Agenda Item H-1
May 16, 1980

MEMORANDUM

DATE: May 16, 1980

TO: Council Members

FROM: Jim H. Branson, Executive Director

SUBJECT: "Accumulation of Plastic Litters on Beaches of Amchitka Island, Alaska"

ACTION REQUIRED

Information only.

BACKGROUND

The Alaska Regional Office of NMFS has requested the Council review this report prepared by Theodore R. Merrell, Jr. The study was conducted several years ago, but the problem is a continuing one. NMFS believes that control of objectionable littering is necessary and could be enhanced by the Council thru FMP's and regulations to the FMP's. A presentation on this will be made by a NMFS staff member.

JW

AGENDA H-1
May 1980

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 1668
Juneau, Alaska 99802

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APR 16 1980

April 14, 1980

Mr. Jim Branson
North Pacific Fishery Management Council
P.O. Box 3136 DT
Anchorage, AK 99510

Dear Jim:

The NMFS for several years has been interested in curbing the discard of litter into the oceans. A study conducted by NMFS several years ago at Amchitka indicated that foreign vessels were the major culprits in discarding material that end up on Alaska beaches. Much of the waste is plastic and extremely enduring. Enclosed is a copy of "Accumulation of Plastic Litter on Beaches of Amchitka Island, Alaska" by Theodore R. Merrell, Jr.

It is well established that derelict nets kill thousands of sea birds, fur seals and other marine life and disable many vessels at sea by fouling props or jamming cooling systems. The long-range effects of discarded plastic on the biota is not yet fully understood--but is objectionable.

We believe that control of objectionable littering is necessary and can be enhanced by the Council through their FMP's and implementing regulations.

It is requested that the topic be included for discussion on the May agenda of the Council.

Sincerely,

Harry

Harry L. Rietze
Director, Alaska Region

Enclosure

ACCUMULATION OF PLASTIC LITTER ON BEACHES OF AMCHITKA ISLAND, ALASKA

by

Theodore R. Merrell, Jr.

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USA

MARINE ENVIRONMENTAL RESEARCH

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CONTENTS

ACCUMULATION OF PLASTIC LITTER ON BEACHES OF

AMCHITKA ISLAND, ALASKA

Theodore R. Merrell, Jr.[1]

ABSTRACT

Between 1972 and 1974 plastic marine litter on ten 1-km beaches at Amchitka Island increased from 2,221 to 5,367 items--a 2.4X increase in a two-year period. Most litter originated from Japanese and Soviet fishing vessels, but some items were from the Asian coast at least 1,150 km distant. In 1974 there were 345 kg of common items of plastic litter per km of beach. In 1972, an estimated 1,664 metric tons of plastic litter was lost or dumped from fishing vessels in the Bring Sea and North Pacific Ocean. Stranded plastic litter persists indefinitely but rapidly becomes buried in beach material or is blown inland and covered with vegetation. The most serious environmental impact is probably entanglement of marine mammals and birds in some types of litter. The accelerating accumulation of litter could be reduced through unilateral action by countries that regulate coastal fishing privileges if these countries make litter control a condition for permission to fish.

INTRODUCTION

Each year approximately 6·4 x 10^6 metric tons of shipboard litter is discarded into the world's oceans (National Academy of Sciences, U.S., 1975). Only 0·7% of this litter is plastic but because most plastics float, they eventually strand on ocean beaches where they persist indefinitely (Cundell, 1974; National Academy of Sciences, U.S., 1975). Plastics production is doubling every 12 years, and accumulation of marine litter will follow a similar trend unless disposal is regulated (Guillet, 1974).

Plastic marine litter occurs throughout the world, but is concentrated unevenly in the Northern Hemisphere (National Academy of Sciences, U.S., 1975). Most accounts of plastic litter pollution and its environmental effects have been limited to short-term observations of floating debris (Carpenter & Smith, 1972; Venrick et al., 1973; Colton et al., 1974; Wong, Green, & Cretney, 1974) or one-time surveys of stranded litter (Scott, 1972; Gochfeld, 1973; Cundell, 1973; Wong, MacDonald, & Bellegay, 1974).

This article describes a 3-year quantitative study of seasonal and annual rates of plastic litter accumulation and degradation on Amchitka Island beaches. Amchitka Island, one of the Aleutian Islands, is in the North Pacific Ocean and is distant from population centers. The opportunity to periodically visit this remote island and observe litter resulted from unrelated studies for the U.S. Atomic Energy Commission (AEC) on environmental effects of underground nuclear explosions.

METHODS

From my first surveys at Amchitka in 1972, I estimated 24,000 individual plastic items on beaches of the 65 km x 5 km island

(U.S. Department of Commerce, 1973; U.S. Senate, 1973). In 1973 and 1974, I repeated and expanded the surveys to estimate annual rates of accumulation and disappearance.

Rates of accumulation and disappearance of plastic litter were estimated from three independent sources of data: 1) total numbers and weights of individual plastic litter items on ten 1-km beaches surveyed once each year for three years; 2) numbers of marked plastic gillnet floats persisting from year to year on two beaches; 3) numbers and weights of plastic litter on a 1-km length of beach from which litter accumulations were cleared on seven dates over a 2-yr period. I observed locations of characteristic litter accumulations and estimated the lengths of sand, boulder, and bedrock beaches for the entire island by circumnavigating the island in a helicopter at 40 m heights.

To ensure comparability of data on repetitive surveys, I personally made all the surveys, with occasional assistance. On each survey, I recorded all plastic litter items visible from walking height according to frequency of types. Weights of common individual items were estimated or measured, and length of rope and strapping were estimated. Surveys included the entire intertidal zone from low tide to the extreme high tide zone. I did not uncover litter buried in kelp, driftwood, or sand and counted only fragments larger than about 5 mm on the beach surface; therefore, only a portion of the total plastic litter actually present was included in my estimates. Only plastic litter was recorded, although negligible quantities of other litter, such as wood, metal, glass, and petroleum residues, were also observed. For example, only three weathered tar balls, one about 5 cm in diameter and the other two about 20 cm, were noted on 40 km of beach surveyed during the three years.

Seven beaches were surveyed on the Bering Sea (northeast) shore of Amchitka, and four on the North Pacific Ocean (southwest) shore (Fig. 1). Seven beaches were predominantly sand and four, boulder/cobble. Bedrock beaches were not included in surveys or estimates because most were precipitous and inaccessible and had only insignificant accumulations of litter and other flotsam.

The amounts and types of litter on each of ten 1-km beaches were compared to determine patterns of accumulation according to physical characteristics of the beach. Amounts of different types of litter on a given beach were similar from year to year, but varied widely between beaches. There were no common patterns of accumulation between sand and boulder beaches, Bering Sea and North Pacific Ocean exposures, or steep and low-gradient beaches; therefore, data for all ten beaches were combined.

Hundreds of kinds of plastic items were found, but only 24 occurred five times or more in any one year (Table 1). Eleven items, comprising over 98% of the total weight, were commercial fishing gear. Trawl web was the dominant item, contributing over 80% of the weight in the three years (Fig. 2). Two large fishery items were not represented in surveys in proportion to their likely frequency of coming ashore: rigid plastic trawl floats and polyethelene inflatable buoys. Both were sought by beachcombers from the AEC work-force, which numbered several hundred at times. The inflatable buoys from United States crab pots were usually found and removed within a few days after beaching and were, therefore, not recorded in my surveys. Trawl floats were not collected by beachcombers until 1974, which is evident by a leveling off in the numbers of trawl floats in my 1974 survey relative to the 1972 and 1973 surveys.

ACCUMULATION RATES

Both the number and weight of the 24 most common items increased substantially on Amchitka Island between 1972 and 1973 and even more dramatically between 1973 and 1974. The number of these items increased from 1,932 (193.2 per km of beach) in 1972, which represented the net accumulation for all previous years, to 2,839 (283.9/km) in 1973, to 4,993 (499.3/km) in 1974--a net increase of over 250% in a 2-yr period (Table 1). The total weight of the 24 most common items increased from 1,216 kg (121.64 kg/km) in 1972 to 1,564 kg (156.42 kg/km) in 1973, to 3,454 kg (345.40 kg/km) in 1974--a 284% increase between 1972 and 1974. If all litter items are included, not only the 24 most common, there were 5,367 (537/km) plastic items of all types of litter on Amchitka beaches in 1974 (Table 2). The rates of increase of the 24 most common items resemble the slope of an exponential curve computed by Guillet (1974) showing the hypothetical world accumulation rate for plastic litter with a half-life of infinity (Figure 3). The weight of accumulated litter on Amchitka Island from 1972 to 1974 increased at an annual rate of 59% or nearly 10 times the rate of Guillet's hypothetical 6% rate. The large difference between Guillet's rate and the Amchitka Island rate may be explained by the special source of the litter (large fisheries in adjacent waters) and by Guillet's conservative assumptions (6% annual production growth, 20% of annual production growth is in packaging, and 2% of packaging becomes litter). Under conditions of large fisheries and attendant accidental loss and deliberate dumping of discarded plastic fishing gear, marine litter accumulates at a rate that exceeds theoretical estimates.

In addition to the annual ten-beach surveys, I repeatedly surveyed the same 1-km section of one beach to measure rates of litter accumulation on Amchitka Island. All plastic litter was counted, weighed, and removed from Rifle Range Beach on seven dates between April 1972 and May 1974 (Table 3). Small litter items were removed from the area; items too heavy or bulky to carry were dragged inland above the reach of tide.

The short-term rate of accumulation on this 1-km section of beach was extremely variable and was markedly increased by storms. On 26 April 1972, an initial 112·3 kg was cleared from the beach and by 10 July 1972, an additional 170·7 kg of plastic litter had accumulated. The beach was again cleared and by 6 October 1972, 132·4 kg of plastic litter had accumulated. Between 6 and 10 October, a severe onshore storm deposited 2.0 kg. Three days later on 13 October after a calm period, only 0·015 kg of additional litter accumulated. Between October 1972 and June 1973, additional net accumulation was 134·2 kg and between June 1973 and May 1974, an additional 249·2 kg accumulated.

The accelerated accumulation on all beaches reflected both increased quantities of litter and the indestructibility of plastic litter. Some unique individual large items were noted each year, for example: monofilament gillnet entangled around driftwood (Fig. 4), fenders (Fig. 5), and large containers with brand names. Not one of these items appreciably deteriorated or changed location between 1972 and 1974.

A long period may elapse between discard of litter at sea and its stranding on a beach. For example, a Japanese fishmeal bag with a 1970 date was found in 1974 that had not been on that beach in 1973 (Fig. 6).

Assuming the bag was discarded in 1970, it required three to four years to come ashore.

DISAPPEARANCE RATES

Japanese gillnet floats were the most abundant single litter item on the beaches of Amchitka Island. Without moving any, I spray painted all of these floats on two beaches on opposite sides of the island to determine how rapidly litter disappeared and whether litter, once ashore, was redistributed to adjacent beaches. One year later, I surveyed these beaches and adjacent 1,000-m beaches on each side of them and examined all floats for marks. On one beach, 70% of the painted floats disappeared and on the other, 25% disappeared (41% combined); but during the same one-year period, a total of 175 additional unpainted floats appeared on the two beaches. Therefore, within one year the number of floats increased 130% even with a 41% disappearance rate. This increase is consistent with the net increase of 176% in the number of all litter items on the 10 beaches between 1973 and 1974 (Table 2). No painted floats were found on any of the four adjacent beaches; most floats--and presumably other plastic litter--did not become redistributed, but remained ashore.

Both physical and biological factors contribute to rapid disappearance of litter at Amchitka, including burial by storm surfs in beach sand and under boulders, transport inland by wind where rank vegetation quickly concealed all but the largest items, abrasion by wind-blown sand, battering by storm-tossed boulders, and gnawing by rats, Rattus norvegicus, which were especially fond of gillnet floats (Fig. 7) and sandals. Microbial degradation and photo-oxidation of litter were probably less important on Amchitka Island than on many other islands. Most plastics are relatively immune to metabolic activities of microorganisms (Cundell, 1974) and the prevailing low temperatures at Amchitka Island would inhibit microbial activity; the mean annual temperature is only 4°C and the maximum recorded temperature is 18°C. Photo-oxidation is probably insignificant because Amchitka Island is usually covered by clouds and fog; a sunny day is unusual.

ORIGINS OF LITTER

Most plastic litter on Amchitka Island originated from enormous Japanese and Soviet fishing fleets on the North American continental shelf, especially, in the Bering Sea (Merrell 1977). Between 1962 and 1974 an annual average of 697 Japanese vessels and 453 Soviet vessels fished off the coast of Alaska (National Marine Fisheries Service, U.S., 1963-1974). Vessels from countries other than Japan and USSR constituted only a negligible portion of the total fishing fleet and were represented by a correspondingly small portion of the litter. Only a few of the plastic items on Amchitka Island could be identified by country of origin but, of these, Japanese items predominated (Fig. 8). Countries represented by litter with identifiable markings included Japan, United States, USSR, South Korea, Canada, Bulgaria, Romania, and Netherlands, in order of descending frequency. Polypropylene fishing trawl web, the predominant item by weight, has no national markings but was assumed to be of Japanese or Soviet origin because trawl fishing in the North Pacific and Bering Sea is primarily by these two nations. Gillnet floats were exclusively Japanese. Identifiable South Korean items were seen only in the final surveys in 1974, indicative of that country's entry into North Pacific/Bering Sea fishing grounds with 39 vessels. Bulgarian and Romanian items were limited to wine bottle sealer-caps, presumably from Soviet fishing vessels. Netherlands was represented by a single milk crate. United States items were mostly of two types: lost or discarded king crab fishing gear, and recent litter from U.S. Atomic Energy Commission or from World War II military activities on Amchitka Island. The majority of local United States litter consisted of polyethylene sheeting and bags, jars and bottles, World War II synthetic rubber military tires (not included in weight estimates), and miscellaneous small items such as expended shotgun shells, styrofoam packing, hard-hats, and ball point pens. The total number and weight of these items were insignificant relative to all the litter on Amchitka Island, with the exception of polyethylene sheeting. In 1972, 124 pieces of sheeting with a total area of 36 m^2 were found; in 1973, 90 pieces with an area of 28 m^2; and in 1974, 143 pieces with an area of 32 m^2.

A few items with national markings evidently originated from Japanese and Soviet homelands which are at least 1,150 km from Amchitka Island. This litter included children's toys (Fig. 9), women's sandals and hair curlers (Fig. 10), baby nursing-bottles, and perfume bottles. Part of the large numbers of Japanese containers for food, liquid detergent, bleach, medicine, shampoo, and liquor could have originated from the Asiatic coast, but most were probably discarded at sea from Japanese fishing vessels.

The purpose of some plastic litter was enigmatic and probably related to specialized applications in high seas fishing operations (Fig. 11).

EXTRAPOLATION OF ESTIMATES

Caution is required in extrapolating Amchitka Island data to regional or world litter estimates. Although the quantity and variety of plastic litter on Amchitka beaches is representative of many Alaskan beaches, especially in the Aleutian Islands, casual observations indicate that many other Alaskan beaches have less litter than those of Amchitka. Another reason for caution in extrapolating Amchitka Island data to other areas is the large variability in quantities of litter from one beach to another, even on similar adjacent beaches of equal length on the same small island (Table 2).

With these caveats in mind, I made two extrapolations from Amchitka data: an estimate of the quantity of accumulated litter on the entire shoreline of Amchitka Island and an estimate of the amount of plastic litter lost or dumped annually by fishing fleets in the Bering Sea and North Pacific Ocean.

On a helicopter reconnaissance of the entire Amchitka Island shoreline, I verified that little flotsam accumulates on bedrock beaches and determined the total lengths of bedrock, boulder, and sand beaches. The length of the Amchitka Island coastline is about 173 km; 73 km of this is bedrock, which was assumed to have no litter. The ten 1-km beaches surveyed during annual foot surveys constitute 10% of the total shoreline that had significant quantities of litter; therefore, total litter for Amchitka Island can be approximated by multiplying by 10 the amounts of litter surveyed (Table 4).

The quantity of plastic litter lost or dumped annually by fishing fleets in the Bering Sea and North Pacific Ocean was estimated from a series of tenuous facts and assumptions:

Facts:

1. Worldwide shipboard-generated litter from personnel on commercial fishing vessels is 340,000 metric tons per year (National Academy of Sciences, U.S., 1975).

2. The plastic (floating) component of litter originating from personnel on commercial fishing vessels is 0·7% of all the worldwide shipboard-generated litter (National Academy of Sciences, U.S., 1975).

3. Worldwide, there are 120,000 commercial fishing vessels (National Academy of Sciences, U.S., 1975).

4. In 1972 there were 1,457 Japanese, Soviet, and South Korean vessels fishing off Alaska (National Marine Fisheries Service, U.S., 1973).

5. Litter on 10 km of Amchitka beaches in 1974 was comprised of 3393·70 kg of lost or discarded fishing gear and 60·32 kg of other litter not directly used in commercial fishing (0·018% is "other" litter) (Table 1).

Assumptions:

1. Virtually all litter on Amchitka beaches originates from foreign fishing fleets in the Gulf of Alaska and Bering Sea.

2. Crews of foreign fleets off Alaska generate the same relative amounts of floating plastic litter unrelated to fishing operations, as the world average.

3. The relationship of fishing gear to other litter on Amchitka beaches in 1974 is representative of what was actually lost or discarded in 1972.

4. Two years elapse between discard and stranding (an arbitrary assumption with no supporting data other than a fishmeal bag manufactured in 1970 and recovered in 1974 [Fig. 6]).

5. All floating commercial fishing gear lost or discarded eventually comes ashore.

Based on these facts and assumptions a gross estimate of the total annual plastic litter lost or discarded in the Gulf of Alaska and Bering Sea can be made in two steps:

$$\frac{\text{Wt. of fishing gear on Amchitka beaches, 1974}}{\text{Wt. of "other" plastic litter on Amchitka beaches, 1974}} = \frac{\text{Wt. of lost fishing gear, world}}{\text{Wt. of plastic litter, world fishing vessels}}$$

or

$$\frac{3{,}394 \text{ kg}}{60 \text{ kg}} = \frac{X}{2{,}380{,}000 \text{ kg plastic litter}}.$$

X = 134,628 metric tons of lost fishing gear, world.

$$\frac{\text{No. fishing vessels, world}}{\text{No. fishing vessels, North Pacific Ocean and Bering Sea}} = \frac{\text{Wt. of lost fishing gear, world}}{\text{Wt. of lost fishing gear, North Pacific Ocean and Bering Sea}}$$

or

$$\frac{120{,}000 \text{ vessels}}{1{,}457 \text{ vessels}} = \frac{134{,}628 \text{ metric tons}}{X}.$$

X = 1,635 metric tons, weight of lost fishing gear, North Pacific Ocean and Bering Sea.

Therefore:

0·018 x 1,635 = 29·4 metric tons, North Pacific Ocean total "other" plastic litter.

1,635 + 29·4 = 1,664·4 metric tons of plastic litter is lost or discarded annually by fishing fleets in the North Pacific Ocean and Bering Sea in 1972.

The 1,664·4 metric ton estimate is many times greater than the 12 metric ton estimate for the same area by the National Academy of Sciences (1975). However, their estimate was based on limited data from my initial 1972 surveys (U.S. Department of Commerce, 1973), and the incorporation of my survey data from 1973 and 1974 provide a sounder basis for the larger revised estimate.

ENVIRONMENTAL SIGNIFICANCE OF PLASTIC LITTER

The environmental significance of plastic marine litter is controversial, but some undesirable or harmful impacts are certain. The most obvious impact is the sight of litter on wilderness beaches, which is aesthetically repulsive. The question of chemical pollution of the marine environment by floating plastic litter is unanswered. PCB's, phthalates, and other toxic chemicals may be leached from litter, contributing to worldwide ocean pollution. Elevated levels of PCB's in rats and intertidal organisms on Amchitka Island may originate from plastic beach litter (White and Risebrough, 1977), but data are inconclusive.

Plastic litter occasionally disables ships, but no statistics are available. Derelict sheet plastic blocks engine cooling water intakes and fouls propellors; floating lines (Fig. 12) and nets become entangled in propellers.

Marine mammals, fish, and birds often become entangled with plastic marine litter. On Amchitka Island, I saw bird and fish bones in some wads of Japanese monofilament salmon gillnet (Fig. 13). Similarly, a marine mammal skull was reported in a 75 m wad of net (Anon., 1973). Derelict nets, floating at the surface, may drift for years and take a heavy toll of fish, mammals, and diving sea birds before washing up on some beach.

Floating marine litter apparently attracts marine mammals, which are also attracted to natural floating objects such as kelp blades. Many plastic squeeze bottles and other containers on Amchitka Island beaches have marine mammal teeth marks (Fig. 14), evidence that they have been tested for palatability, or perhaps been bitten in play.

The problem of marine mammals becoming entangled in derelict nets and strapping is more serious. Since 1967, records have been kept on numbers of net-entangled fur seals on the Pribilof Islands, the principal breeding areas of northern fur seals (North Pacific Fur Seal Commission, 1977). Before 1960, when the great expansion of Japanese and Soviet fishing fleets in the Bering Sea and Gulf of Alaska began, few northern fur seals trailing plastic debris were noted, but by 1964 entangled seals were a common occurrence. The number and percentage of entangled males that were harvested have increased dramatically in recent years (Table 5).

An increasing number of Pribilof fur seals have also been afflicted with plastic strapping bands encircling the neck (Fig. 15). None were noted in 1969, 5% of the total entanglements were strapping bands in 1970, and over 30% in 1973 and 1974. These strong bands, about 15 mm wide and 0·5 mm thick, are used to strap bundles of new netting and crates and are numerically the second most common item on Amchitka Island beaches (Fig. 16, Table 1). When the strap loop is not cut before discarding, a fur seal may put its head through the loop and then cannot remove the strap.

These observations are only of fur seals that survive--an unknown number are fatally entangled and never reach the breeding grounds; dead entangled seals have sometimes been observed at sea, having died of malnutrition and exposure. The importance of derelict gillnets in contributing to mortalities of fur seals is illustrated by the fact that more than 3,000 fur seals are estimated to be killed annually in gillnets of the Japanese gillnet fishery for salmon in the North Pacific Ocean.[2]

POTENTIAL SOLUTIONS TO THE CONTROL OF MARINE LITTER

It is unrealistic to expect voluntary actions by operators of offending ships to be effective in reducing litter because the cheapest, easiest, and customary solution to disposal is to throw litter overboard. Education programs to make individuals aware of the problem and its environmental consequences might achieve a long-term reduction in marine litter, but quicker, more effective measures are needed.

Mandatory constraints with enforcement provisions should be implemented to control disposal of shipboard litter and provide disposal facilities on shore. These controls could be implemented by: 1) Intergovernmental agreements through treaties or international organizations and 2) unilateral action by countries in geographic areas under their control.

Several international treaties address the problem of oceanic pollution, but none have yet been adopted by all nations. Agreements relevant to the western Aleutian Islands are: 1) recommendations of the Standing Scientific Committee of the North Pacific Fur Seal Commission (NPFSC) (North Pacific Fur Seal Commission, 1974); 2) the 1972 Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter (Ocean Dumping Convention); and 3) the 1973 International Convention for Prevention of Pollution from Ships (Marine Pollution Convention). These two conventions are administered by the Intergovernmental Maritime Consultative Organization (IMCO).

At the 1977 Annual NPFSC meeting the Japanese, United States, and Canadian governments agreed to distribute posters and brochures to their fishing industries explaining the problem of plastic debris and requesting that it not be discarded at sea (North Pacific Fur Seal Commission, 1977). This was followed by a letter from the Executive Secretary of NPFSC to nations fishing in the North Pacific Ocean, calling attention to the problem. This means of litter control is, of course, limited to nations signatory to the Interim Convention on Conservation of North Pacific Fur Seals.

IMCO is working toward full implementation of the Ocean Dumping and Marine Pollution Conventions. In 1974, the United States ratified the Ocean Dumping Convention (U.S. Congress, 1972) and has assumed leadership in urging adoption by other nations. Under terms of Annex I of this Convention (Intergovernmental Maritime Consultative Organization, 1972), deliberate dumping of persistent plastics such as netting and ropes is prohibited except in an emergency.

The Marine Pollution Convention covers a wide range of ocean pollutants, including oil, noxious substances, sewage and garbage (i.e., synthetic fishing nets and ropes), and seeks to eliminate intentional pollution and minimize accidental pollution (Intergovernmental Maritime Consultative Organization, 1973). Because of its broad scope and the practical problem of providing shore reception facilities for pollutants retained aboard ship, adoption on a worldwide basis is likely to be slow. However, the amendments adopted at the 1978 Tanker Safety and Pollution Prevention Conference held in London in February of that year, will help to accelerate the coming into force date of the Marine Pollution Convention. President Carter recommended ratification by the United States in his Message to the Congress in March 1977, but this has not yet been accomplished. A draft bill is currently being considered by the 96th U.S. Congress preparatory to implementation and ratification.

Control of oil pollution, which has captured world attention, is closely related to control of litter pollution, which has not yet been recognized as a significant problem. In fact, the Marine Pollution Convention addresses both oil and plastic litter.

Unilateral action is the most effective interim solution for control of marine oil pollution (Mostert, 1976; Waldichuck, 1977) and may also be the most effective solution for control of marine plastic pollution. Organizational mechanisms already exist for regional control of litter from fishing fleets in the Bering Sea and Gulf of Alaska--the Bilateral Annual Agreements of the North Pacific Fur Seal Commission between the United States, Japan, and the Soviet Union, and, more recently, in the United States, through the Fishery Conservation and Management Act of 1976 (more commonly known as Extended Jurisdiction) which became effective 1 March 1977. Under terms of this act, the United States has created a 200-mile fisheries zone off its coasts, which establishes the terms under which fishing is permitted and creates mechanisms for enforcement of the act. Ships could be required to retain all litter aboard for shore disposal as a condition for securing a fishing permit. Canada has established a similar 200-mile fishing zone that, together with the United States zone, provides a means to quickly control litter disposal for most of the North American continent.

These measures, alone or in combination, can alleviate the growing litter problem but not eliminate it. The world's oceans are awash with indestructible floating plastic litter that will continue to accumulate even if littering is stopped. Furthermore, some fishing gear litter is unavoidable because it is lost during fishing operations as a result of storms, structural failure of the gear, or snagging on foul bottoms. It is clear that plastic litter, predominantly from fishing fleets, is a significant oceanic pollutant, and recognition of its magnitude is a first step in devising effective controls.

ACKNOWLEDGEMENTS

I am indebted to the Atomic Energy Commission for logistics on Amchitka and transportation to and from the island. I also thank several colleagues from the National Marine Fisheries Service Auke Bay Laboratory who assisted in the surveys, especially John Karinen who participated in planning and execution of the initial 1972 survey.

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FOOTNOTES

[1] Northwest and Alaska Fisheries Center, Auke Bay Laboratory, National Marine Fisheries Service, NOAA, P.O. Box 155, Auke Bay, Alaska 99821, USA.

[2] National Marine Fisheries Service, Marine Mammal Laboratory, Seattle, Wa., USA.

LIST OF TABLES

Table 1. Abundance (weight and number per kilometer) of common items of plastic litter on ten 1-km beaches on Amchitka Island, 1972-73-74. * Indicates fishing gear.

	Weight (kg)/km			Number/km		
Item	1972	1973	1974	1972	1973	1974
* Trawl web	103·87	122·15	271·75	12·3	16·7	23·7
* Polypropylene rope[1]	6·21	13·20	36·08	10·1	20·0	25·9
* Trawl floats	4·70	10·09	18·25	1·7	5·2	5·0
* Gillnet floats	3·15	4·44	6·03	65·6	92·5	125·6
* Polyethylene bulk containers	0·53	0·92	3·21	1·2	1·9	5·4
* Fish baskets	1·08	2·14	3·03	1·0	1·2	1·7
Beer cases	0·19	0·96	1·91	0·1	0·5	1·0
Squeeze bottles	0·43	0·81	1·45	8·2	15·6	27·8
Other bottles	0·16	0·32	0·80	3·1	6·3	15·9
Plastic fragments	0·12	0·23	0·57	33·5	64·0	137·4
* Spongex floats	0·16	0·18	0·54	2·3	2·6	8·0
Polyethylene pails	0·20	0·22	0·44	1·1	1·3	2·6

Table 1. Continued.

Item	Weight (kg)/km 1972	1973	1974	Number/km 1972	1973	1974
Sandals	0·36	0·22	0·31	3·0	1·8	2·6
Bleach bottles	0·18	0·17	0·22	1·3	1·2	1·6
Bottle lids and tops	0·07	0·07	0·14	11·9	13·0	25·0
* Chemical ampules	0·04	0·04	0·13	3·0	2·9	9·0
* Outboard oil containers (1 quart)	0·03	0·06	0·12	0·6	1·1	2·0
Cups and bowls	0·09	0·08	0·12	2·1	1·9	2·9
* Crab bait boxes	0·01	0·04	0·12	0·1	0·5	1·6
* Strapping	0·05	0·05	0·11	30·1	32·0	70·7
Soap dishes	0·008	0·013	0·029	0·2	0·3	0·7
Cap visors	0·003	0·005	0·018	0·1	0·2	0·7
Gloves	0·000	0·003	0·015	0	0·1	0·5
6-pack yokes	0·003	0·006	0·010	0·6	1·1	2·0
Total	121·64	156·42	345·40	193·2	283·9	499·3

[1]Total length: 1972, 255 m; 1973, 501 m; 1974, 802 m.

Table 2. Frequency of all plastic litter items on ten 1-km beaches on Amchitka Island, Alaska, 1972-74. See Figure 1 for locations.

Beach		Number of items found		
Name	Composition	1972	1973	1974
Makarius	Sand	485	392	817
Rat	Sand	294	253	513
Clevenger Creek	Sand	194	328	898
Crown Reefer	Boulder	133	359	573
Petrel Point	Boulder	145	225	319
Sand Beach Cove	Sand	276	377	508
Sea Otter Point	Boulder	235	496	391
Silver Salmon	Sand	228	266	522
Square Bay	Sand	63	119	308
Stone Beach Cove	Sand	168	239	518
Total		2,221	3,054	5,367

Table 3. Accumulation of plastic litter on Rifle Range Beach, Amchitka Island, during various time intervals from 26 April 1972 to 25 May 1974. The beach was cleared of all litter during each survey, except as indicated.

	Weight of items (kg)					
Date of clearing	Trawl web	Gillnet floats	Rope	Other	Total	Remarks
26 Apr 72	90·2	8·0	0	13·6	112·3	Gillnet on log not removed
10 July 72	170·1	0·2	0	0·4	170·7	
6 Oct 72	122·3	3·2	0	6·9	132·4	Before storm
10 Oct 72	1·4	0·4	0	0·2	2·0	After storm
13 Oct 72	0	0	0	0·02	0·02	After calm weather
12 June 73	12·9	1·2	116·0	4·1	134·2	
24-25 May 74	207·3	11·8	0	30·1	249·2	Beach not cleared

Table 4. Extrapolated estimate of numbers of all plastic litter items and weight of most common items on Amchitka Island, 1972-74

Year	Number of items	Weight of 24 heaviest items (kg)
1972	22,210	1,216
1973	30,540	1,564
1974	53,670	3,454

Table 5. Number and percentage of harvested male northern fur seals entangled in plastic debris, 1967-77.

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Number	75	75	67	122	143	156	135	211	268	102	327
Percent of total	0·17	0·21	0·21	0·29	0·45	0·42	0·47	0·64	0·92	0·44	1·15

FIGURE LEGENDS

1. Locations of plastic litter surveys on Amchitka Island 1972-74.
2. Large section of trawl netting on Rifle Range Beach, Amchitka Island, 26 April 1972.
3. Accumulation of marine litter on Amchitka Island beaches (dashed lines, extrapolated data; solid line, actual data) and hypothetical world litter accumulation (Guillet, 1974).
4. Monofilament Japanese gillnet tangled in driftwood, Petrel Point Beach, Amchitka Island.
5. Plastic ship's fender, Crown Reefer Beach, Amchitka Island.
6. Japanese fishmeal bag from Sea Otter Point Beach, Amchitka Island.
7. Japanese gillnet floats with rat teeth marks.
8. Japanese squeeze bottle in tangle of large diameter plastic rope, Rifle Range Point Beach, Amchitka Island.
9. Children's toys found on Amchitka beaches.
10. Women's sandals and hair curlers found on Amchitka beaches.
11. Common plastic objects, whose purpose is unknown, found on Amchitka beaches.
12. Large plastic rope, Petrel Point Beach, Amchitka Island.

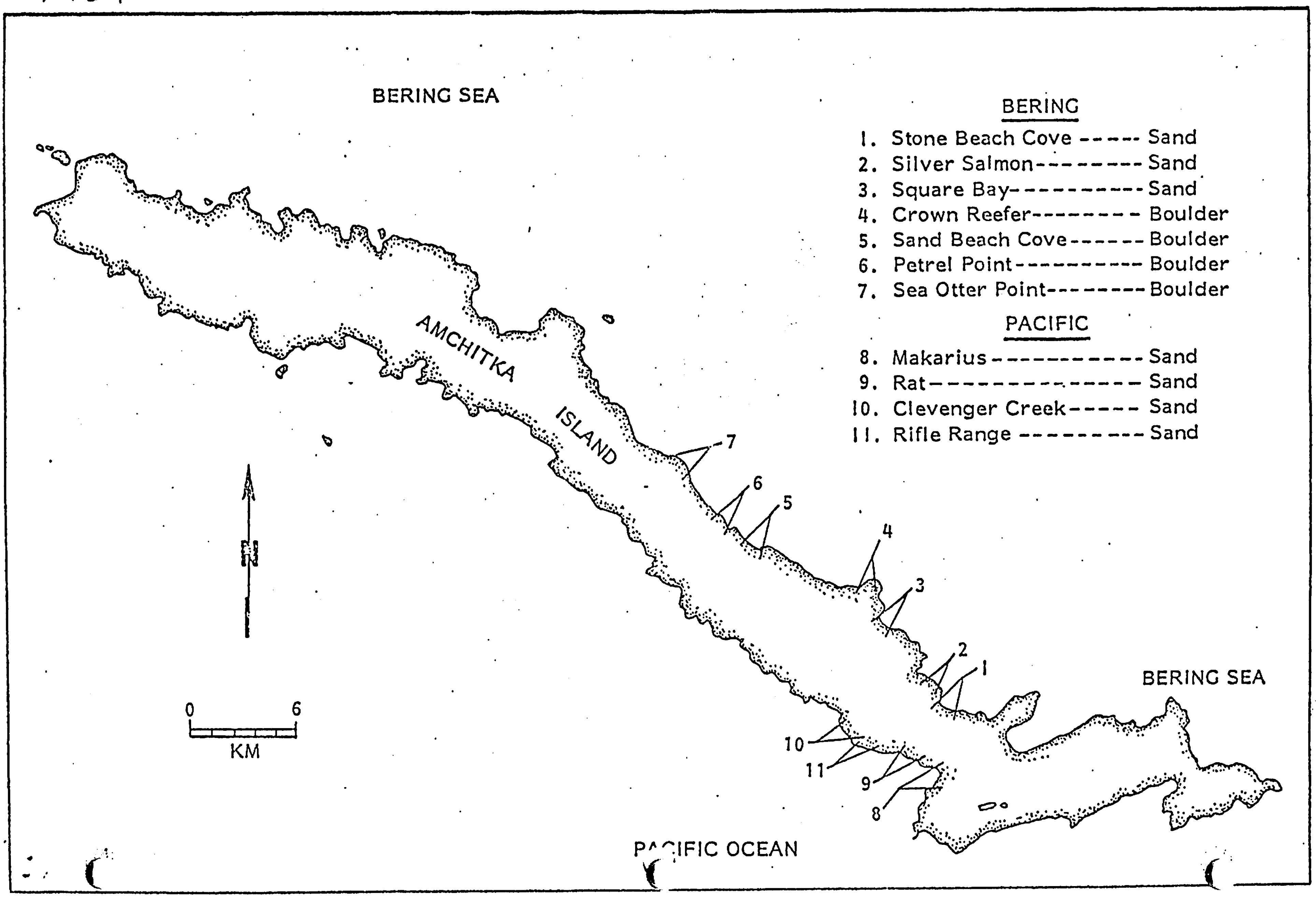
13 Skeletal remains of sea birds entangled in Japanese monofilament gillnet, Sea Otter Point Beach, Amchitka Island.

14. Japanese squeeze bottle with mammal teeth marks.

15 Fur seal, St. Paul Island, Pribilof Islands, with plastic band caught around shoulders.

16. Plastic band on Japanese wood crate, Silver Salmon Beach, Amchitka Island.

FIG 1



BERING SEA
AMCHITKA ISLAND
BERING
1. Stone Beach Cove ----- Sand
2. Silver Salmon -------- Sand
3. Square Bay ---------- Sand
4. Crown Reefer -------- Boulder
5. Sand Beach Cove ------ Boulder
6. Petrel Point ---------- Boulder
7. Sea Otter Point -------- Boulder
PACIFIC
8. Makarius ----------- Sand
9. Rat --------------- Sand
10. Clevenger Creek ----- Sand
11. Rifle Range --------- Sand
N
0 6
KM
BERING SEA
PACIFIC OCEAN

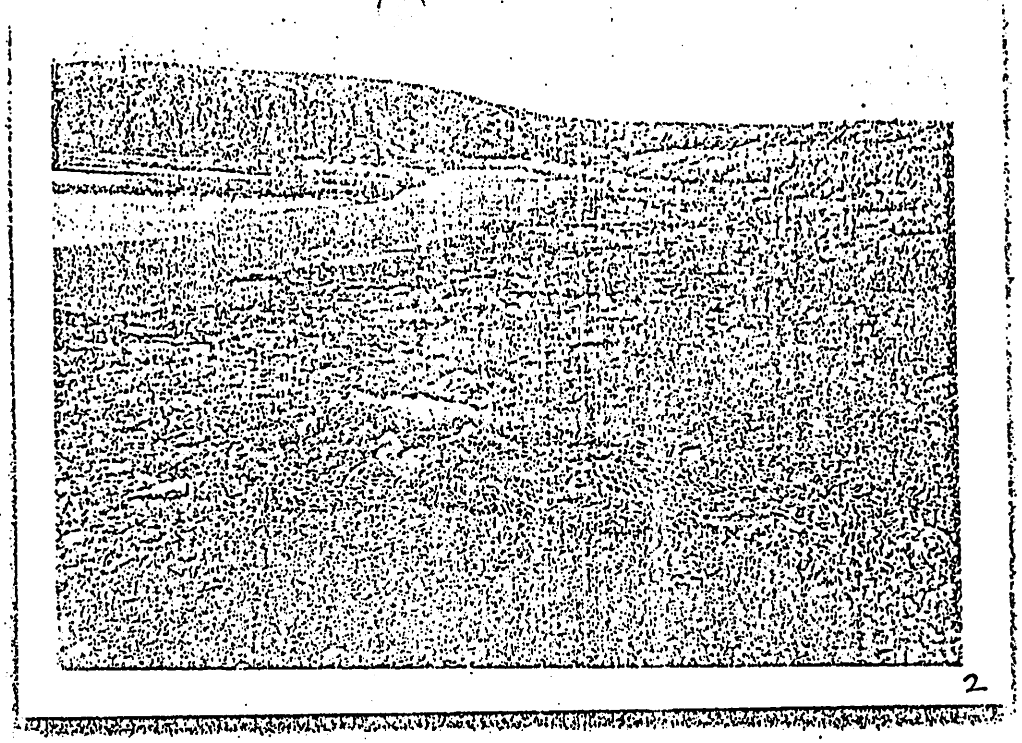


FIG 2

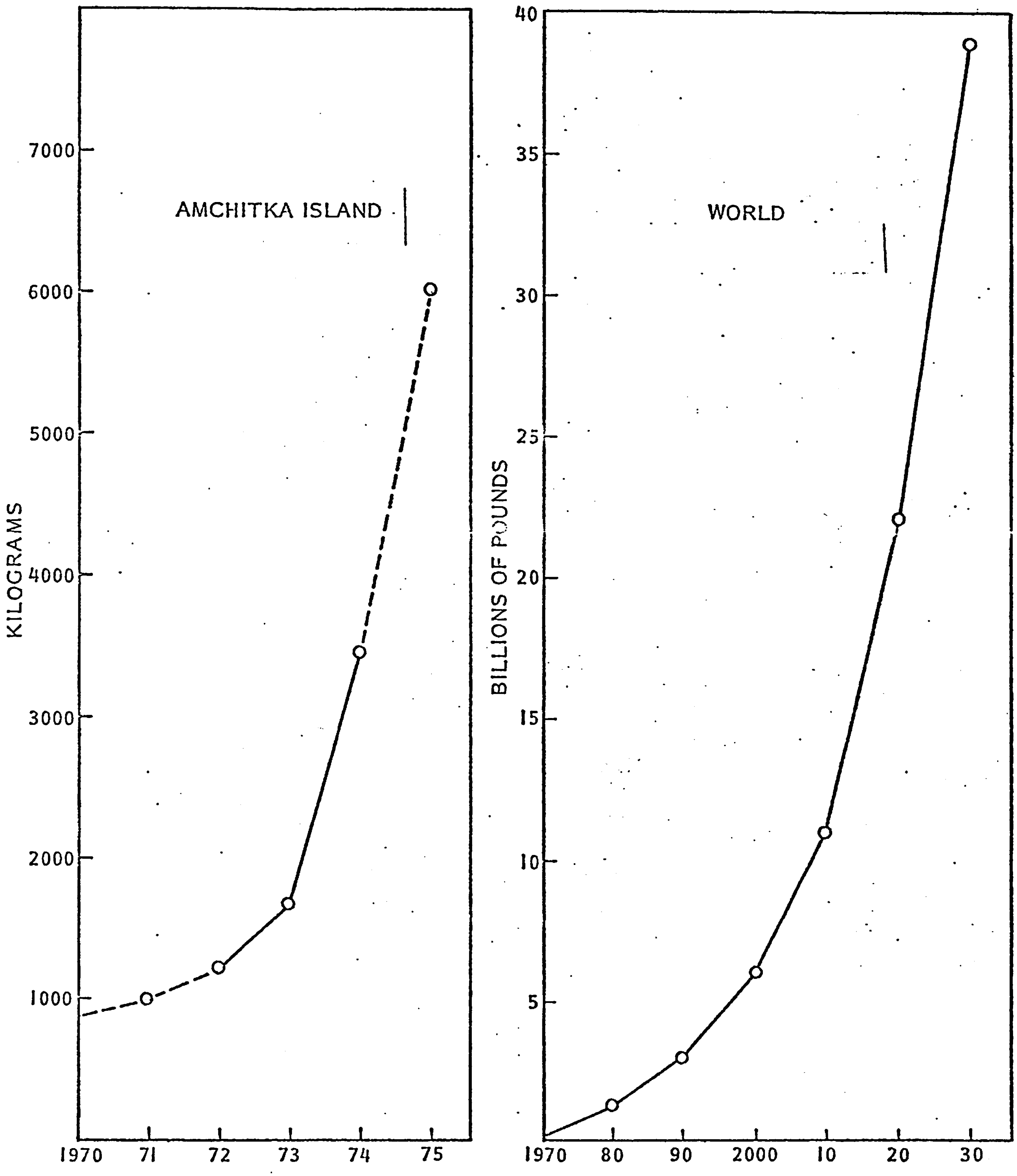
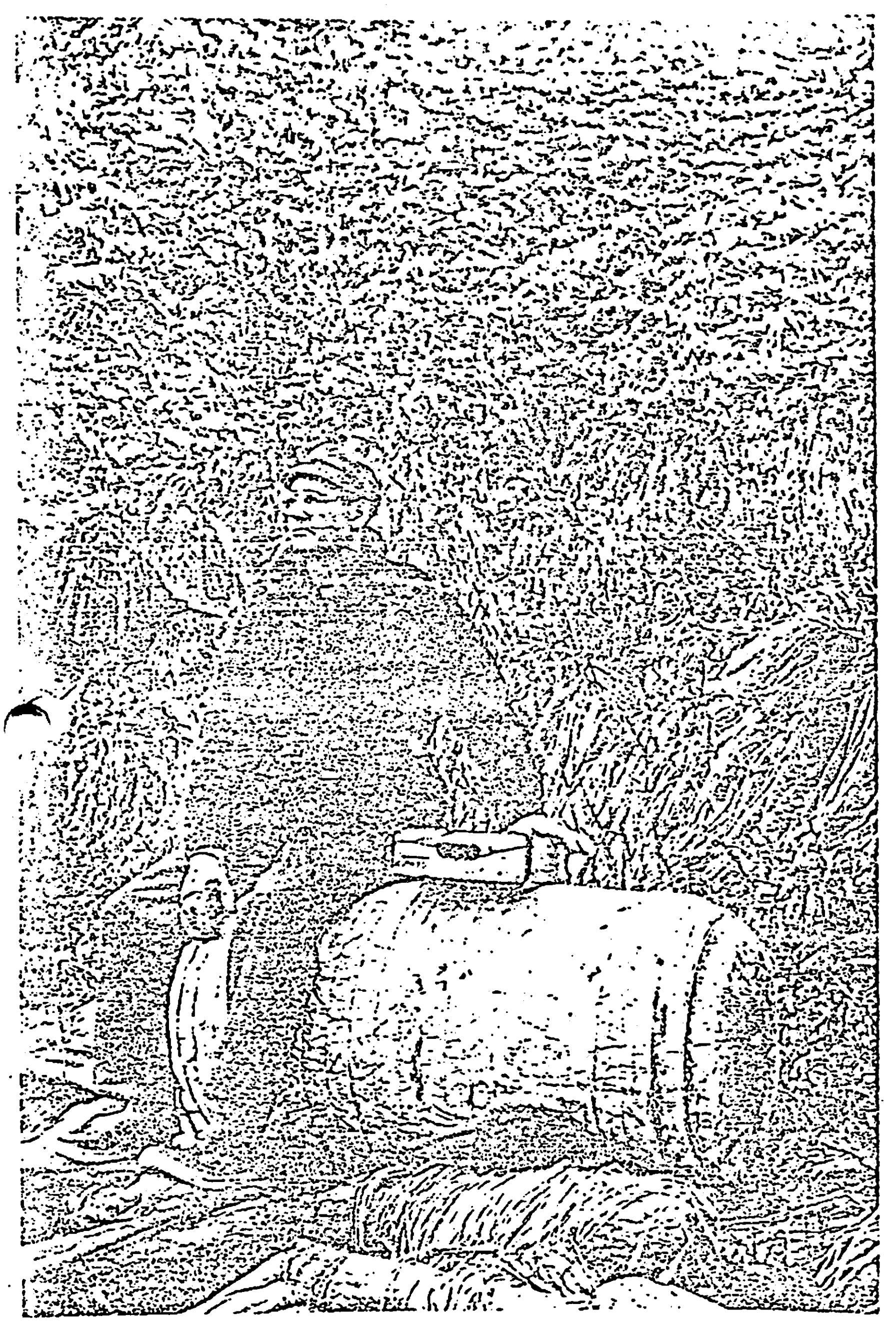

AMCHITKA ISLAND
KILOGRAMS
7000
6000
5000
4000
3000
2000
1000
1970
71
72
73
74
75
WORLD
BILLIONS OF POUNDS
40
35
30
25
20
15
10
5
1970
80
90
2000
10
20
30

FIG 3

FIG 4



5

FIG 5

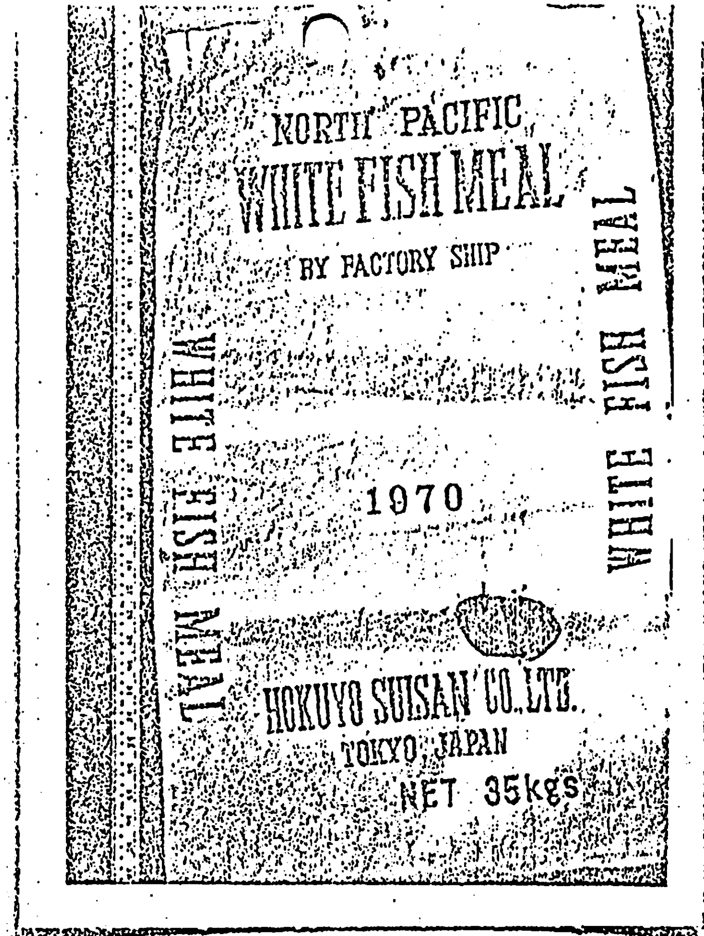

NORTH PACIFIC
WHITE FISH MEAL
BY FACTORY SHIP
WHITE FISH MEAL
WHITE FISH MEAL
1970
HOKUYO SUISAN CO. LTD.
TOKYO, JAPAN
NET 35kgs

FIG 6

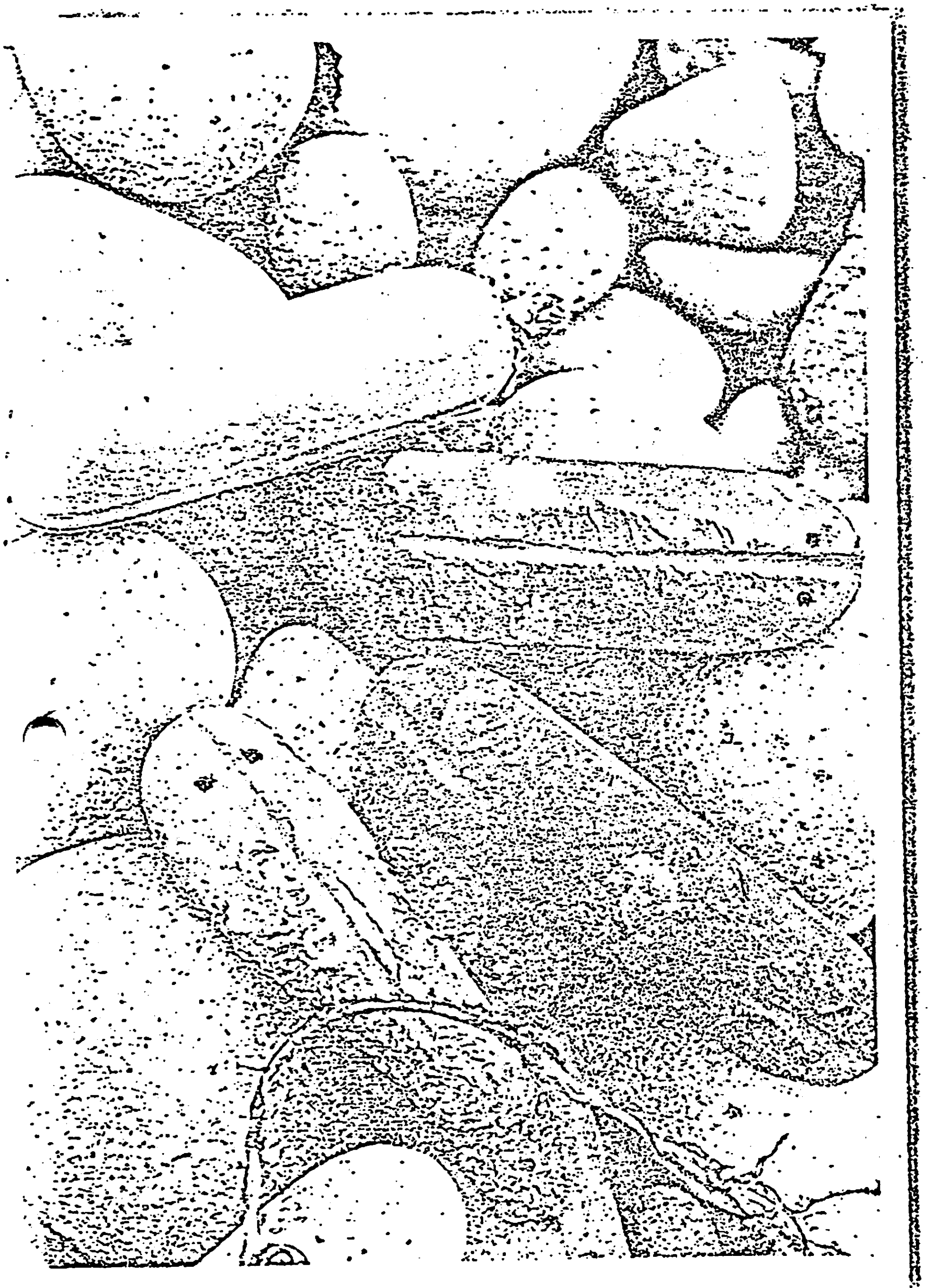
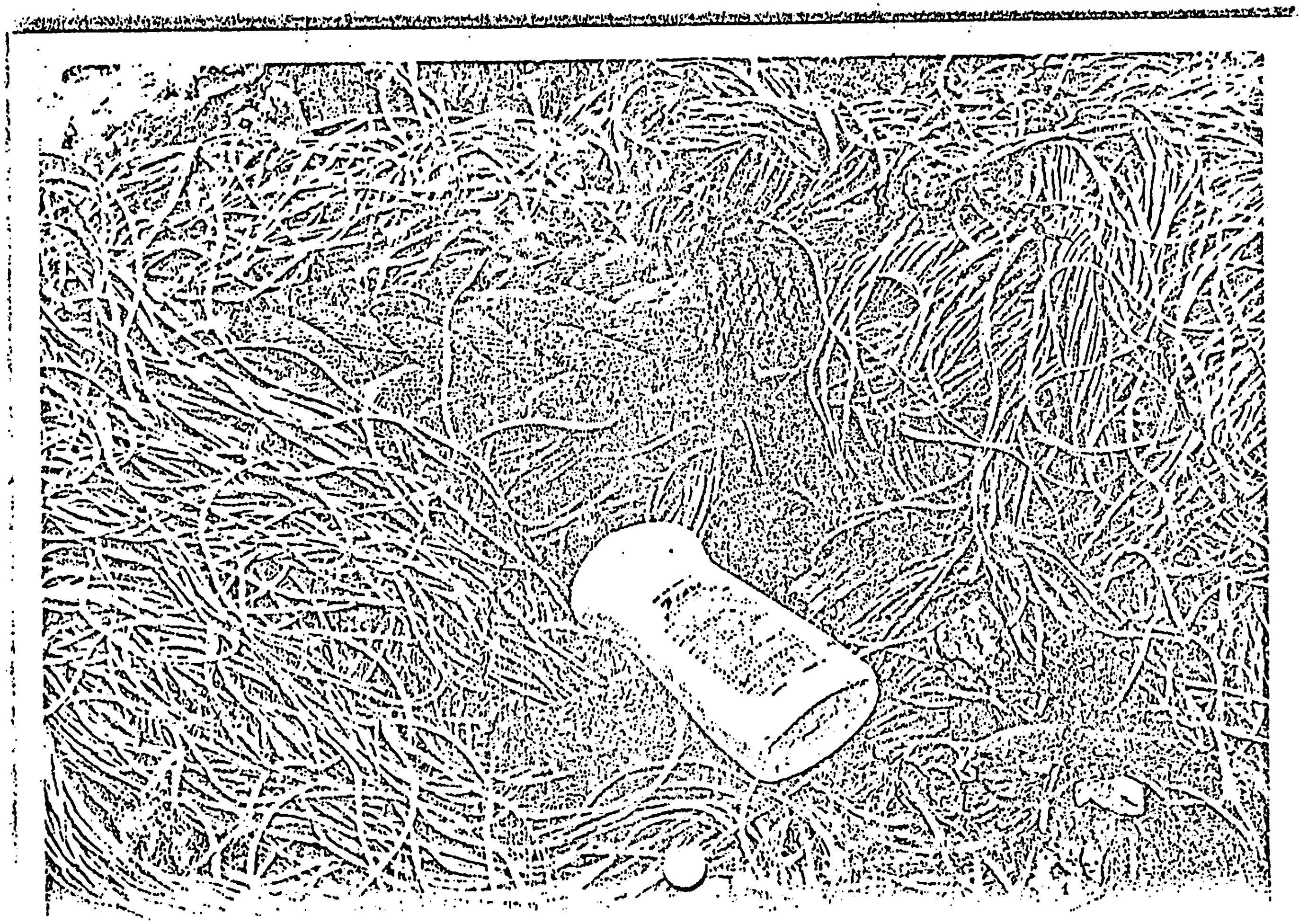
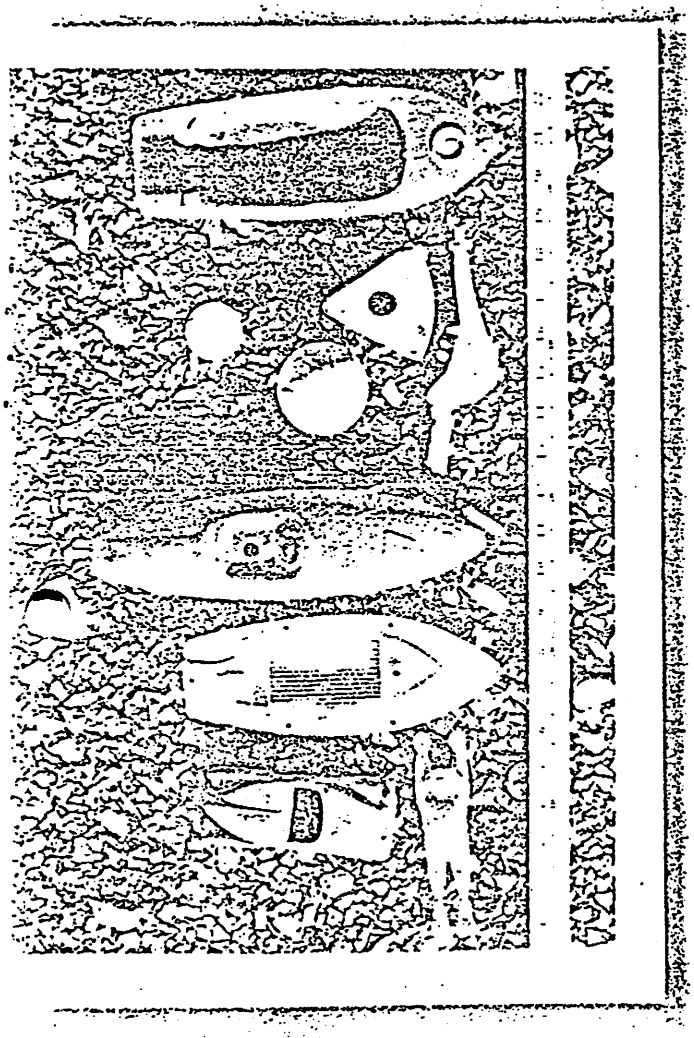


FIG 7

FIG 8





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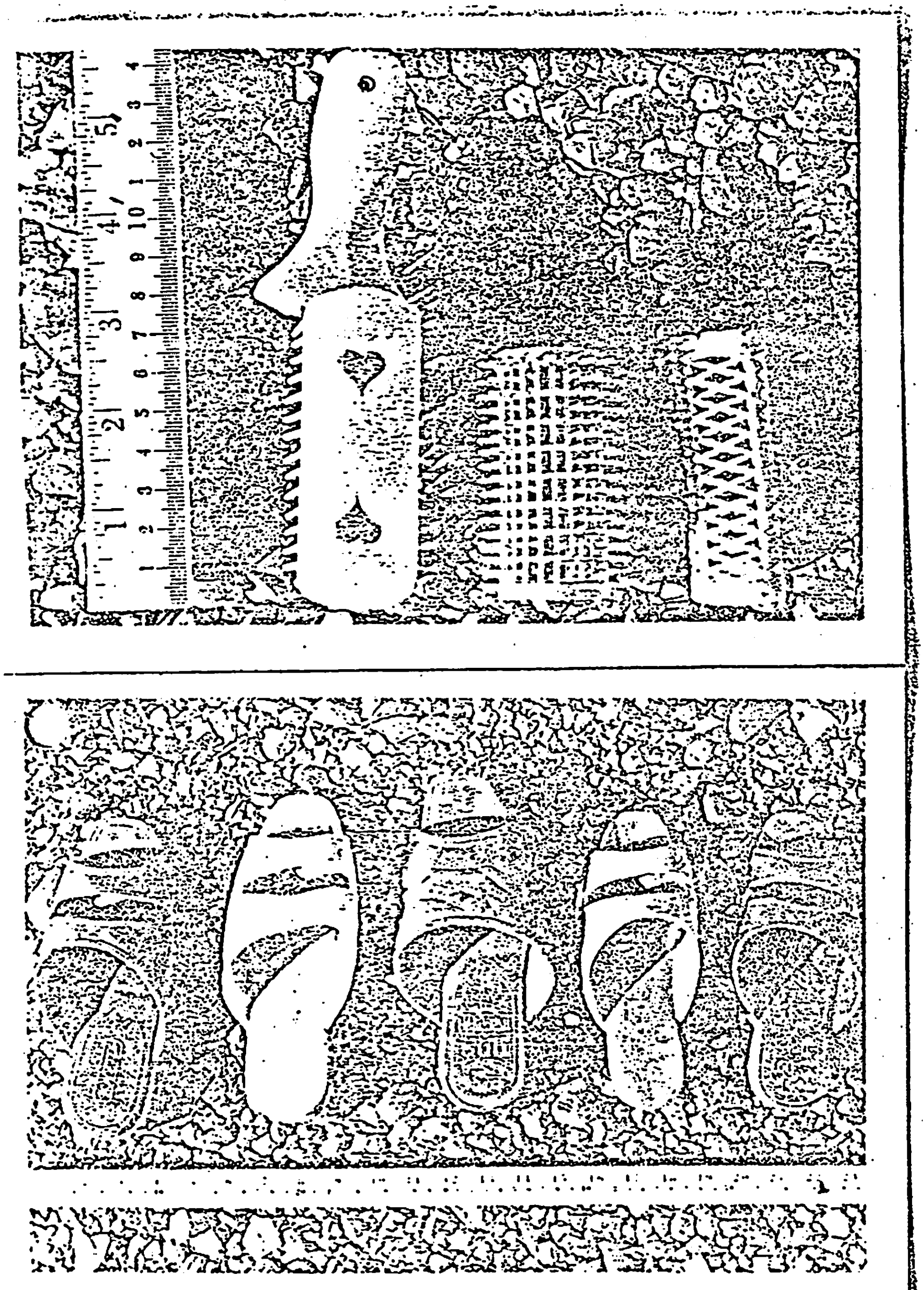

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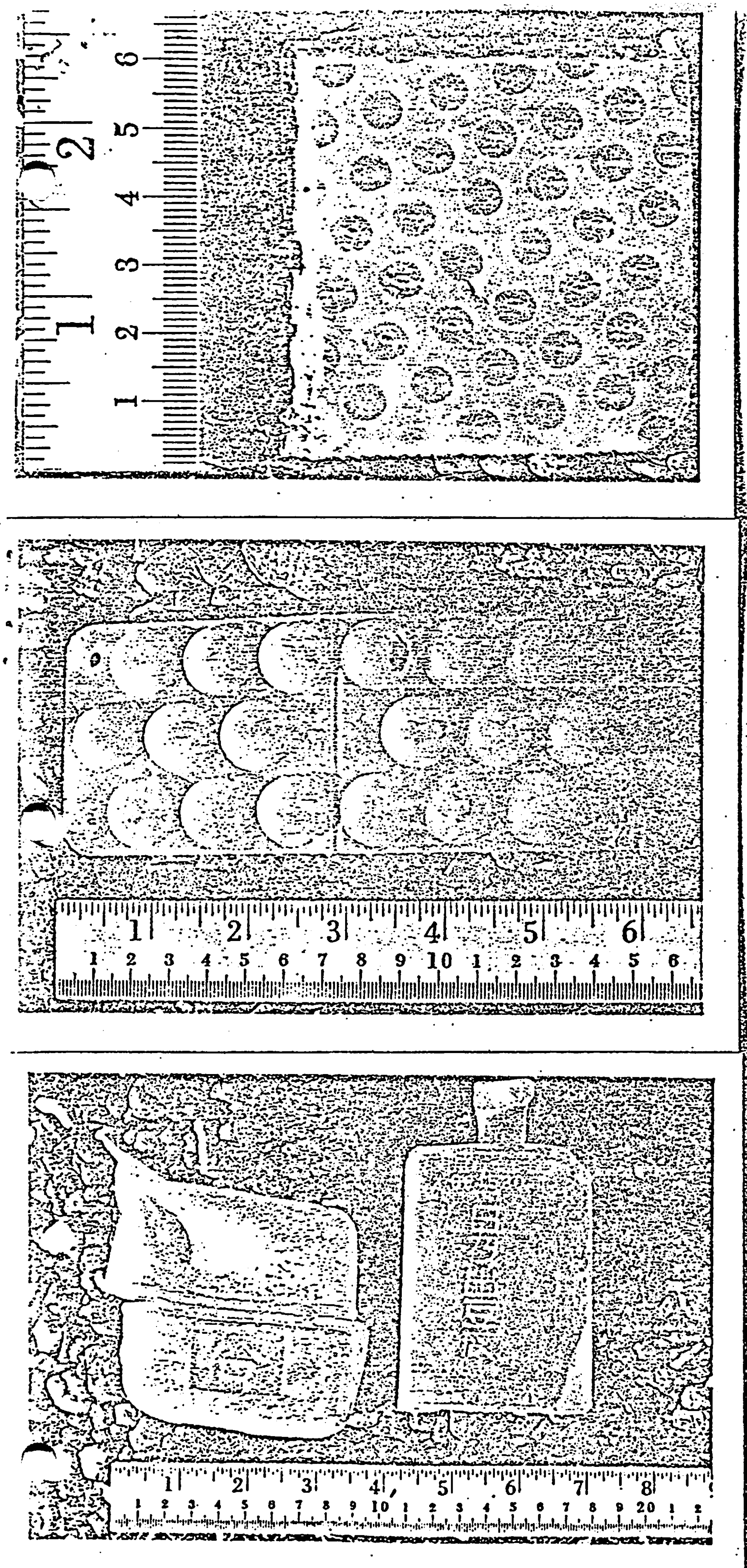
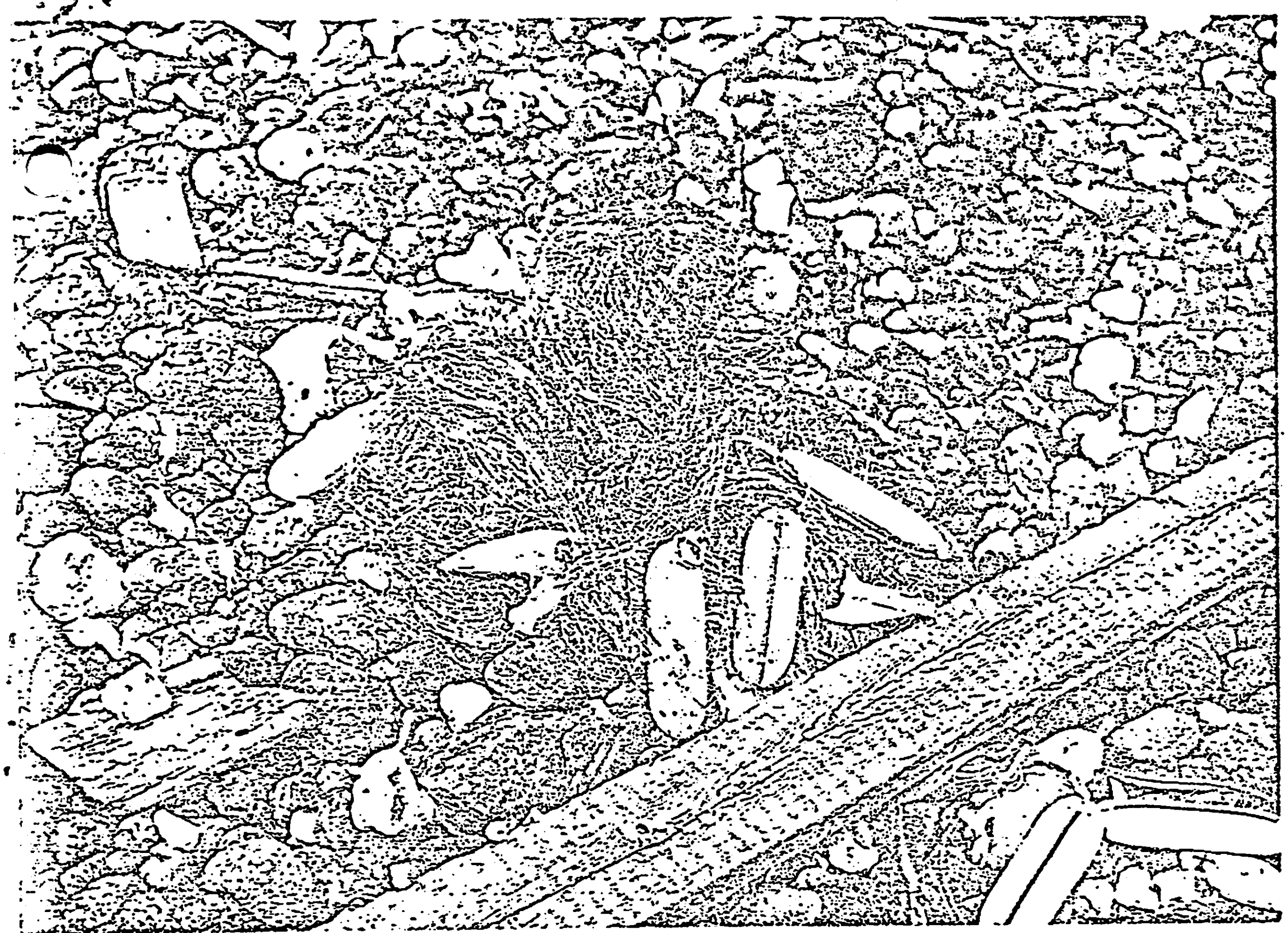


FIGURE 11

FIG 12



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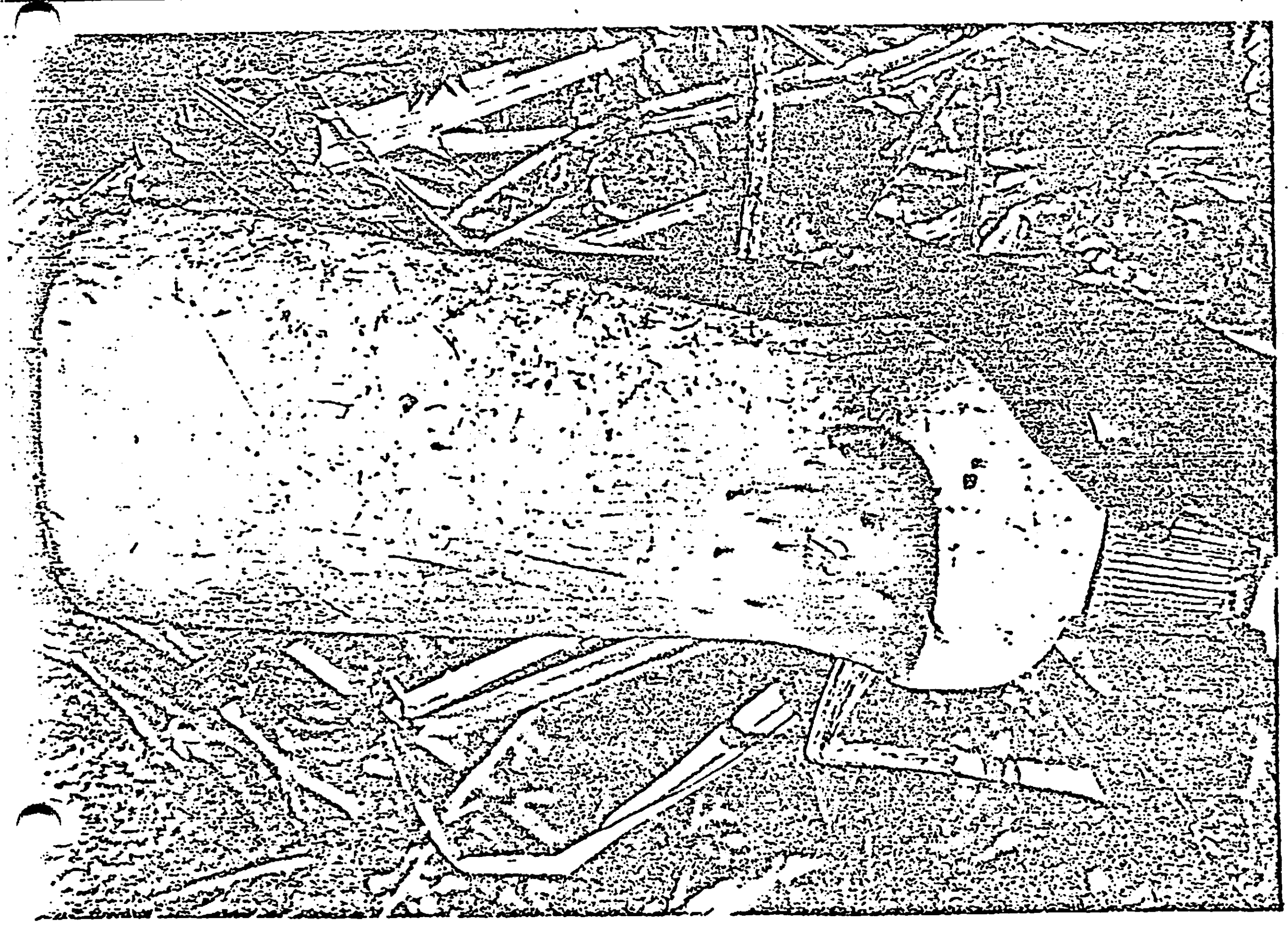

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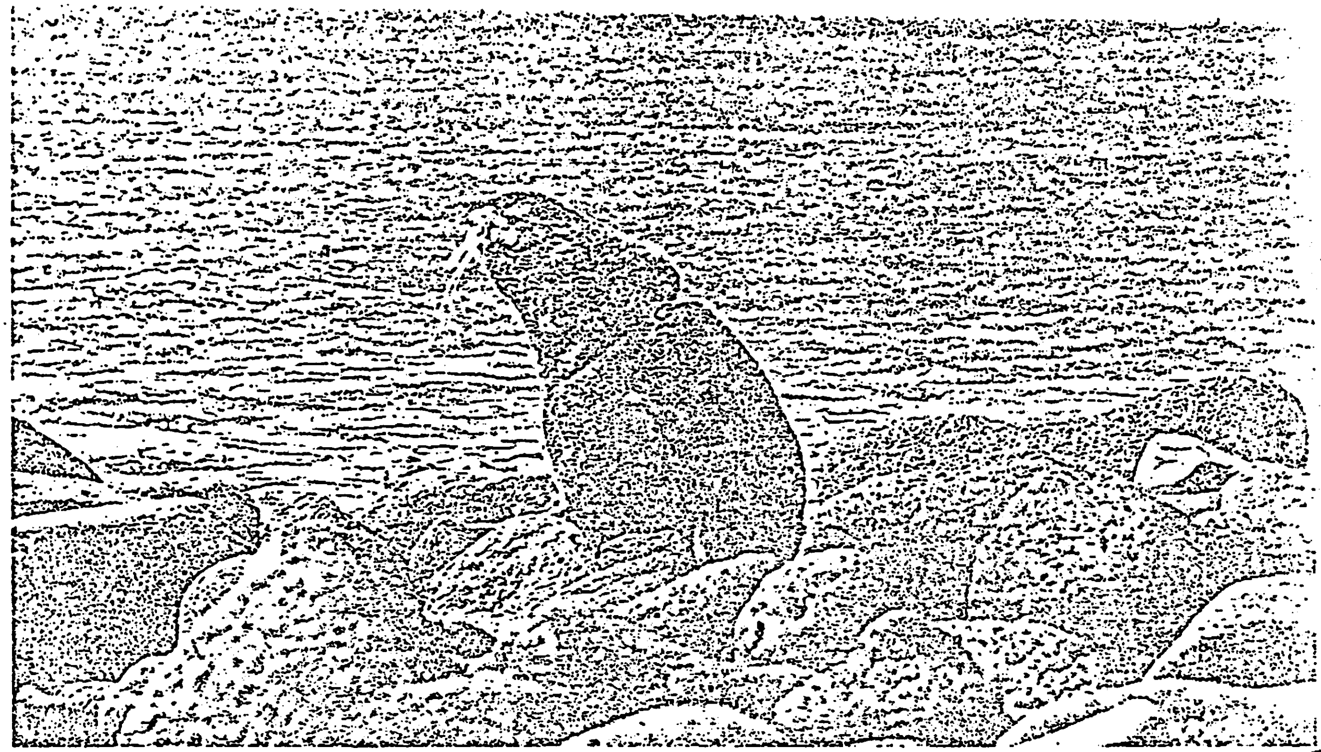

Fig 15

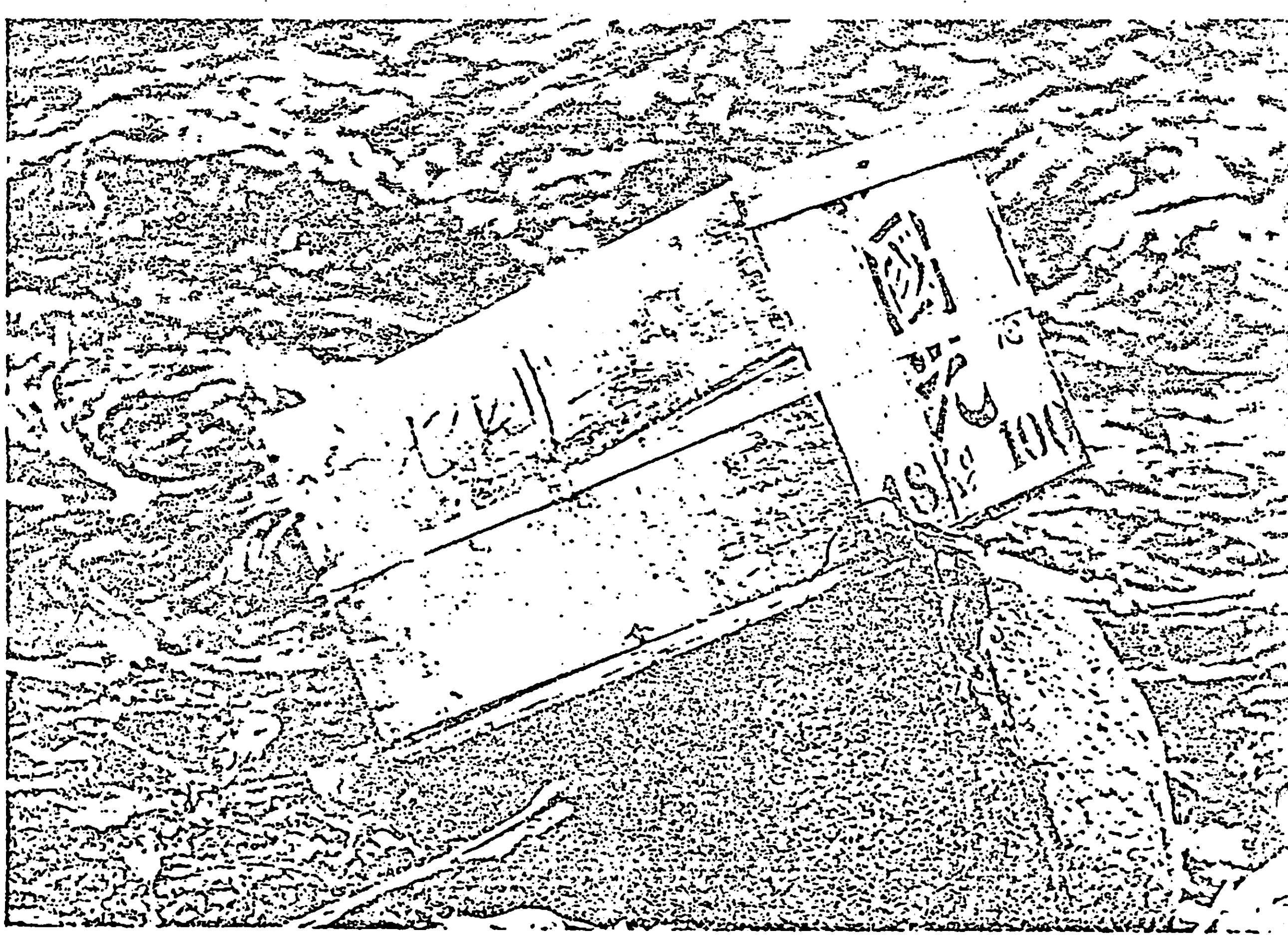

Fig 16