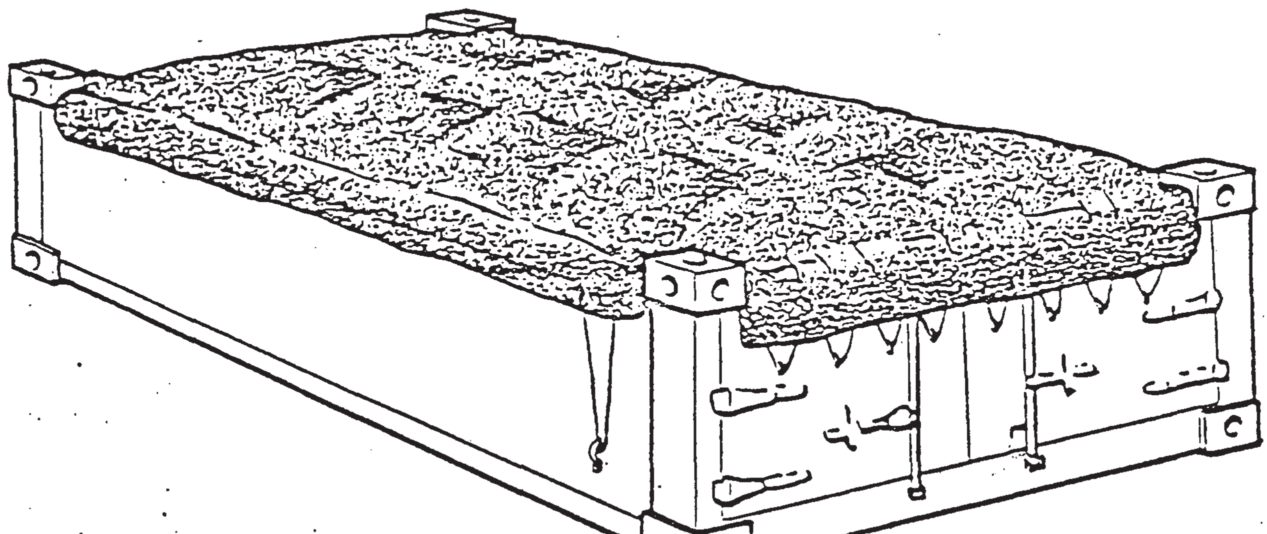
Disadvantages; Not weather-proof. With no ends or walls, securing of some cargoes can be a problem. Any extra fittings (portable ends, battens, wires stanchions and tilts) require special stowage position when not being used - are easily lost.



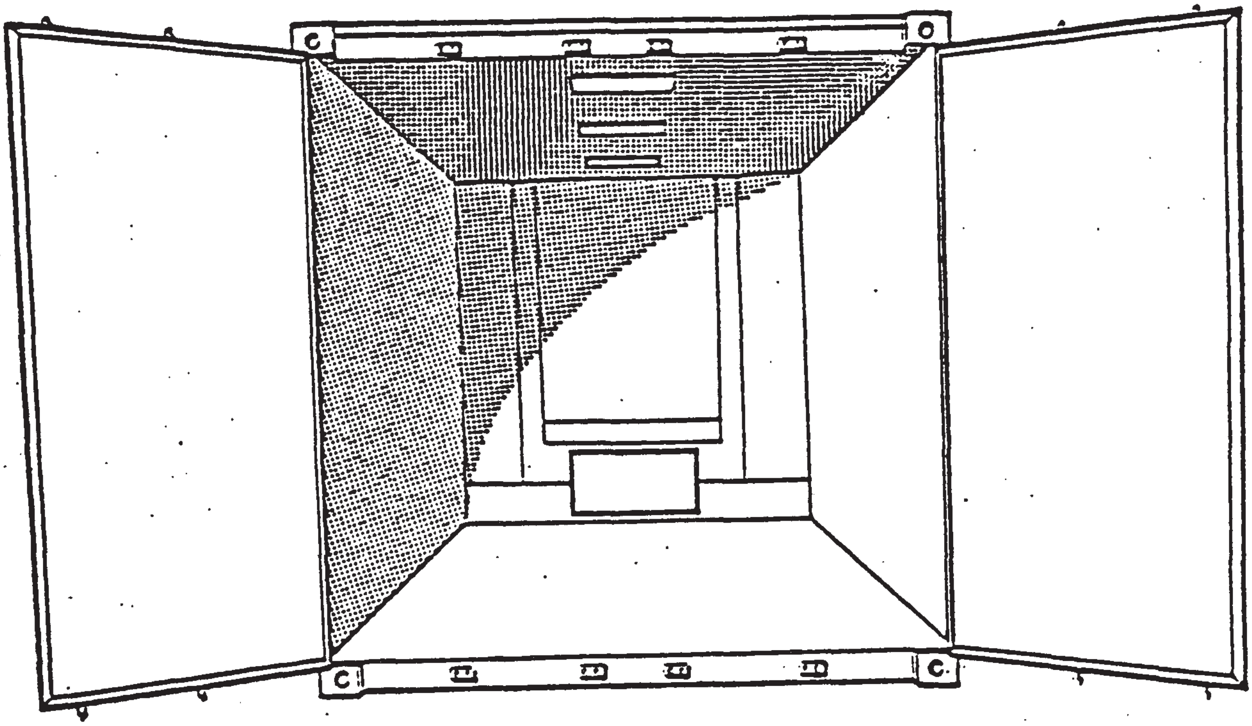
HALF HEIGHT CONTAINER

Description; Of ISO length and width, but only half the ISO recommended height (e.g. 4 ft. or 4 ft. 3 ins. and not an ISO type). May be built with the characteristics of an ISO type. (e.g.


DETAIL OF
TYPICAL
SECURING
ARRANGEMENT.



DRY BULK CONTAINERS



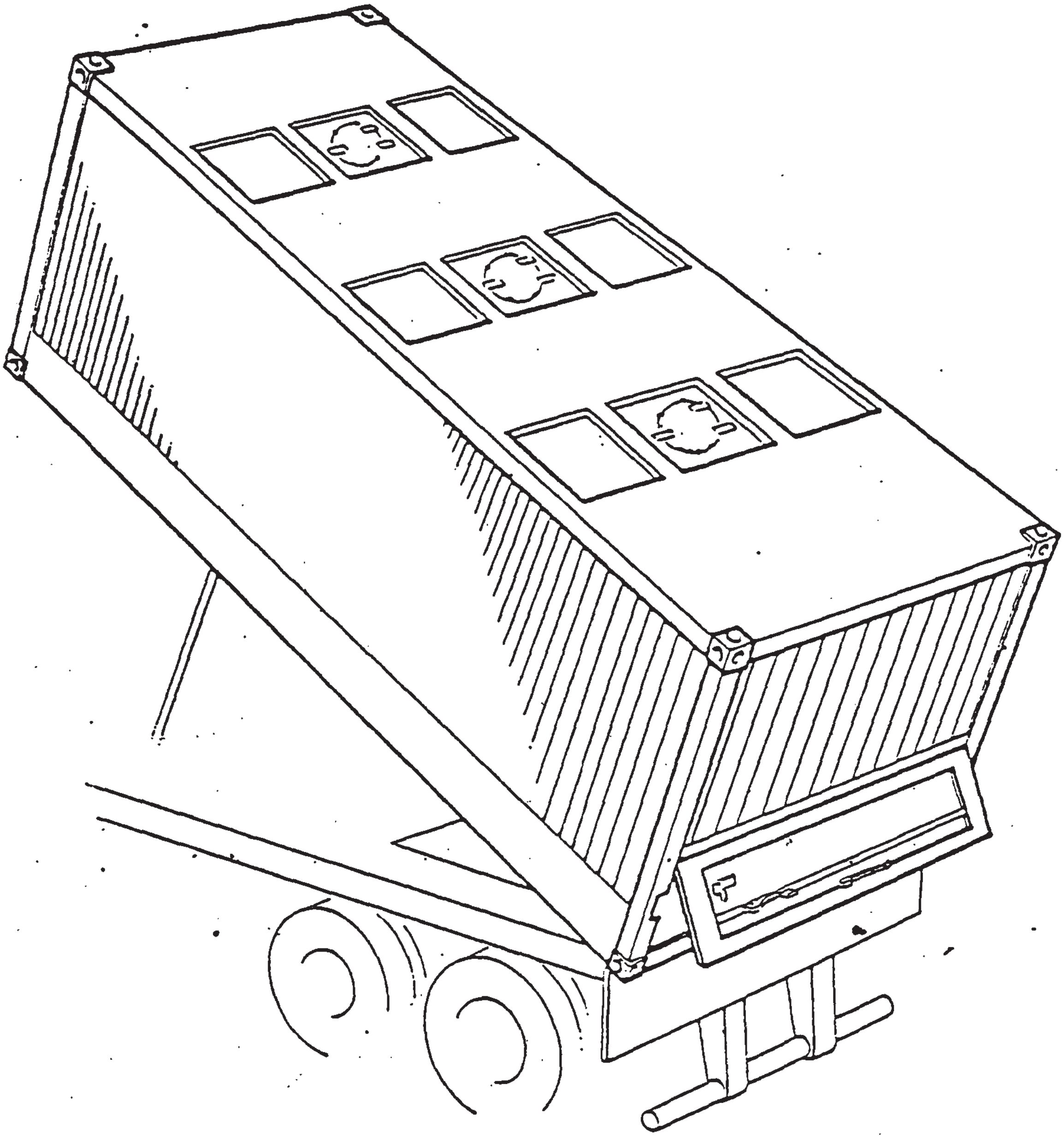
Description; May have arrangements for either gravity or pressure discharge. Some are constructed as several hoppers within an ISO framework. Others are of a tank type. Others again may have full size doors at one end and a smaller discharge hatch at the other (although in some instances this discharge hatch may be set in the doors). Filling hatches (usually two or three) are set in the roof. Some have provision for aeration or vibration to assist discharge.

Other names; Bulker.
Bulk Freight Container.

Suitable cargo; Free flowing solids (e.g. granules; powders; grains).

Advantages; Labour saving to fill and empty. Can sometimes be used for general cargo (the container if suitable - can be treated as a dry freight container and packed through the rear doors).

Disadvantages; High Tare weight. If a tipping trailer is used then road weight limitations may require a reduction in payload. More than minimum maintenance. The number of doors and hatches

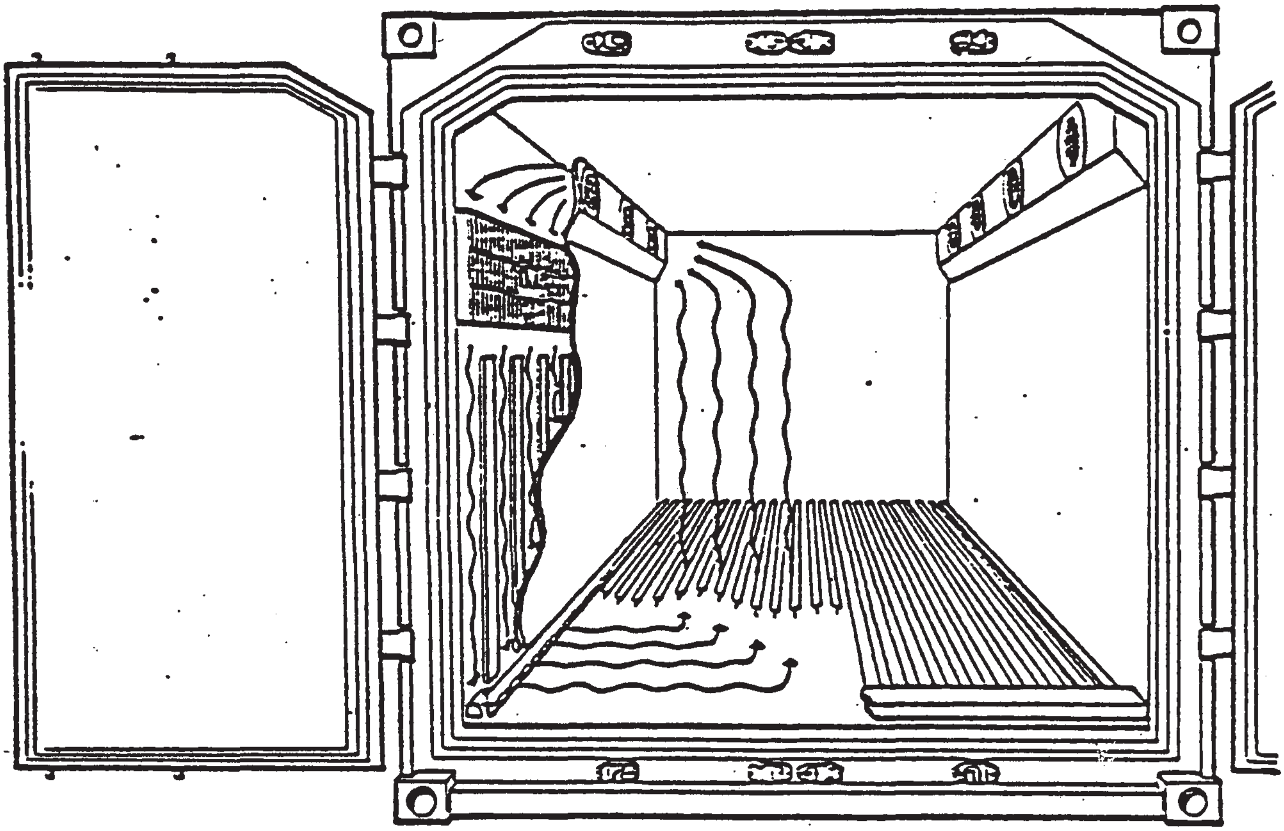


THERMAL

Insulated Containers

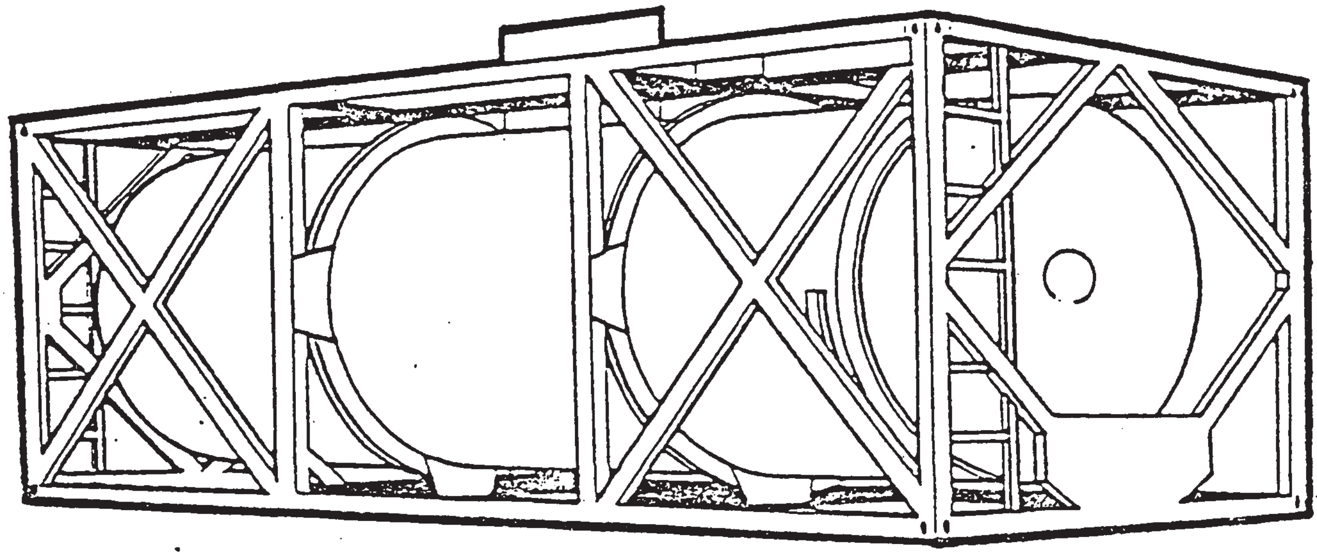
Heated Containers

Refrigerated Containers



Description;	All have walls, floor, roof and doors insulated to reduce temperature movement between the inside and outside of the container. Some have mechanical refrigerating equipment and/or heating equipment built into one end or the sides of the container. Others rely for refrigeration on Clip-on Units attached at the front of the container, or central refrigeration systems at Terminal and Ship. Some rely on Cryogenic refrigeration (see "Temperature Control"). Some have no means of refrigeration at all.
Other names;	Reefer Containers. Insulated/Heated Containers.
Suitable cargo;	Perishables. Any that will suffer from variations in temperature. (See "Temperature Control").
Advantages;	As per the insulating/refrigerating/heating properties.
Disadvantages;	Insulation and (if applicable) the refrigeration unit add to the Tare weight of the container. They also reduce the internal volume available for cargo. Greater maintenance required if mechanical equipment is built in.

TANK CONTAINERS



Description; Steel tanks built within a framework conforming to ISO measurements. Capacity of 20 ft. units usually in the region of 4,000 gallons (15140 litres). May be heated and insulated.

Suitable Cargo; Hazardous (provided necessary approvals etc. have been obtained; see "Dangerous Goods" and "Bulk Cargo"). Containers are usually designed with particular commodities in mind.

Advantages; Minimum labour required to fill and empty. Can be used for temporary storage.

Disadvantages; High initial cost. High upkeep cost. Continual cleaning costs between cargoes. Difficult to transport if large ullage. High Tare weight.

CATTLE CONTAINERS

Description; ISO Container permanently fitted out with stalls for cattle. May or may not be convertible into a container suitable for carrying General Purpose cargo.

Suitable cargo; Cattle.

Advantages; Purpose built for carrying cattle.

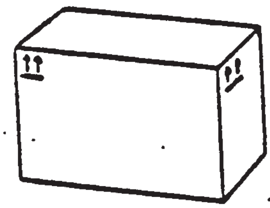
Disadvantages: Cleaning problems between cargoes. Possible quarantine problem in some countries when empty cattle containers are returned for further loads. (See "Livestock").

VISUAL WARNING LABELS SHOW WORKERS HOW FRAGILE CARGO IS

FRAGILE HANDLE
WITH CARE

USE NO HOOKS

THIS WAY UP

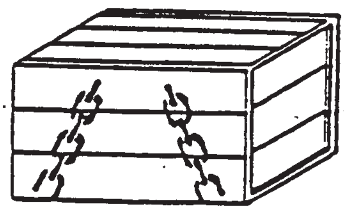


(EXAMPLE)

KEEP AWAY FROM HEAT

CENTRE OF GRAVITY
(MACHINERY IN CRATE)

SLING HERE



(EXAMPLE)

KEEP DRY

PICTORIAL MARKING FOR HANDLING OF GOODS (GENERAL SYMBOLS)
FROM ISO REC. R.780.

LIFE SAVING AT SEA ON CONTAINER VESSELS

Search and Rescue (SAR) for Containership Personnel

A containership is a unique vessel. From the new bulb bow through the vertical cells which hold the uniformly shaped cargo boxes, to the stern empty container storage area, these facilitators of international commerce represent a new challenge to Search And Rescue at sea. Today's containerships have over 10 holds, with deck space above for additional boxes. Larger ships carry over 1,000 containers of various sizes.

Newer ships transport the boxes, sometimes with other freight at speeds above 25 knots, and carry 39 people. One large apartment building-like structure on the aft deck contains the residence of the human cargo, mess facilities, bridge, navigation and communication equipment and life-saving gear. Partial containerships, roll-on/roll-off (ro-ro) multi-deck vessel, barge carriers, break-bulk and oil-bulk-ore ships share, in proportion, the SAR factors described herewithin.

With rare exception, very few new ship designs have enjoyed the fine safety at sea record now held by containerships. The concept has rapidly spread since Malcom McLean's IDEAL C made its pioneering voyage in 1956. This history is without a major tragic incident or extensive loss of life at sea, at this time. The notable exception was the collision between the SEA WITCH and ESSO BRUSSELS within the Port of New York and New Jersey. Many lives were lost in the fire following the collision, despite the readily available emergency equipment, helicopters, fireboats, and tugs which sped, with the United States Coast Guard to the rescue.

Lacking experience with containership distress, the marine industry may need to focus more attention on the unique SAR techniques, preparation and crew training needed to maintain the present fine safety record. This preparation is insurance against a potential mid-ocean 'abandon containership' distress call. The SAR goal of this eventually will be to save the greatest number of lives, and where possible, to protect and recover valuable property.

For Whom the Bell Tolls

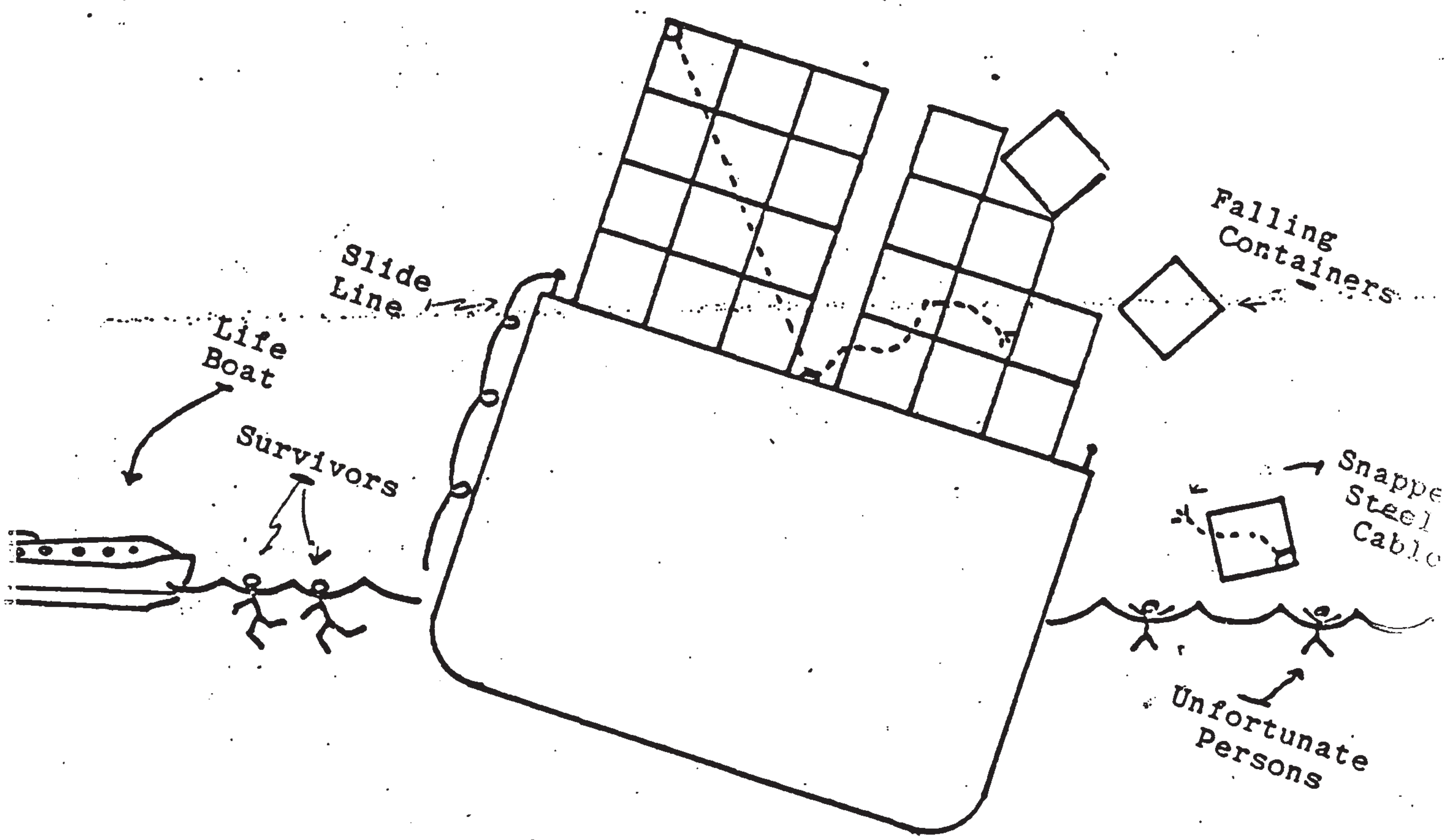
In Lloyd's London Underwriting Room hangs the LUTINE Bell. Back in 1799 the bullion ship H.M.S. LUTINE sank off the coast of Holland, and took $5 million in gold to the bottom with her. Now her bell, which hangs over Lloyd's rostrum, rings once to record the loss of a ship insured by the syndicate. This toll summons the different underwriters to hear the unhappy news.

In a recent 11 year period, the bell rung hundreds of times for sunken vessels. Thirty-six of these ships disappeared without leaving a trace. In many cases, ships went down without even sending a distress message. Their fate would have remained a mystery, and still be classified in the 'missing' category, had not one or more of her survivors been picked up by passing vessels, so the true story of the ship's demise could be told. Typical causes for sudden sinkings are explosions, hull failure, or capsizing as a result of synchronous rolling in heavy seas.

SAR Precautions for "Abandon Containership"

If 'abandon containership' is sounded on a modern vessel, consider some of the SAR techniques which could be applied promptly to save human lives from the depths of the sea. Assuming that rough seas were present, with flying spume encircling the potential grave site, the beleagured crew, wearing life jackets with safety lamps, should lose no time in going over the side in advance of the ship sinking.

If the deck was already inclined, the side which is lowest to the sea should not be utilized as the escape route. The strong gravitational pull placed on the deck container restraining cables and locking blocks, coupled with heavy seas, probably would cause the container boxes to tear loose. When they fall, due to the heavy listing of the ship, a cascade of 40 x 8 x 8 foot or other size containers would mix with the raging sea. These boxes could crush, dismember or drown the desperately struggling men.



Jumping overboard from the higher deck is equally inadvisable. The sea water, like granite, is not compressable. The shock of falling a distance onto the sea surface could cause a man to loose his breath, sense, and life from the abrupt deceleration. To avoid both described problems, a rope slide will provide a means of reaching the sea surface with a minimum of falling distance. Two or three men should go over together to provide mutual aid and avoid having a separated man lost in rough seas.

Once in the water, previously launched lifeboats or floatage can be a refuge in the storm. It is possible that, for a short time, partially floating containers can be used, naturally, the greater the size of the total floatage, the easier it is for SAR teams to spot the disaster site.

Collision is still a major cause of loss the ships at sea. The majority of these incidents occur at night, in fog, rain or snow, and along heavily traveled sea-lanes or in harbor and river entrances. Sea swells are usually low and wave action moderate in such locations/which may permit more rational SAR. Help is nearby on shore or in nearby cities to provide evacuation and medical assistance. Collision is a particular danger for containerships, where a deep slice into the container holds could rapidly sink the vessel.

Following a collision, one of the damaged vessels can usually operate to recover victims onboard the less fortunate ship, as in the collison of the STOCKHOLM and ANDRIA DORIA.

<u>A New Arrangement System for Launching Containership Life-Boats</u>

This new System for launching of Life Boats (LB) is based on an entire new principle, on which patent is now pending on behalf of Captain L. Bratlid, Oslo, Norway*. The main principles are described as follows:

This invention is claimed to concern a device in connection with the release of the LB from a ship under emergency circumstances, and where the life boats are stored under deck, preferably at the rear part of the vessel. These can be in combination with lifeboats on the upper deck, which can either be launched by conventional davits, or the new chute method, as shown below.

*L. Bratlid & Co., Skipsmeglere, Baldersgt. 4, Olso, Norway.

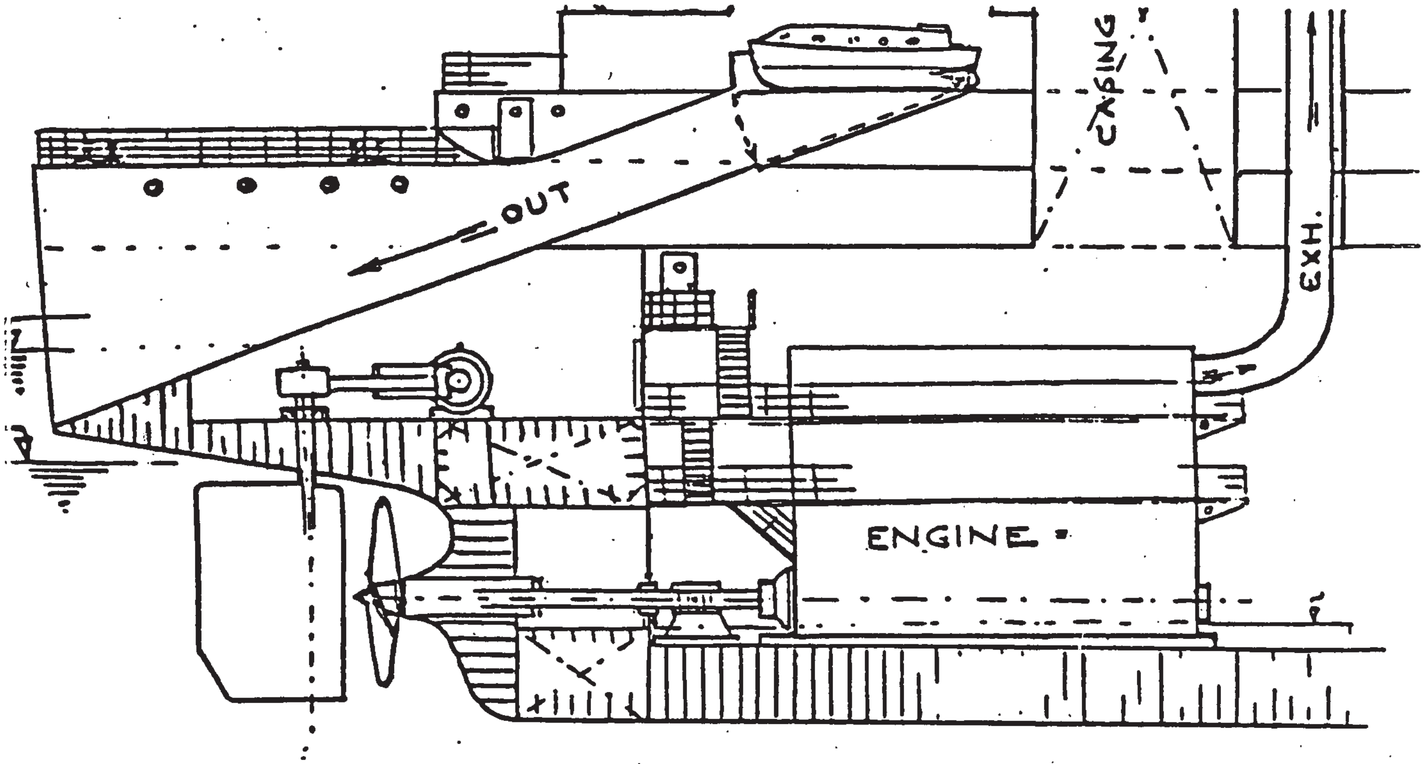


Figure 2 Survivors enter Life Boat on level deck, then weather-tight the boat prior to sliding safely down the "U" shaped chute to the level of the sea.

From this storage room and eventually also from the upper weather deck, there is arranged a "U" shaped sliding chute, having a certain angle in relation to water level, and ending on its lowest point near - or slightly above - the sea level, and which slip is uncovered and open upwards.

Now in case of an emergency on a containership or other vessel, the lifeboats would take the crew and passengers on-board under covered and protected conditions, thus being fully protected in spite of weather conditions. Later, the persons inside would most likely be relatively dry and comfortable until rescued.

Upon a release, the life boat will then slide down the "U" shaped slip-channel (chute), during which travelling the lifeboat's center of gravity always will adjust itself at the lowest position. The life boat may be fitted with rollers or balls, so it will easily slide down the outlet channel toward water line. This also facilitates any needed movement of the entire lifeboat in the covered loading shed, where several life boats may be stored.

The outlet from this open slipchannel at the middle of the vessel, is ending aft of rudder and propellor installations, eliminating any collisions with gear, etc. Plus, this launch gives the life boat a speed out and away from the main vessel. Speed away from the vessel can be increased if a wake current is present from the forward motion of the vessel. This rapid departure form the stricken vessel can also be aided further by means of the built-in engine of the lifeboat, which even could be started before the LB leaves the covered loading shed onboard vessel.

Under critical circumstances, one or more life boats could be released almost immediately and in a safe way for the crew and passengers despite weather conditions. It is no problem to launch the life boat both via slip-channel or davit. The patent covers other alternative ways of releasing lifeboats.

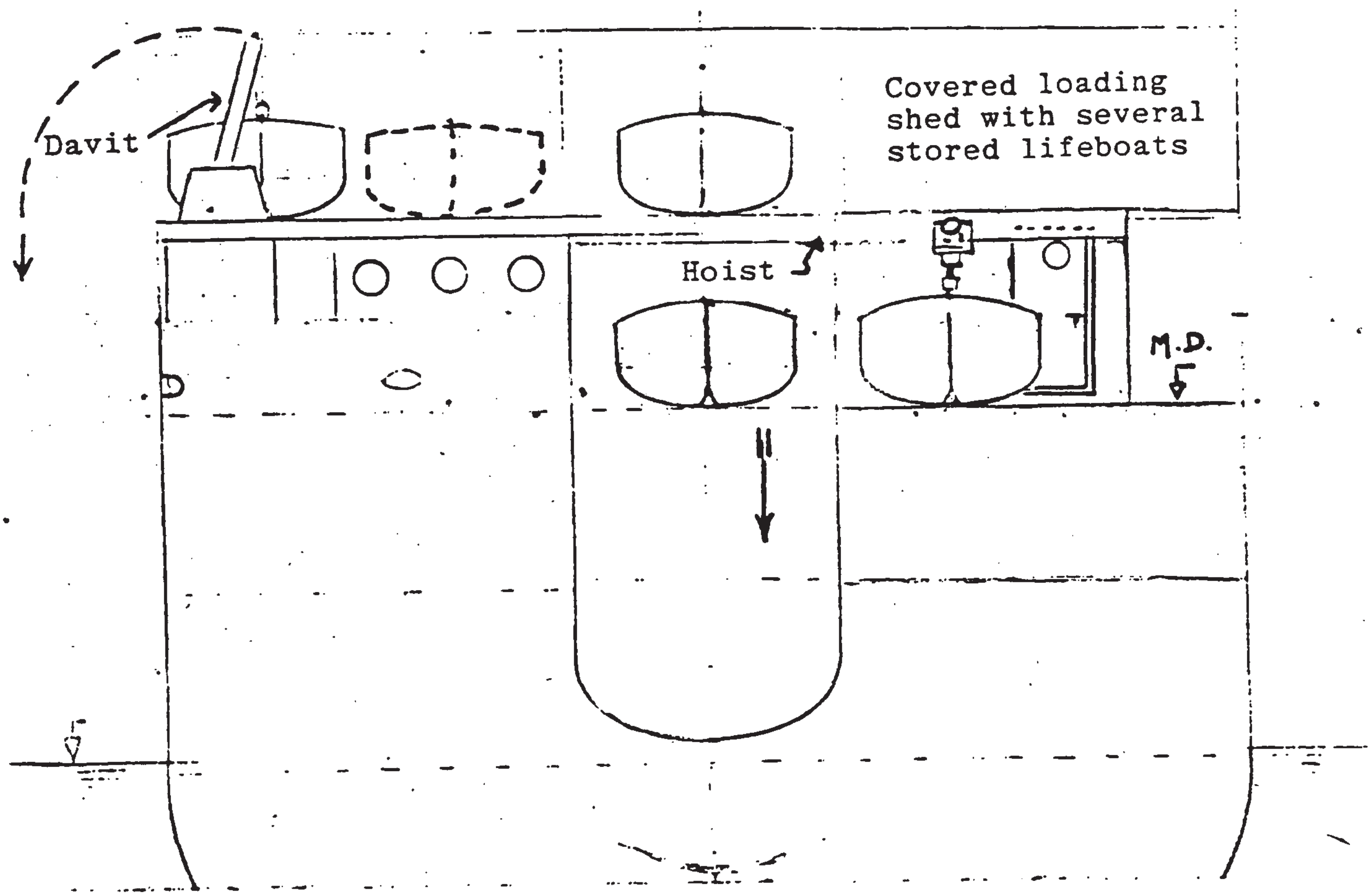


Figure 3 Aft view of covered loading shed, lifeboat storage, alternate davit launch and slip-channel.

One of the greatest advantages of this system is, that the outlet from the ship takes place so very near the waterline. This is vital should the vessel be listing. The result is that the lifeboat will hit the water surface in a smooth way, independent to movements of the vessel, because of the radius design of the "U" shaped slip-channel. Below is a cross view through the rear part of a vessel with Bratlid LB.

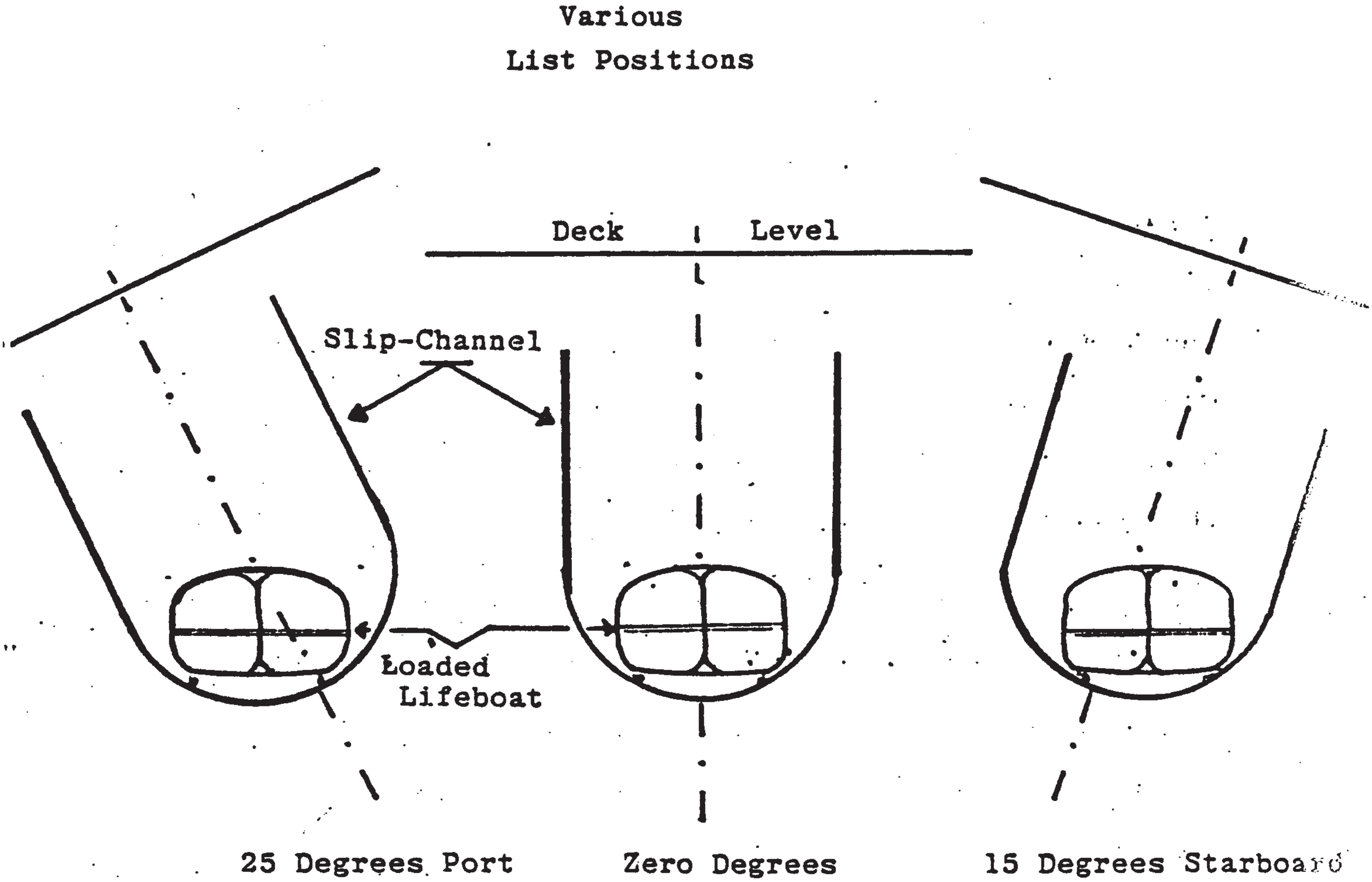


Figure 4 The loaded lifeboat is released safely with rollers or balls self-leveling the craft, regardless of the list of the main vessel.

Through this combination of slip-channel and davits, different ways of launching the lifeboats, it is always possible to select the best way to abandon ship according to existing circumstances.

The new arrangement for lifeboats is best installed in ships being planned or now in progress. Modification of any cargo vessel, containership, tanker or passenger/cruising ship are also possible. The drawings indicate how lifeboats are stored under deck at the rear part of the vessel, and how other lifeboats could be brought in place on the outlet slip as soon as a first boat is released.

The idea is to have a quick releasing device or arrangement, and assure that lifeboats could be launched almost immediately in case of a disaster. Master controls would be duplicated by the lifeboat station and on the bridge. Captain Bratlid's concept mentioned here is a safer way to SOLAS, all the time protecting the crew and passengers during the launching operation.

Search for Life in Open Seas

The search for the fabled needle in the hayloft is similar to scanning the seas in search for life. When a containership is distressed, the very nature of her routes aids in discovery. Fortunately, they move along the predictable routes of containerized commerce. Unlike tramp ships, some tankers, bulk carriers, and most pleasure craft, their routes are straight and direct. Also, competition for freight has lead containership owners to route their ships between major ports of container traffic generation and receipt. The North Atlantic Essential Trade Routes are but one example. These routes are regularly transversed by merchant and military ships of many nations.

In the skies above a distressed containership are commercial and military aircraft which travel over most of the same trans-ocean or Great Circle routes. This adds another dimension to the SAR effort. Thus, rescue can be effected by a ship in the vicinity, from sightings and reports made by aircraft.

In the ocean, if containership speeds are an average of 27-30 knots, the trip is shortened. A North Atlantic crossing in moderate seas may be 5-7 days. A search would be started promptly, in the absence of either communication with the ship or if the estimated time of arrival (ETA) passed.

When a ship is missing, prompt discovery of the vessel may be achieved through the United States Coast Guard's Automated Mutual-assistance Vessel Recue system (AMVER). Merchant vessels of all nations on offshore passages through-out the world are encouraged to send plans upon departure from port, and peiodic position reports en route, to cooperating radio stations who will forward them to the AMVER Center on Governors Island in lower New York Harbor. There the information is entered into a computer which calculates positions by dead reckoning for the ships throughout their voyages, based upon most recent information. Using reporting lines, participating ships in the vicinity are asked to aid in the SAR. This can be accomplished with little or no diversion form the searcher's own route, but can be achieved by increasing the alertness of the crew's visual and electronic sweep of the horizon.

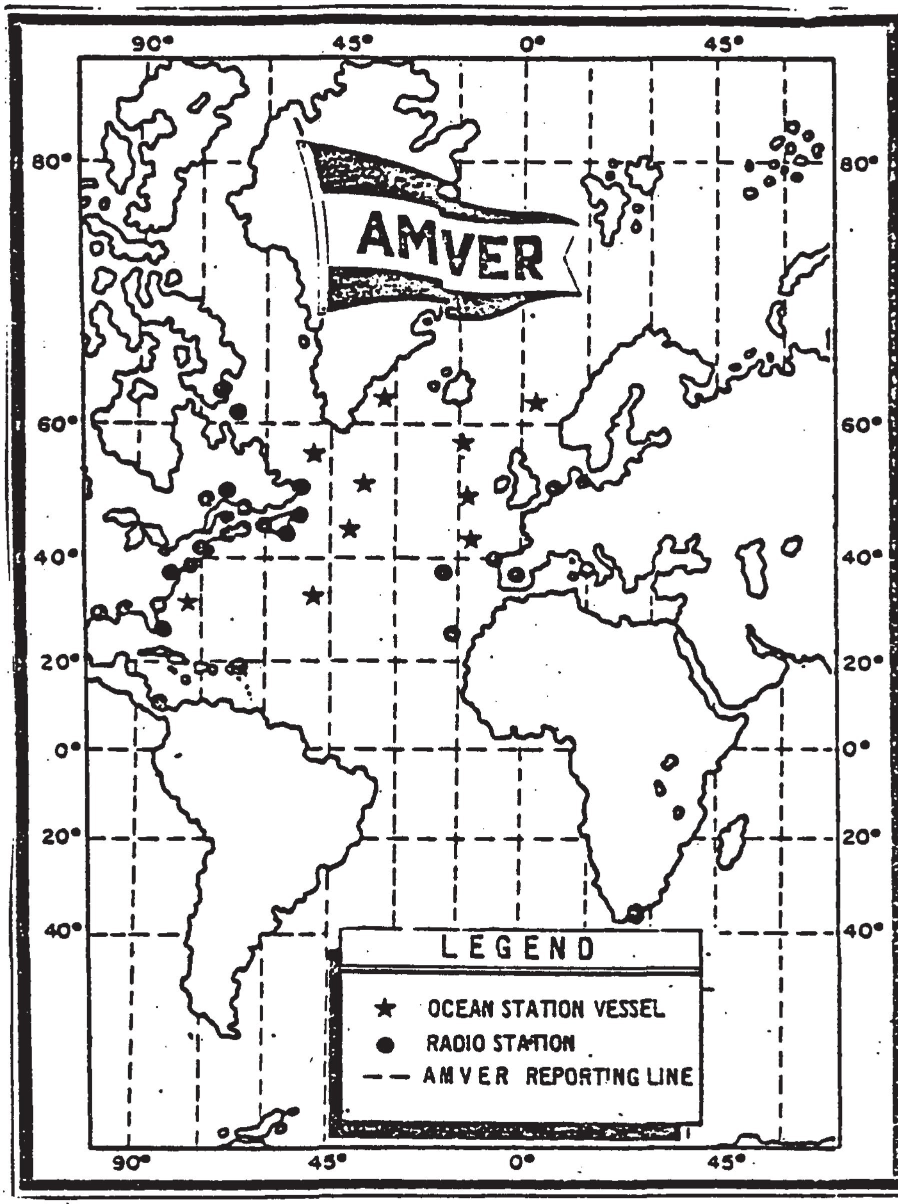


Figure 5 AMVER's world-wide network has a heavy concentration of SAR stations on the North Atlantic, which is the route of the majority of the int'l container fleet.

Containership SAR Aided by Vessel Configuration

Clues to the possible disaster site are provided by the design configuration of the containership, including LASH and Seabee ships. The deep holds are designed to carry as many stacked containers as possible. This means that the needed fuel, sludge, water, and liquid cargo tanks run along the sides of the ship. In a collision or ship split, these tanks would rupture, releasing a spill detectable to searchers. The deep spaces become places where the crew leave rags, boards, papers cans, bottles, clothing, rope, and other floatage. These will wash free as the ship sinks. In the holds themselves, various items will float upward when they are filled with sea water.

In rough seas, the containers themselves may split and release packing materials, braces, blocks, merchandise, paper, plywood, foam and other insulation. Unlike many ore-bulk-oil (OBO) vessels, which are so well buttoned-down they can go to the bottom without a trace, the containership will leave traces.

For example, the MARINE SULPHUR QUEEN enroute from Beaumont, Texas to Norfolk, Virginia disappeared with no trace of her or the 39 men aboard. Possibly, even whole containers or weatherproof LASH/Seabee barges will free themselves from the mother ship and float loose. If any quantity of floatage is found, a Datum Marker Bouy can be used to calculate the drift and the potential site of the vessel.

Safety of Officers, Seamen and Passengers from Containerships

Men overboard face dangers from the water, its contents and temperature. In warm waters, while the time overboard may be more comfortable than chilly, it is not without accompanying dangers. Departure from the ship should always be made via slideline. In shark infested waters, experience has demonstrated that these flesh eaters are attracted by the unclothed body. Therefore, clothing (socks, pants, shirt) and a lifejacket should be kept on at all times until rescue is completed.

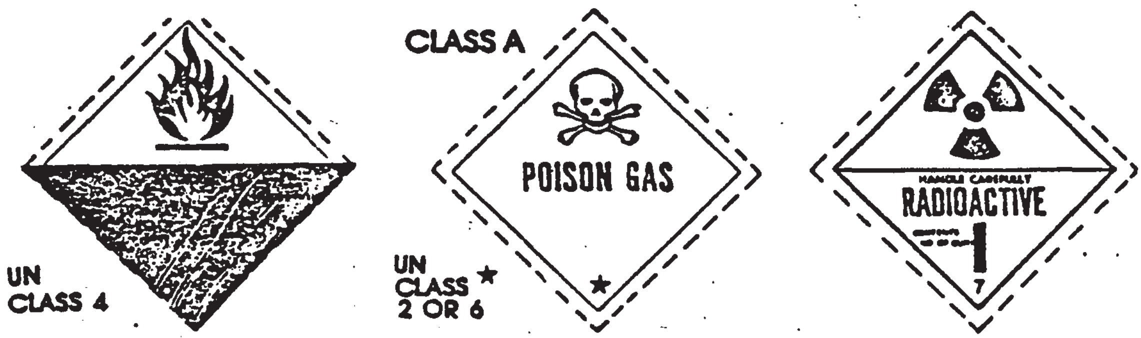
Never rush a rescue in sharkwater. The USS SAUFLEY was standing calm to pick up 37 survivors of an ill-fated West Air C-46 ditched 450 miles off Jacksonville, Florida. When the survivors approached the ship in a string of eight rubber liferafts only 30 yards off, an impatient man jumped out and began to swim toward the aft boarding net. A large mako shark started for him, but alert sailors along the rail of the ship opened up with rifle fire, and the shark turned away. A few seconds later, it turned quickly, and hit the unfortunate man, removing an arm and shoulder. He died shortly after being brought aboard and left the scent of blood in the water to draw more sharks.

In winter or polar latitudes, containership SAR is hampered by the cold temperature of the air and seawater. Men overboard following a disaster should use lifeboats, containers or large floatage as a raft, even if partially submerged. A wise man will climb onto the object and stand up. This leaves only his lower legs and feet in the chilling water. If he kept most of his body underwater, the frigid temperature would cool his blood (body temperature). causing in succession, paralysis, delirium, coma and death. If the box or floatage suddenly sinks, then the standing human is in a relatively good position to avoid being sucked downward in the vacuum effect.

Many lives have been saved through this simple, but effective, on your feet thinking. The tragic 1912 R.M.S. TITANTIC sinking exemplified the shortcomings of inter-national SAR at the time and the inability of icy water to sustain life for more than just a few minutes. The chill quickly extinguished body heat and maybe the will to live.

SOLAS via Adequate and Proper Cargo Classification and Marking

Basic to SOLAS is the proper communication of cargo dangers. This very elementary omission can be fatal. Cargo incorrectly marked can be placed in a containership in an inaccessible hold, hull areas too warm or cold causing undesired chemical reactions, or in relation to other dangerous cargo. Innocent cargo, when in chance combination with other mismarked cargo can cause explosion or fire. Chemicals, munitions, compressed gas, some fertilizers, plastic resins, or flamable fabrics, paper and rags may lead to a disaster at sea if not properly classified and marked. To eliminate this danger, the U.S. Department of Transportation has authorized DOT labels for hazardous materials. Based upon the United Nations labeling system, they are authorized for domestic and foreign shipments. A few of the ones now in use are shown below.



U.S. Department of Transportation authorized hazardous material labels aid proper cargo identification, storage and crew protection.

<u>Good Containership Stowage Stability Reduces Need for SAR Efforts</u>

On containerships, sudden shift of cargo is largely eliminated due to the unitization of cargo. The ship and crew can be saved, even if a portion of the cargo is lost. Conventional ships have seen improper stowage of cargo as a major cause of accidents at sea. A synchronous motion of the ocean, pushed by winter or heavy seas, can cause such a sudden bulk shift (coal, grain, minerals, etc.). The result is a dangerous list, ship split or complete keel over. This happened to the collier S.S. PATRICK SWEENEY enroute from New Jersey to Yarmouth, Nova Scotia. No distress message could be transmitted, and the flare from the lifeboat was the first indication to the outside world of any distress.

In rough seas, containers on deck are under strain, as the deck pins, weight of higher boxes, lock blocks, steel cables and chains, stack guides and other devices attempt to keep the boxes in place. If they fail, one or more boxes may fall overboard. Weight distribution of the vessel is also disrupted. In severe cases, some containers may have to be released to restore stability. This is done when it is clear that the lives of those onboard, the remaining cargo, and the vessel itself are in danger.

Many other events may lead to a containership distress, including sudden and violent disasters which immediately kill electric power, split ships, destroy communication antenna wires or otherwise prevent the transmission of a MAY DAY call and position report. In all these cases, the SAR must begin immediately after a determination has been made that a vessel is missing at sea, has failed to maintain a predetermined communication schedule, or is noted as overdue at the arrival port.

Conclusions

Life saving at sea on container vessels is one of the new challenges to search and rescue. The differences from regular vessel to containership are significant when fire or collision occur. The containership routes favor prompt SAR, if a distress and position report can be broadcast before 'abandon containership' is sounded.

With modern ships of all types locating the living quarters aft, the new lifeboat launching system described in this discussion should be seriuosly considered. Deck space would not be lost, due to the covered area surrounding the lifeboat room. Finally, proper marking to United Nations classes will warn cargo handlers, ship captains, customs personnel, and carrier corporations of any potential danger, which might lead to the loss of life aboard containerships at sea.

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