SHIPWORMS AND OTHER MARINE BORERS

Shipworm, genus Teredo, being drawn from a test block. Photograph by Robert F. Sisson, credit: National Geographic Society.

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF COMMERCIAL FISHERIES
WASHINGTON, D. C.

FISHERY LEAFLET 505

CONTENTS

SHIPWORMS AND OTHER MARINE BORERS

By

Michael Castagna
Fishery Research Biologist
U. S. Fish and Wildlife Service
Oxford, Maryland

INTRODUCTION

As long as man has launched wooden boats or built wooden structures in the sea, he has suffered from the activities of shipworms and other marine boring animals. Wherever a wharf or piling stands in salt water these seldom-seen enemies are ready to attack. Records show that as far back as 412 B.C. arsenic and sulfur mixed with oil was used on wooden structures to prevent shipworm invasion. During Columbus's time, bottoms of ships were covered with a mixture of tallow and pitch in hope of discouraging shipworms and various fouling organisms. It is possible that the crew sailing with Columbus wanted to turn back not in fear of the unknown but rather that they might not return to land before the shipworms sank their vessels. In the reign of Henry VI (1421-1471), a ship sent on a voyage of discovery records the use of land sheathing around the keel to keep out worms "which many times pearseth and eateth through the strongest oak that is."

The unfortunate introduction of the European shipworm in San Francisco Bay about the year 1913 resulted in an unprecedented destruction of exposed wooden structures. In the period of a few years following their introduction at least $25 million damage was attributed to these "termites" of the sea.

Today, large sums of money are spent annually for the control of these animals. Even so, periodic replacement of submerged structures is still necessary.

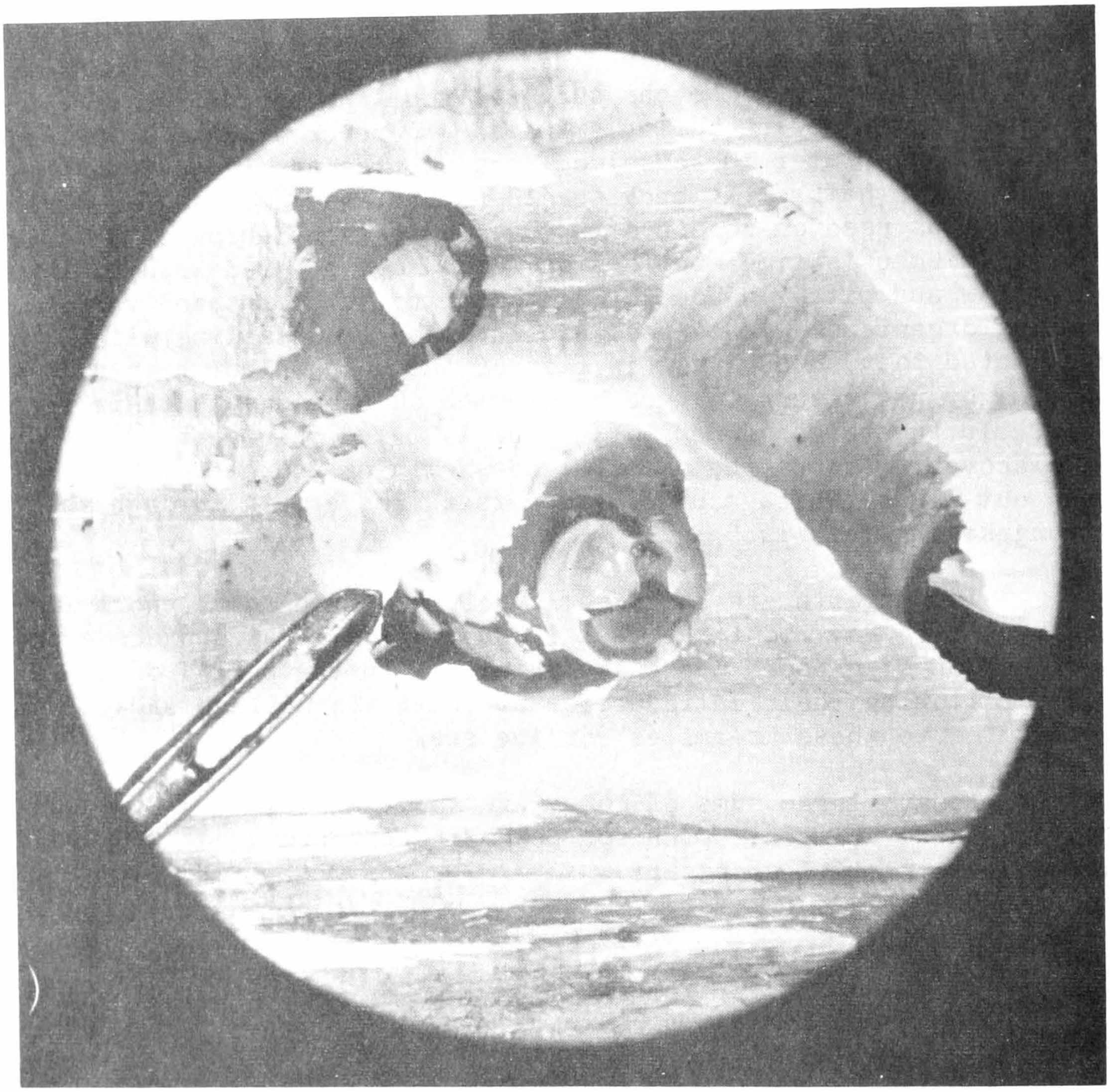
MOLLUSKS

Shipworms

The most destructive of the marine wood borers is the shipworm or teredo. This mollusk enters submerged timbers when it is very small and grows rapidly inside the wood. Myriads of these creatures riddle the interior of the wood until, without noticeable damage on the outside, an entire structure may suddenly collapse.

Classification.--Shipworms are mollusks belonging to the class Pelecypoda which includes such bivalves as clams, oysters, and mussels. They are members of the family Teredinidae in the order Teleodesmacae. Teredo and Bankia are the two common genera found along the coasts of the United States.

Description.--The shipworm is unusual in its relation to its habitat. Few instances can be cited wherein marine organisms are dependent upon organic products from the land, as is the rule with this molluscan wood borer. Parts of its body have become greatly modified in adaptation to its peculiar mode of life and, though the shipworm is a bivalve mollusk, it differs greatly in appearance from such familiar bivalves as clams and oysters.



Head of shipworm enlarged 10 times. The dark wedge on left of the spherical head is the mouth. On either side of the mouth appear the twin valves of shells forming movable curved plates with rows of file-like teeth which rasp away the wood. A sailmaker's needle indicates their size. Photograph by Robert F. Sisson, credit: National Geographic Society.

It has an elongated, naked, worm-like body. This superficial resemblance to worms misled early investigators who failed to recognize it as a mollusk. The two valves of the shell are reduced to a pair of small, curved plates that lie alongside the head where they serve as boring tools. The edges of these reduce shells are equipped with rows of fine teeth which make them efficient rasping organs. The soft body, though greatly extended, is fundamentally the same as that of typical bivalve mollusks.

An average adult shipworm measures 4 to 6 inches in length and less than one-quarter inch in diameter, but some species grow to considerable size. An Australian species, Dicyathifer, sometimes exceeds 1 inch in diameter and 6 feet in length. This shipworm is often used for food by the Australian aborigines. The natives of Tierra del Fuego also consider one of the larger species of shipworm an excellent sea food and even anchor logs in infested areas where they can be recovered and the mollusks harvested.

A pair of tube-like structures is located at the rear end of the body. These are the incurrent and excurrent siphons which are used in feeding and respiration. When the animal is normally extended, the siphons protrude through the opening of the burrow into the water. By the movement of numerous small hair-like cilia which line the body canal, water is continuously swept into the incurrent siphon, through the gills, and out the excurrent siphon. The sea water contains minute plant and animal organisms known as plankton. These organisms, most of which are microscopic in size, are the food of the shipworm. They are strained from the water circulating through the body canal and passed into the gullet by means of the gills. Dissolved oxygen in the water is taken up by the blood as it passes through the gill. The current of water also keeps the body moist and carries away waste materials which are discharged through the excurrent siphon.

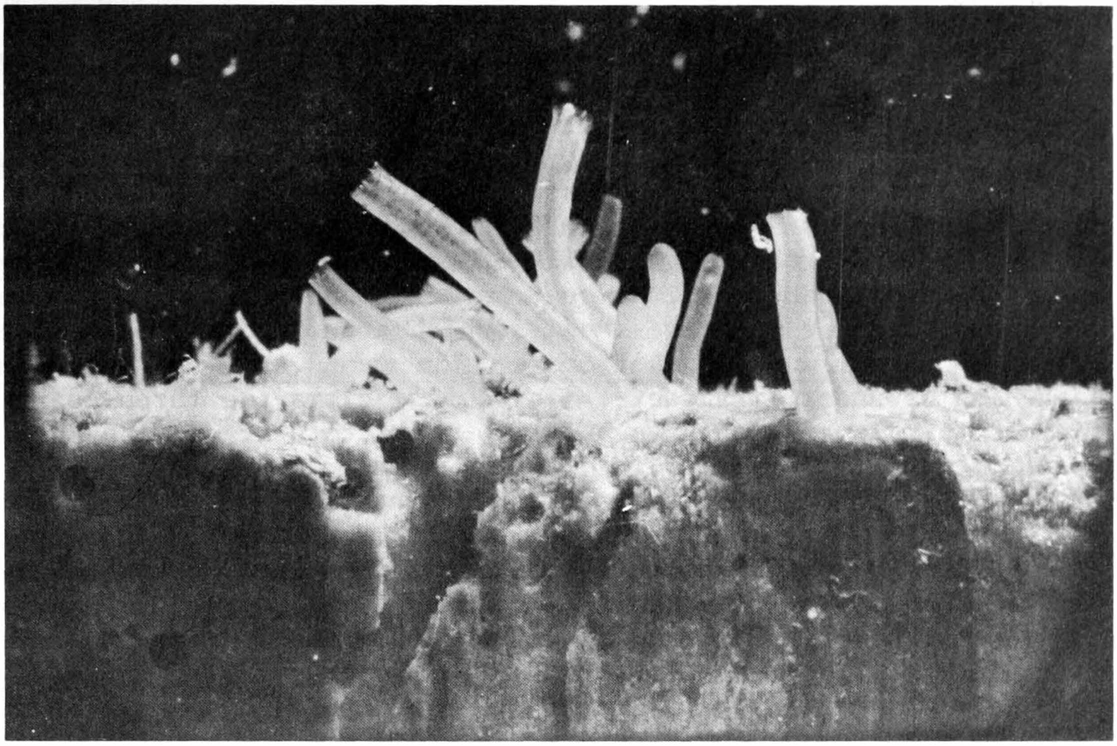
A large quantity of fine sawdust, produced by the shells rasping against the wood, is swept into the digestive tract. There is some controversy as to whether shipworms drill into timber for food. Considerable evidence is available to indicate that, like other bivalves, they bore into such material mainly for its support and protection. However, shipworms do contain in their liver an enzyme capable of producing a simple sugar from some parts of the wood. This suggests that wood may be used as a source of nourishment to some extent. In most cases, however, the wood particles are expelled unchanged in composition. Members of this family have been found boring into asphalt, bakelite, concrete, limestone, rubber, micarta, paraffin, neoprene, manila, sisal, and a considerable number of plastics, none of which can be considered as a nutrient material.

At the rear end of the body, near the siphons, is a hard, calcarious, paired structure known as the pallet. The pallet is an organ peculiar to the shipworm and varies in size and shape in the different species. If for any reason conditions outside the burrow become unfavorable, the siphons are drawn into the burrow and the pallet is thrust into the opening to serve as a plug. Enough water is retained in the burrow in this way to keep the body moist until the siphons are again extended and a normal water current re-established.

Reproduction and Early Life History.--Some species of shipworm are hermaphroditic, alternately producing sperm or eggs, but in other species the sexes are separate. Eggs and sperm are discharged through the excurrent siphon, and fertilization usually takes place while they are floating free in the water. Water temperature controls the general period of the breeding season and initiation of spawning. In some species, including *Teredo navalis*, the eggs are retained in the gill chamber of the female where they are fertilized by sperm drawn in with the entering current of water. In other species, the eggs develop into larvae inside the burrow of the female. A female shipworm may discharge as many as 100 million eggs; thus infestation can spread quickly if unprotected wood is available.

Upon development the fertilized egg of the shipworm becomes a free-swimming larva. It soon develops a bivalve shell into which the entire body can be withdrawn. Like other bivalves it has a velum, a paddle-shaped swimming organ covered with beating hairs called cilia, by which it propels itself about during its free-swimming existence. It also develops a relatively large muscular foot that enables it to crawl over submerged objects. After 1 or 2 weeks the larva is ready to transform into its adult form and ceases its purely planktonic life. It begins to crawl about until it finds a suitable notch or crevice in a submerged wooden structure. It then secretes a thread-like byssus by which it attaches itself to the surface of the wood. This is the beginning of its sedentary existence. The shell transforms into the rasping organ previously described, the foot develops into a pestle-shaped organ which assists the shell with its boring, and the swimming organ is absorbed.

The young shipworm then bores a tiny hole just large enough to admit its body and begins to burrow and grow. As the tunnel is deepened, it is enlarged to about one-quarter inch in diameter to accommodate the growing animal. The body elongates and completely fills the burrow but the entrance hole is never enlarged. The walls of the burrows are lined with a thin layer of calcareous material which is secreted by the mantle tissue of the animal. As the shipworm tunnels, it becomes completely dependent on its burrow and cannot live if removed. Should the burrow be punctured, respiration ceases and the animal dies. The burrows never connect or break through to the outside and external contact with the sea water is maintained only by the extended siphons.



Teredo siphons extended out of entrance holes in infested timber. When disturbed the shipworm pulls in siphons and blocks the entrance with twin calcareous plugs. Enlarged 20 times. Photograph by Robert F. Sisson, credit: National Geographic Society.

Distribution.--Adult shipworms are spread as the wood they occupy is carried by water currents as well as by movements of wooden-hulled vessels. Probably because of this they have almost worldwide distribution. All infestations of shipworms were once believed to be caused by one species, *Teredo navalis*. Although *Teredo navalis* does have a wide distribution, it is now known that there are a great many species of shipworm that occur in different parts of the world. Each species has its definite geographical range to which it is restricted by such factors as water salinity and temperature.

Damage by Shipworms.--The annual destruction of submerged wooden structures by shipworms is enormous. The U.S. Navy has estimated that damage to boats, barges, bulkheads, docks, piles, and bridges in the United States exceeds $50 million annually. This damage is especially dangerous since the animals enter the wood as minute individuals leaving a very small entrance hole. Because this hole is never enlarged, a thoroughly honeycombed piece of timber may look sound externally. Thus shipworms are not easily detected, and their infestations can be treacherous and costly.

Boring Clams

Clams of the family Pholadidae are another important group of boring marine animals.

Description and Natural History.--These are bivalve mollusks closely related to the shipworms. Unlike the shipworms, the boring clams are not worm-like in appearance but have retained the typical bivalve form with the body usually enclosed in two shells. Martesia, the wood piddock, is the best known member of this family and one of the most destructive species which attack wood. It has been known to attack creosoted timbers, concrete, and even the lead sheathing of underwater cable. The boring clams are three-quarters to 1 inch in length and have brittle, white to dark grayish shells which gape at both ends. These clams are usually elongated and narrow and somewhat wedge shaped toward the rear end. The front end of the shell is armed with rough, abrading ridges. Some species have additional shelly plates reinforcing the hinge or the margin of the shell. Boring is accomplished by a rocking and heaving motion of the shell, produced by a strong abductor muscle. The

adductor

Piling ravaged by gribbles. Unlike the shipworm, this easily spotted marine borer attacks the surface of wood, destroying it layer by layer. Photograph by Robert F. Sisson, credit: National Geographic Society.

boring clams penetrate an inch or more into the wood usually working toward the grain.

Distribution.--These animals live in sea water of full salinity or only slightly brackish water. They have an almost worldwide distribution but are not as common as shipworms. Three species of Martesia are found along almost all our shores.

There are a number of other marine bivalves that are capable of burrowing into submerged rock, concrete, or stone sometimes causing damage to structures built of these materials. The most important species belong to the general Pholadidea, Zirfaea, Petricola, Platyodon, Saxicava, Carditramera, and Lithophaga.

CRUSTACEANS

Types and Descriptions

Three genera of the class Crustacea include some important marine boring animals: Limnoria, Sphaeroma, and Chelura. These are often collectively called gribbles. The most important of these is Limnoria, an animal one-eighth to one-quarter inch in length somewhat resembling a wood louse. One species, L. lignorium, a member of the order Isopoda, is found along our shores. It has a cylindrical, slipper-shaped body divided into segments and capable of rolling into a ball. It has a small head and a broad tail-plate, used to seal off its burrow. There are seven pairs of jointed legs, each terminating with a sharp, curved claw. Five pairs of legs, each having two wide plates which act as gills, are located under the posterior part of the body. These gill-plates are also used as paddles for swimming. The horny jaws are modified for boring; the right jaw has a sharp point with a roughened edge which fits into a groove, and the left jaw has a rasp-like surface. Together, they form an efficient rasp and file combination. The burrow is about one-twentieth of an inch in diameter running at a slight angle under the surface of the wood. The burrows interlace, generally following the softer spring wood between harder layers of autumn growth.

This animal is especially dangerous because it can attack creosoted as well as untreated timbers. The damage is not as extensive as the burrowing of shipworms, for instead of boring deeply into the wood the gribble excavates galleries just under the surface. As the underlying wood becomes honeycombed, the surface layer is usually worn away by water currents exposing the damage and giving ample warning of the need for repairs. As the burrows are exposed, the animals tunnel into the next layer of wood.

Limnoria migrates short distances from one wooden structure to another, and the new location then becomes a breeding site. The females are fertilized directly by a male and carry their eggs

Portion of piling infested with shipworms. Dissecting needle indicates the small entrance to a shipworm burrow.

beneath the abdomen. Breeding occurs at least once a year and females produce from 6 to 17 young in each brood. The young, when hatched, look like miniature adults and bore at once into the wood. Since they start their burrow near the parents, infestation spreads slowly from a center.

Sphaeroma, also an Isopod, is much the same in appearance and habits except it is larger, usually about one-half inch in length. The body is oval, convex, and also capable of rolling into a ball. The burrows of this borer are substantially larger than those of Limnoria, sometimes exceeding one-half inch in diameter.

Chelura is another boring crustacean but, unlike Limnoria and Sphaeroma, it is in the order Amphipoda. Its body is cylindrical and shrimp-like, about one-quarter inch in length. It can be distinguished from Limnoria and Sphaeroma by its longer antennae and tail appendages. Its habits are similar to those of Limnoria, but its burrows are somewhat larger.

Distribution

These crustacean borers are found throughout the world.

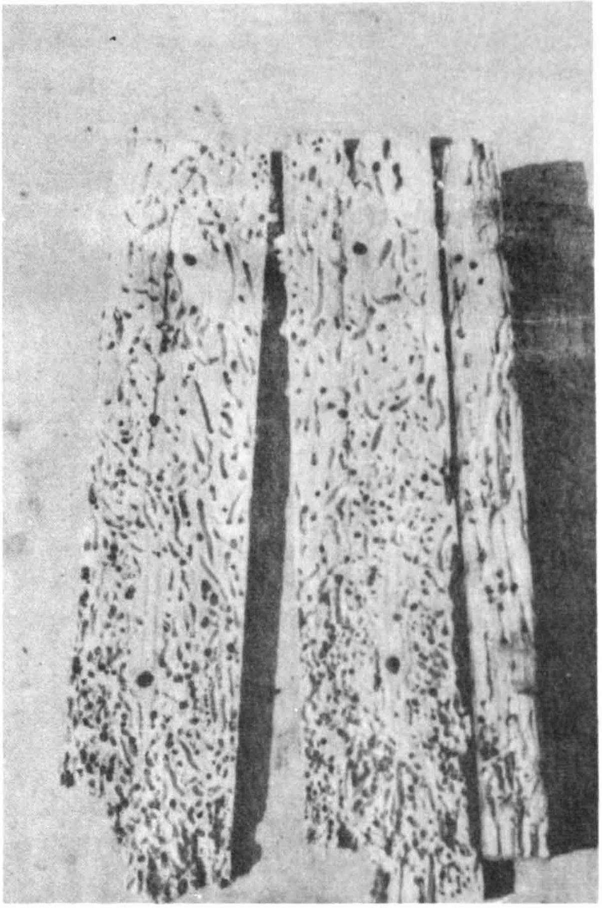
Limnoria has an especially wide distribution and is plentiful in northern harbors as well as in the tropics.

Other groups of invertebrate animals including polychaete worms, sponges, and bryozoans are also considered to be marine borers. Although these organisms do penetrate into the outer layer of submerged wood, the damage they do is only superficial. It is very unlikely that these animals alone could cause damage to submerged structures. They are often present on gribble-infested timbers and thus share some of the blame for any damage.

CONTROL AND PREVENTION

Shipworms and marine borers have few natural enemies. Principal among them are carnivorous worms which prey on shipworms, and many species of small fish which attack exposed gribbles. However, these animals do very little to keep shipworms and borers in check. Environmental factors are the main restriction on their activities. Low water temperatures and salinities can cause them to become dormant and water currents over $1\frac{1}{2}$ knots can prevent larval shipworms from becoming attached. Pollution, especially industrial effluents,

Base of piling showing gross destruction to wood caused by gribbles, Limnoria.



Section of damaged piling, split lengthwise, showing numerous shipworm burrows. At this stage of infestation, pilings frequently collapse.

is a deterent to shipworms, and almost immediate invasion take place in areas when such conditions are corrected. Dense distributions of plankton organisms, fouling organisms, or even organic material in the water can also inhibit the setting of shipworm larvae.

The most effective control of shipworms and other marine borers is by chemical treatment of submerged wooden structures. Today, protection of submerged structures is essentially an engineering and chemical problem. Thousands of dollars are spent annually in testing and developing new protective processes. In general, wooden materials can be protected by impregnating the wood with some substance that is repellent to boring animals; or by covering the surface with metal sheathing, concrete, or a hard coating, such as fiberglass; or by painting with a repellent or poisonous paint. Creosote mixtures are the most widely used for impregnation. Although they do not give absolute protection, they prolong the life of wooden structures by many years. The effectiveness of this type of treatment is dependent upon the kind of wood, method of impregnation, composition of the creosote material, and the locality. Metal sheathings are effective but need frequent replacement as a result of the corrosive action of sea water. Concrete sheathing is also affected by sea water. Hard coatings, such as fiberglass, seem to be effective and long lasting. Many antifouling paints have been developed which contain a variety of materials toxic to shipworms. Probably the most commonly used active ingredient is copper or a copper compound. Of course, paint requires periodic renewal making it useful only on floating equipment or structures which can be hauled out for repainting.

BIBLIOGRAPHY

Selected Publications on Shipworm and Other Marine Borers.

ATWOOD, WILLIAM G., and A. A. JOHNSON.
1924. Marine structures, their deterioration and preservation. Report of the Committee on Marine Piling Investigations. National Research Council, Washington, D. C., 534 p. (A monograph of the subject from the standpoints of physics, chemistry, biology, and engineering; contains an extensive bibliography.)

BARTSCH, PAUL.
1922. A monograph of the American shipworms. Bulletin U. S. National Museum, No. 122, 51 p.

CLAPP, WILLIAM F., and ROMAN KENK.
1956. Marine borers, a preliminary bibliography. Part 1. Technical Information Division, Library of Congress, Washington, D. C., 346 p.

1957. Marine borers, a preliminary bibliography. Part II. Technical Information Division, Library of Congress, Washington, D. C., 350 p.

LANE, CHARLES E.
1961. The Teredo. Scientific American, vol. 204, no. 2, p. 132-142.

RAY, DIXY LEE.
1959. Marine boring and fouling organisms. University of Washington Press, Seattle, Washington. 480 p.

SMITH, F. G. WALTON.
1956. Shipworms, saboteurs of the sea. The National Geographic Magazine, vol. CX, no. 4, p. 559-566.

UNIVERSITY OF MIAMI, MARINE LABORATORY.
1953. Report of marine borer conference sponsored by the William F. Clapp Laboratory and the Marine Laboratory, University of Miami, Coral Gables, Florida. Twenty reprints, various pages.

WALLOUR, D. B.
1958. Eleventh progress report on marine borer activity in test boards operated during 1957. William F. Clapp Laboratory, Report No. 10677, Department of the Navy, Bureau of Yards and Docks, Contract No. NOy-91481, 64 p.

WOODS HOLE OCEANOGRAPHIC INSTITUTION.
1952. Marine fouling and its prevention. U. S. Naval Institute, Annapolis, Maryland, 399 p. (Contribution No. 580, Woods Hole Oceanographic Institution.)

June 1961
MS #977

INT.DUP.,D.C.61-96570