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The Mizushima Oil Spill – A Tragedy for Japan and a Lesson for Canada

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THE MIZUSHIMA OIL SPILL – A TRAGEDY FOR JAPAN AND A LESSON FOR CANADA

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ABSTRACT

On the night of December 18, 1974, a huge oil tank in the Mizushima refinery on the Inland Sea of Japan developed an eight-metre rupture and lost millions of gallons of hot Bunker C oil. Environment Canada sent Mr. C. W. Nicol of Environmental Protection Service in Vancouver to observe the impact of the spill on the environment and the clean-up measures employed. The cost of the clean-up and compensations, still continuing in mid-1976, will be in the order of hundreds of millions of dollars. More than 200,000 persons took part in the clean-up process, and over 38,000 vessels and 300 aircraft. This report summarizes Mr. Nicol's observations on the environmental damage and the clean-up efforts resulting from this catastrophic spill.

RÉSUMÉ

Dans la nuit de 18 décembre 1974, la paroi d'un énorme réservoir de la raffinerie Mizushima s'est déchirée sur une longueur de 8 métres et des millions de gallons de mazout lourd chaud ont été perdus dans la mer du Japon. M. C.W. Nicol, du Service de la protection de l'environnement, région de Vancouver, a été dépêché sur les lieux par Environnement Canada afin d'observer les effets de cet incident sur l'environnement, ainsi que les techniques de nettoyage utilisées. Les coûts résultant des dédommagements et des opérations de nettoyage toujours en cours au milieu de 1976, atteindront les centaines de millions de dollars. Plus de 200 000 personnes ont pris part à ce nettoyage, au cours duquel plus de 38 000 bateaux et 300 aéronefs ont été mobilisés. Le présent rapport résume les observations que M. Nicol a faites relativement aux dégâts occasionnés â l'environnement et aux efforts de nettoyage déployés par suite de ce déversement catastrophique.

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1 INTRODUCTION

During the last week of December, 1974, the Canadian press carried small articles about an oil spill of dramatic proportions in the Inland Sea of Japan. The Inland Sea, or Seto Naikai, is a body of water embraced by the main islands of Honshu, Shikoku and Kyushu (Figure 1).

Despite the difference in latitude, similarities do exist between the Inland Sea of Japan and the Georgia Strait, Gulf Islands and Puget Sound areas of Canada and the United States. Both have Pacific waters and Pacific fauna and flora. Both have rugged coast-lines and scenic islands. Both have fast currents, tidal rips and similar mixing patterns. Both are subject to storms. And both are rich in fisheries.

Because of these similarities, the Environmental Protection Service in Vancouver felt a keen sympathy and interest in the Mizushima spill. On December 30, 1974, Mr. C. W. Nicol, a senior technician with the Environmental Emergency Branch, was asked to investigate the environmental effects of the spill and the techniques and systems of the clean-up operations. It is of interest to note that the author had spent four and a half years in Japan, and had studied for a year in a Japanese fisheries college. In his attempt to obtain accurate information through Japanese sources in Canada, he faced much difficulty due to the holiday season in Japan. He therefore phoned Japan, and was able to talk to officials of Mitsubishi Oil Company who were working through the holiday season. Having explained why Canada was interested, the Mitsubishi men proved to be friendly, cooperative and precise. On the basis of information gathered by telephone, Mr. Nicol left Vancouver for Japan on January 5, 1975. He would later revisit the Inland Sea in November of 1975.

2 THE INLAND SEA

The Inland Sea, or Seto Naikai, is a body of water hemmed by the main islands of Honshu, Shikoku and Kyushu, and opening into the Philippine Sea through the Bungo Straits and the Kii Straits, and into the Japan Sea through the narrower Kanmon Straits. The sea area is roughly 7,000 square miles, with an extremely rugged and mountainous coastline, forested with pine, and with groves of bamboo and the finest oranges. The Inland Sea is dotted with hundreds of rocky islands, the greater part being a national park. Despite the tremendous and varying currents, there is a central area of rather low flushing rates in the approximate middle of the Inland Sea, where the waters entering from the Bungo and Kanmon Straits mix with the waters coming in through the Kii Straits. The currents and mixing of waters have made the area incredibly rich in fisheries. Fish culture has developed to a level of high intensity, as has the culture of prawns, oysters, and the two main types of edible seaweed which form a major part of the Japanese diet.

Subject to dangerous currents and sudden winds, the area of the Inland Sea produced a population relying on sea foods, with very tough, independent fishermen, who generation after generation had lived in close harmony with the sea. The area has its own distinct cultural flavor, with its own dances, folk songs, fishing methods and customs. In short, fishing is not simply a commercial enterprise, but a

way of life. In the early part of this century, when Japan began to be a great naval power, the Inland Sea also developed as a centre for other marine activities, being an ideal anchorage for large fleets of vessels. Today, eight large oil tankers and about 1,800 freighters, barges and ferries ply the inland passages each day. The inevitable concentration of shipping and industry in the area has brought with it the ecological threats of pollution.

In the past twenty years, and more particularly in the last five years, government and industry responding to the mounting pressure of public opinion, have been cooperating to clean-up the Inland Sea. From local reports, it would seem that the waters and beaches of the Inland Sea had been at its cleanest for a long, long time, and that Japanese people had begun to see glimmerings of hope for its ecological survival.

3 THE MIZUSHIMA REFINERY - LOCATION OF THE SPILL

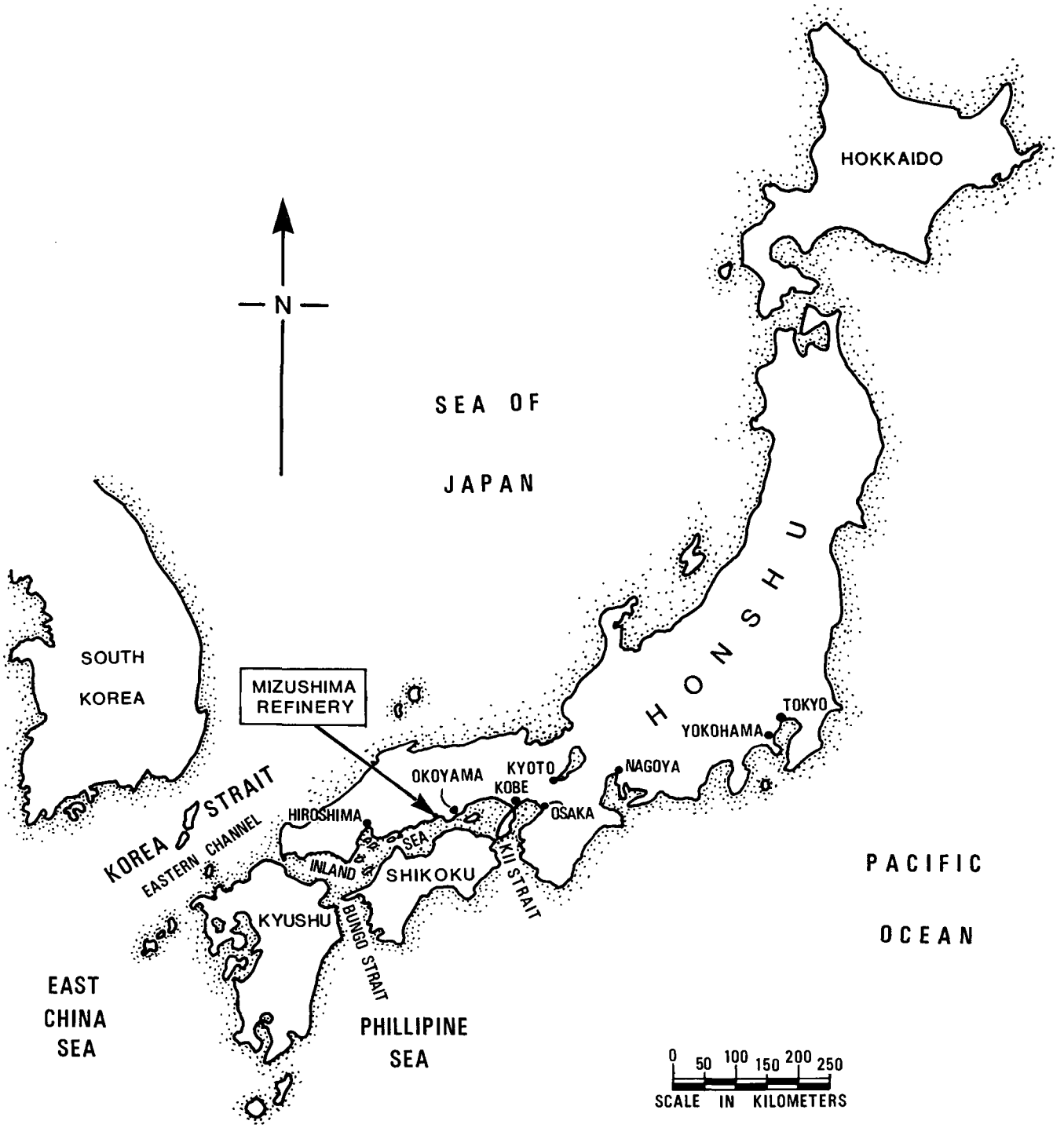
The Mitsubishi refinery in Mizushima occupies about 367 acres of landfill edging into the Inland Sea from the Honshu coastline. It is in the prefecture of Okayama, roughly four hundred miles from Tokyo, and lying between the giant port of Kobe and the ship building yards of Kure (Figure 1).

The Refinery which was completed in 1961 is one of the most modern in Japan. It has a crude oil processing capacity of 270,000 barrels per day and produces fuels (gasoline, diesel, kerosene, fuel oil, etc), lubricating oils, and aromatics. It is the largest aromatic centre in Japan. At its deep water crude oil pier, ocean tankers can offload at a rate of 50,000 barrels an hour through a 77 cm. pipeline into one of the largest crude tanks in the world which has a capacity for 735,000 barrels. In total, the refinery has seventeen crude oil tanks with a total capacity of 10,377,000 barrels.

About 65 percent of the refinery's oil products are shipped by coastal tankers and barges. Thirty percent of the products are conducted by pipelines directly to Mitsubishi Chemical Company, Mitsubishi Gas Chemical Company, Kawasaki Iron and Steel Company, Chugoku Electric Power Company and other industries in the area (Figure 2). The remaining products are shipped by tank cars and trucks.

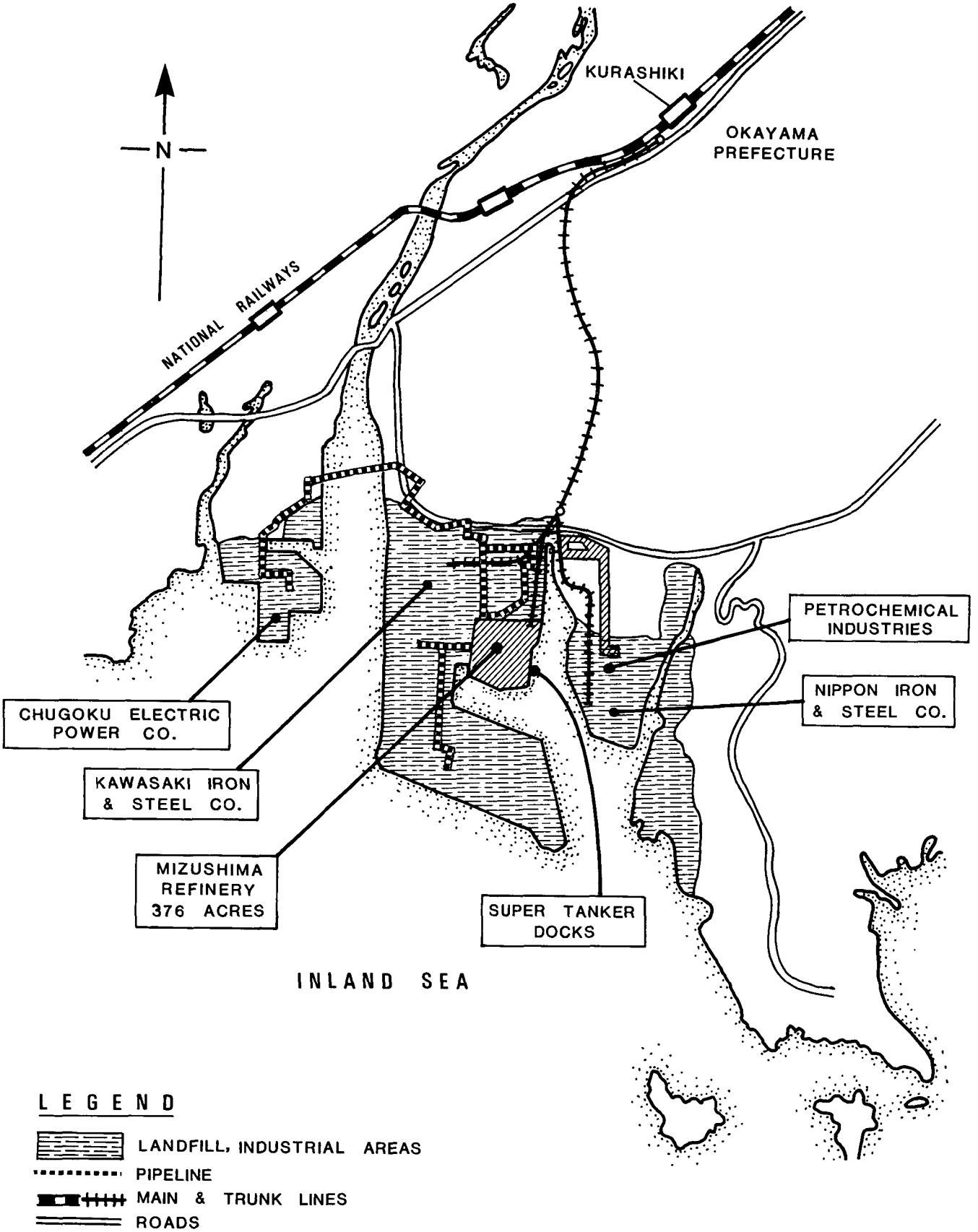
The management of the refinery have been very sensitive to public opinion and the growing insistence in Japan for anti-pollution measures. According to Mr. Ogawa, Chief of the Water Pollution Control Board, a Japanese government agency, based in Tokyo, government and industry have been working towards cleaning up pollution problems in the Inland Sea for twenty years, and that it had recently been possible to fish for marketable prawns close to the refinery. Refinery staff conducted regular training sessions in fire-fighting, laying of oil booms etc. However, nobody was really prepared for the accident occurring at tank number 270.

Tank number 270 was one of six tanks in the ''direct desulfurizing plant''. It was a large tank, 52 metres in diameter and 30 metres from its bottom to the high point of the domed roof, the side walls were about 24 metres high. The capacity of tank 270, and of its neighbour, 271, was 50,000 kilolitres (eleven million Imperial gallons).



LOCATION OF THE MIZUSHIMA REFINERY
IN THE INLAND SEA OF JAPAN

FIG. 1



MIZUSHIMA

THE OIL REFINERY AND ASSOCIATED INDUSTRIES

FIG. 2

4 THE CIRCUMSTANCES OF THE SPILL

The exact cause of the collapse of the bottom of tank 270 is under intensive government investigation, but the result was an 8-metre split between the side walls and the bottom of the tank. On the night of December 18, only a minor leak was first noticed. Thinking to level the head of oil between the two tanks, since 271 was less full than 270, the operators opened the connecting valve between tank 270 and 271. Apparently this is standard operating procedure. Soon afterwards, the bottom gave way. Oil came out of the split with tremendous force, spraying as far as a hundred metres.

The escaping oil was at a temperature between 80 and 90 degrees Celcius, making it virtually impossible to stop the flood. It was some time before men could get to the valves connecting 270 and 271 to shut them off. By this time, most of the oil was gone, and the huge tank buckled and split like a paper bag.

Figures given out by the refinery state that the amount of oil lost from tanks 270 and 271 was 42,888 kilolitres, (9,434,309 gallons Imperial). According to the official Japanese government report, *General Investigation into the Environmental Influences of the Mizushima Oil Spill of 1974,* only 7,500 to 9,500 kilolitres (1,649,816 to 2,089,767 Imperial gallons) were presumed to have escaped from the land to the sea. (It must be stated, however, that these figures were held in doubt by the Japanese press.)

The tank area was enclosed by a somewhat fragile concrete retaining wall, but when the oil rushed out it displaced the concrete and steel base of the tank's stairway, and this base, weighing 34 tons, smashed through the retaining wall.

The escaped oil flowed along refinery roads for a few hundred yards and entered a canal which led to an oil separator. The oil flowed over the separator and into the artificial harbour of the Mizushima Industrial Area. The volume and the temperature of the escaping oil made it difficult if not impossible to control on land and in the canal, and once into the harbour, strong winds, waves and darkness made efforts at containment futile. Booms were placed, and the Maritime Safety Agency contacted. Nobody was really prepared for this accident, and when it happened, the most immediate and pressing fear was that of fire.

The Maritime Safety Agency mobilized 41 patrol vessels and tried to emulsify the oil with dispersants. In retrospect, it is easy to understand why this effort would fail: firstly, the amount of chemical dispersants and associated spraying and mixing equipment was not available to deal adequately with the enormous volume of spilled oil; secondly the temperature of the sea was low enough to make the heavy Bunker C "tacky" and difficult to emulsify; and thirdly, the oil was moving quickly.

The head of the No. 1 Shimotsui Fishery Cooperative, Mr. Katsumi Koyama, is reported to have telephoned the Maritime Safety Agency at 0600 hours on the morning of December 19, when most of the oil was still inside the port of Mizushima. He offered help to the office, but help was refused by the agency, which claimed they could better handle it themselves. Seven representatives of the fishery cooperative visited the agency in the afternoon of December 19, and again offered to help, but again were

turned down. Finally, after consultation with the prefectural governments, help was requested, and on the morning of December 20, 75 fishing boats set sail to join the clean-up effort, but by this time the oil slicks had escaped far into the Inland Sea, carried by strong north westerly winds and by the swift tidal currents (Figures 3-9).

5 MOVEMENT OF THE OIL

Northwesterly and westerly winds carried the oil along the southern coast of Honshu, severely polluting the beaches and shore installations of Okayama and Hyogo prefectures. Winds during those first days of December 18 to 25 reached the 20 metre-per-second mark (45 mph). The oil spread out in long, broad striations across the Inland Sea to the northern coast of Shikoku, touching the eastern beaches of Ehime prefecture and severly polluting the shores of Kagawa prefecture, and finally the beaches of Tokushima prefecture.

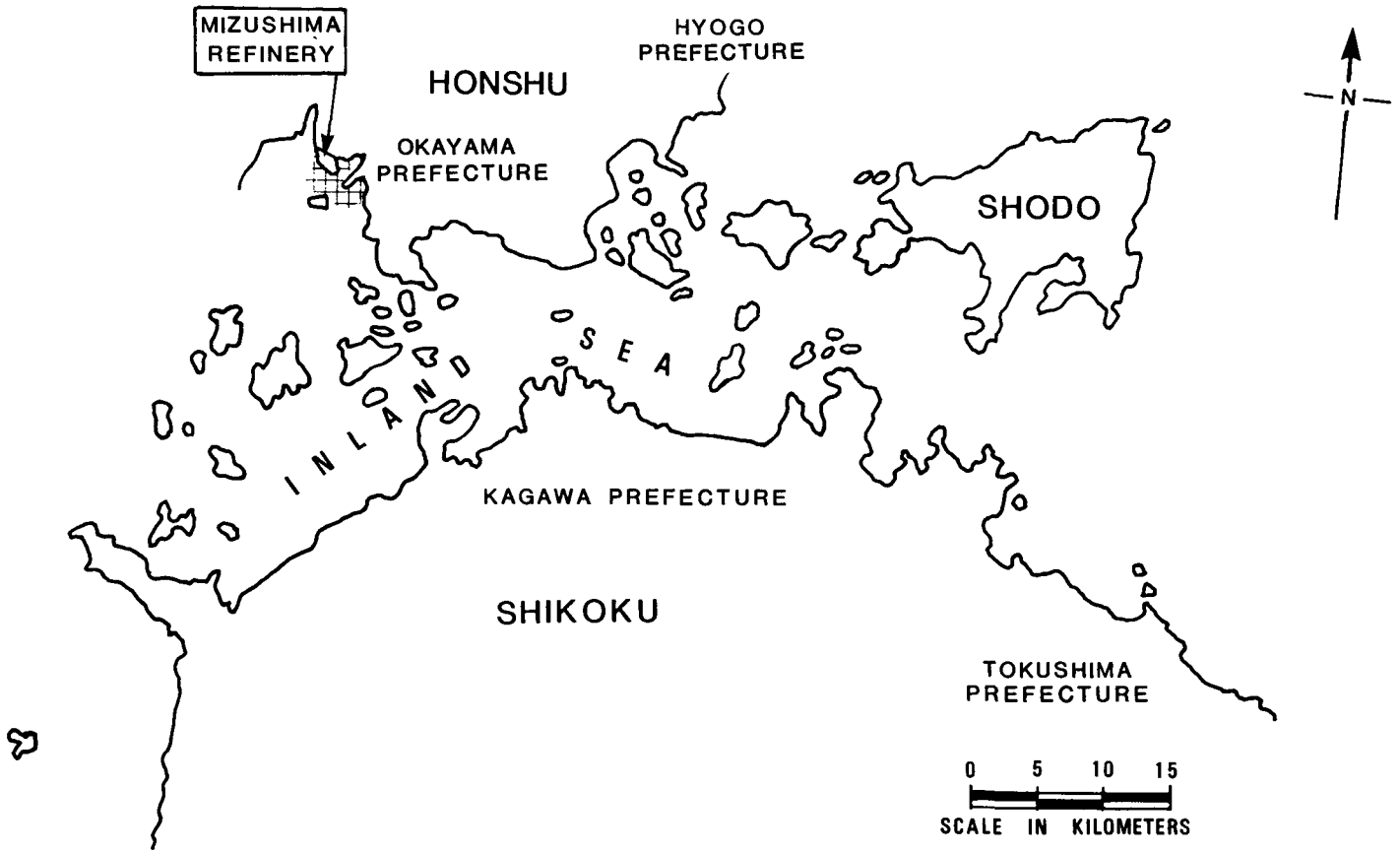
Dramatic pictures appeared in the International Press of oil being swirled around in the famous whirlpool of Naruto, between the coasts of Tokushima and the big island of Awaji in the mouth of the Kii Straits. By January 7, 1975, an unspecified amount, referred to as ''a lot'' by some authorities had gone out into the open ocean.

In the first and second weeks of January, oil was pushed into the harbours and bays of northern Shikoku (Kagawa and Tokushima prefectures) and accumulated in depths of 10 to 25 cms.

The islands between the prefectures of Okayama and Kyogo on the main island of Honshu, and the prefectures of Kagawa and Tokushima were all seriously polluted, as were southern beaches and shores of Awaji Island. In all 469 kms. of coastline were polluted by the Mizushima oil.

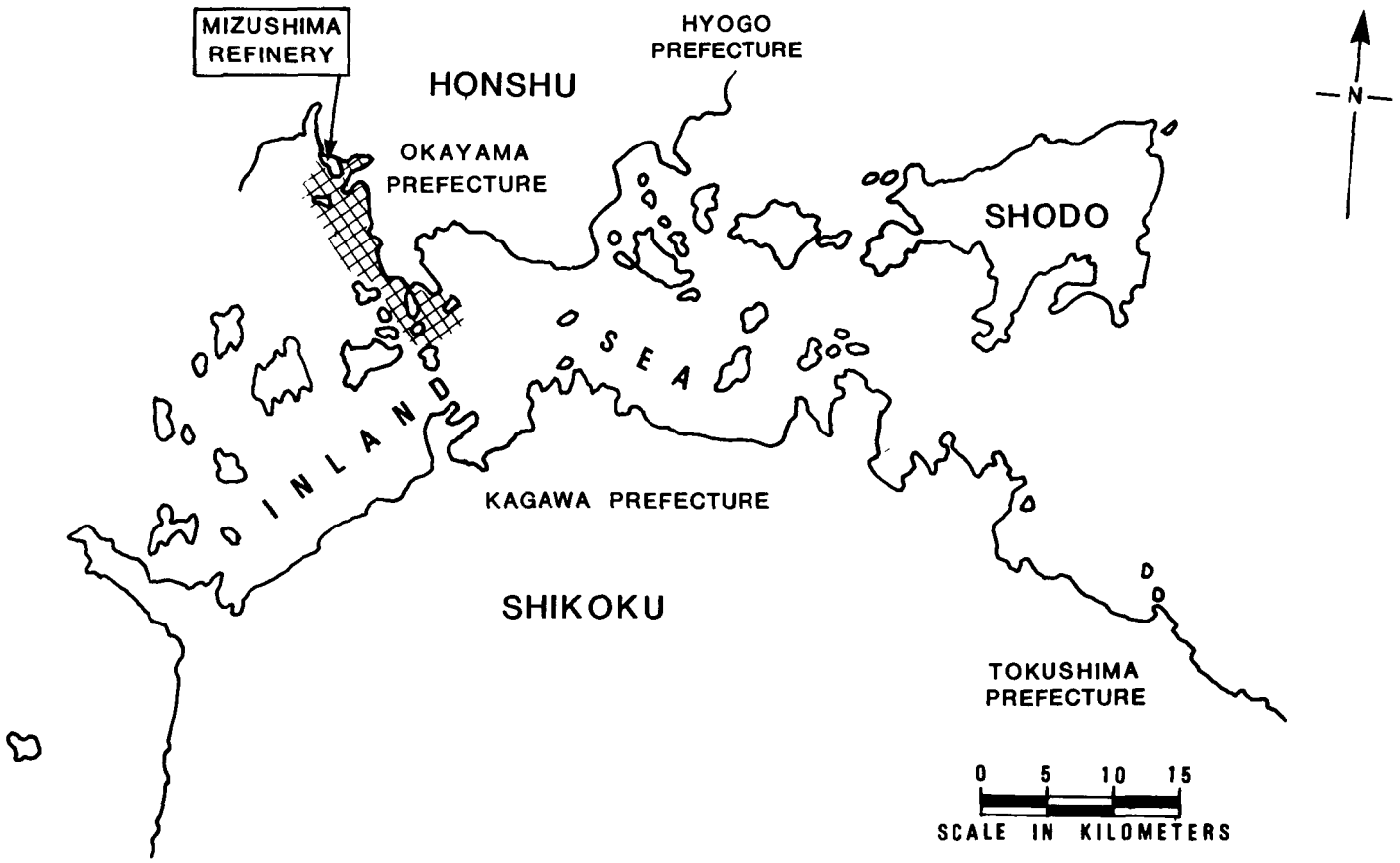
The general appearance of the oil on the water was of striations, up to three kilometres long, with heavy cores of thick oil and with much wider and thinner edges. However, the nature of the oil was soon changed by the low temperatures and by the physical action of waves and currents. The Bunker C that came from the refinery was blackish in colour, while the muck that was moving on the sea, on the shores, bays, harbours and channels of Kagawa and Tokushima had, by January 10, become a thick, reddish-brown sludge, referred to in oil spill literature as 'chocolate mousse'. The Japanese fishermen had a far more prosaic and accurate, if vulgar, description for it.

The author arrived on the scene January 8. On January 11, massive amounts of this oil sludge were observed in Tokushima perfecture, fifty, sixty and seventy miles from the spill site. Some of the sludge was reaching the point of negative buoyancy and was beginning to sink, slowly. Along several rocky shore lines, big blobs of sludge were seen to sink, stay under water for several seconds, then slowly come to the surface again. An unknown amount of sludge eventually sank to the bottom at several places in the Inland Sea. This fact has raised some controversy between various private research groups and fishermen and agencies of the Japanese government who took part in the investigations which formed a basis of the long report on the environmental influences of the Mizushima spill. Fishermen and many private or university researchers claim that considerable amounts of sludge sank to the bottom.



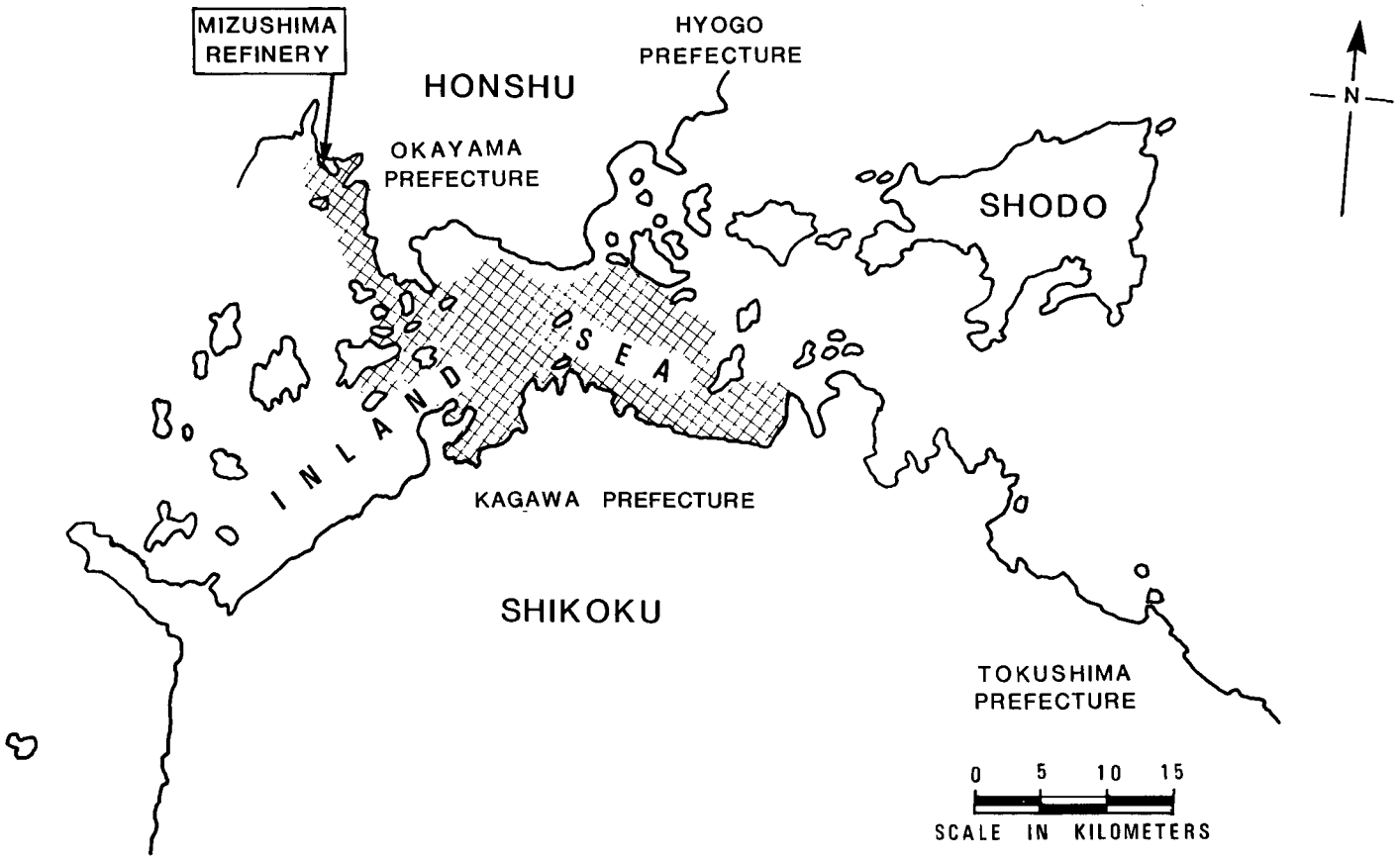
THE INLAND SEA OIL SPILL - DEC. 19th at 0900 Hrs.
Spreading of Oil, Dec. 19th - Dec. 23rd, 1974

FIG. 3



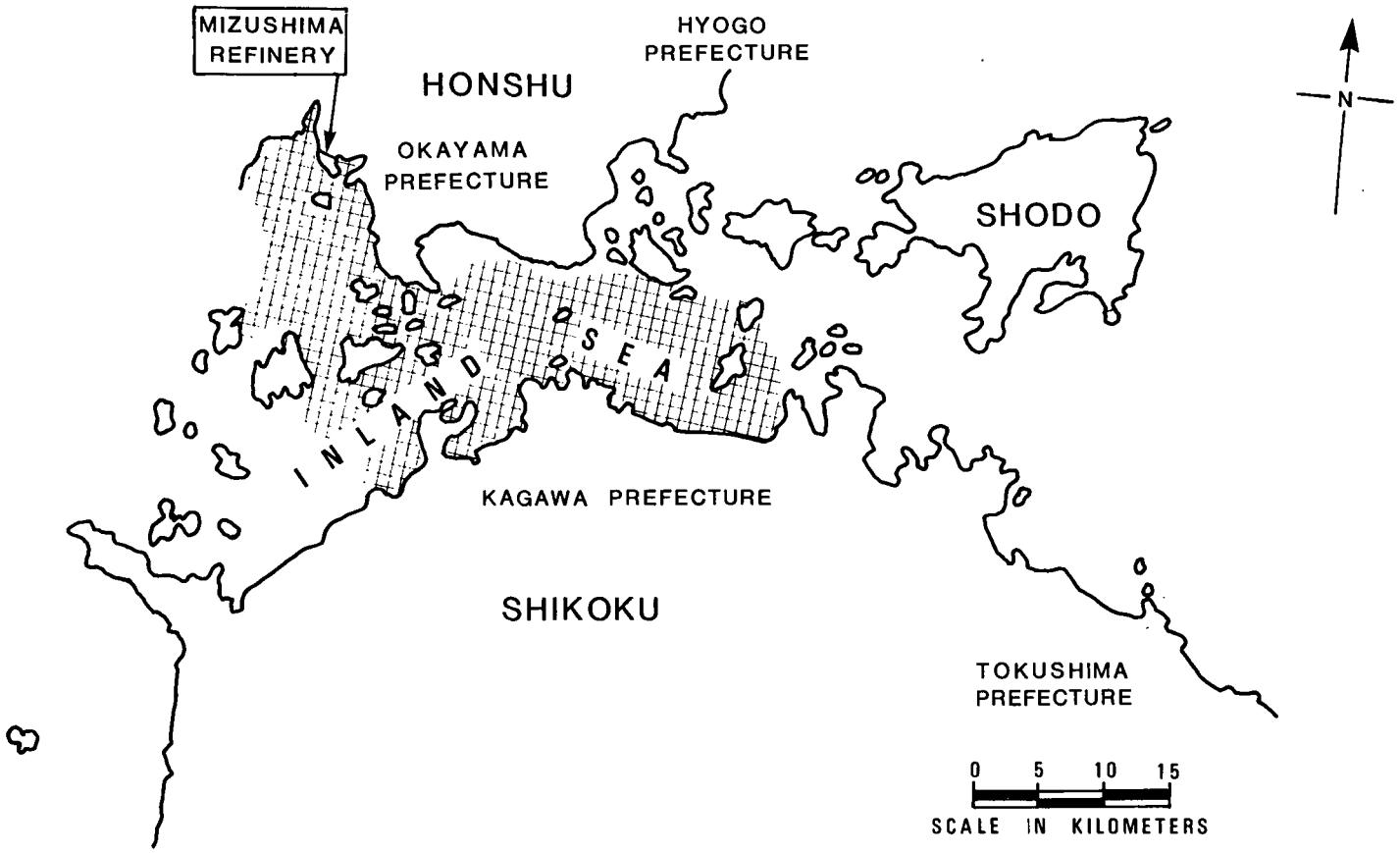
THE INLAND SEA OIL SPILL - DEC. 19th at 1615 Hrs.
Spreading of Oil, Dec. 19th - Dec. 23rd, 1974

FIG. 4



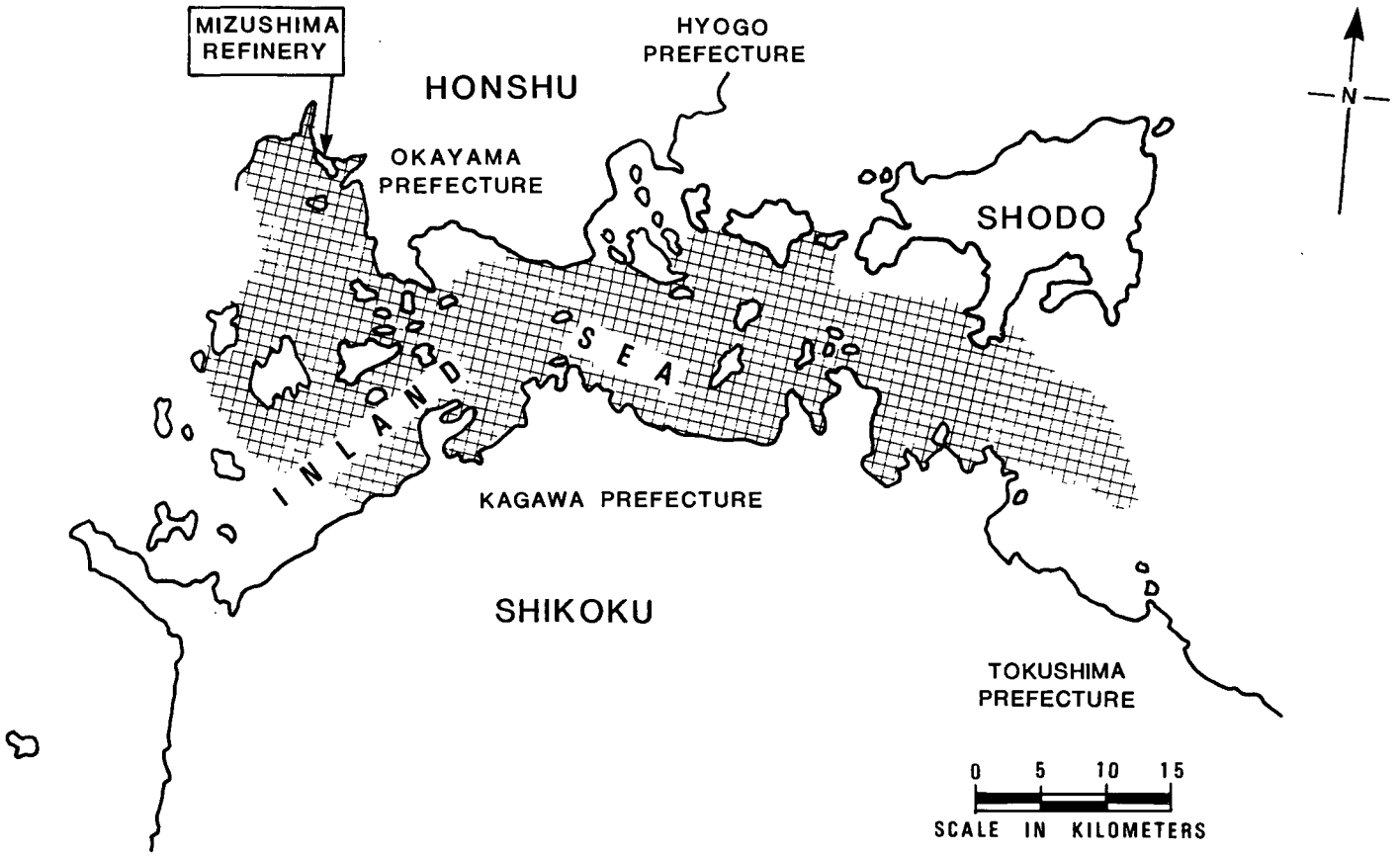
THE INLAND SEA OIL SPILL DEC. 20th at 0900 Hrs.
Spreading of Oil, Dec. 19th - Dec. 23rd, 1974

FIG. 5



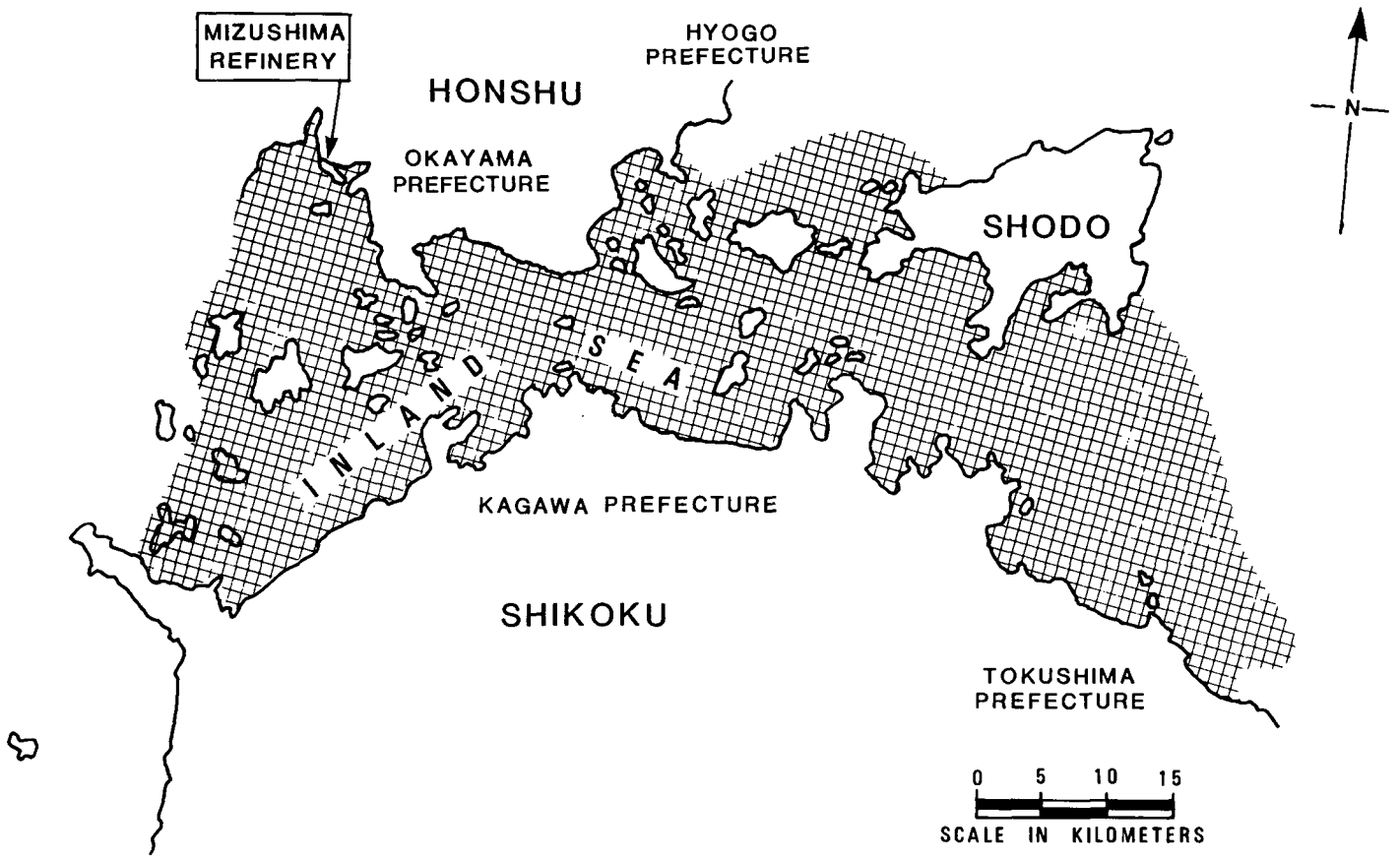
THE INLAND SEA OIL SPILL - DEC. 20th at 1345 Hrs.
Spreading of Oil, Dec. 19th - Dec. 23rd, 1974

FIG. 6



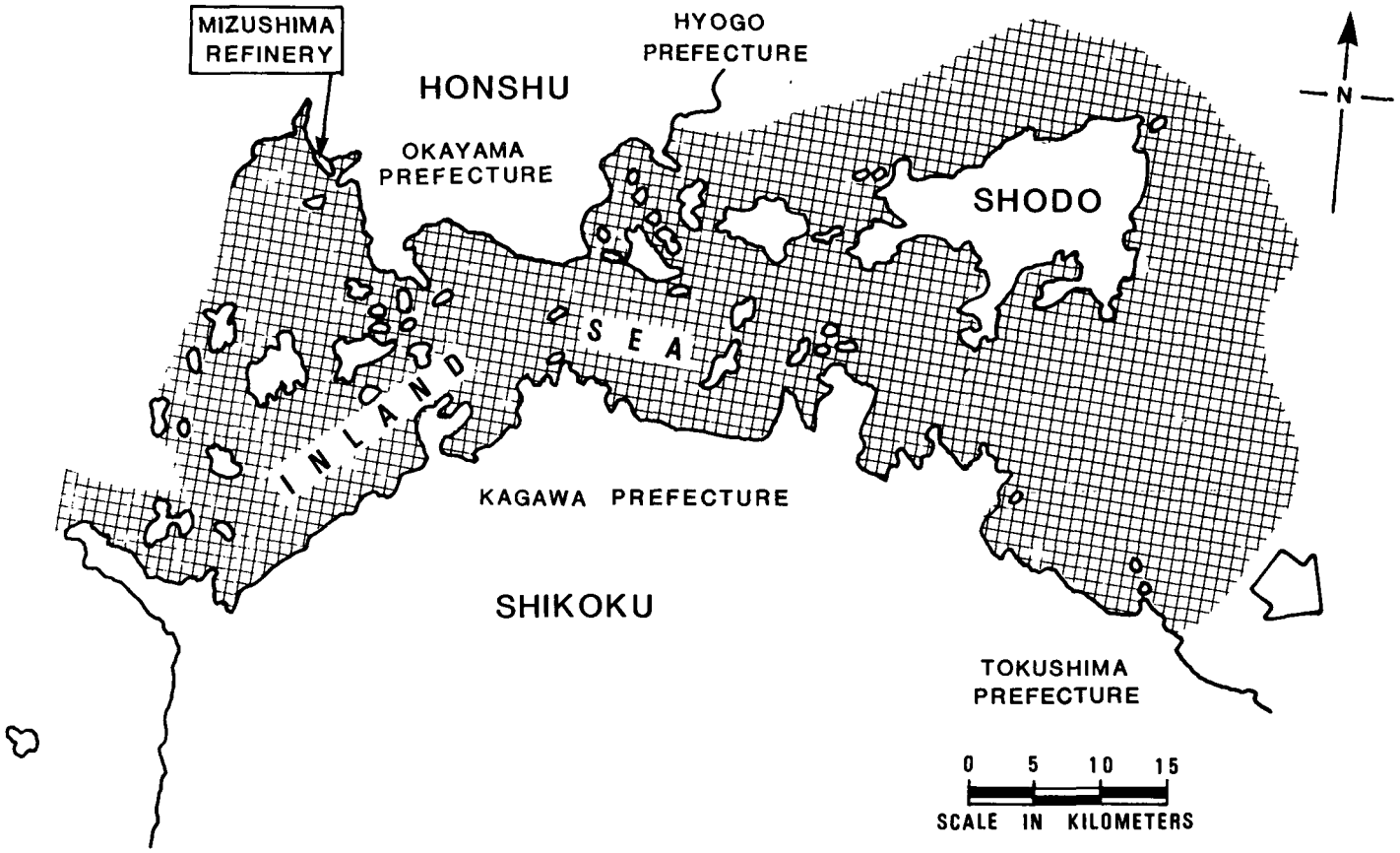
THE INLAND SEA OIL SPILL – DEC. 21st at 1420 Hrs.
Spreading of Oil, Dec. 19th – 23rd, 1974

FIG. 7



THE INLAND SEA OIL SPILL - DEC. 22nd at 1530 Hrs.
Spreading of Oil, Dec. 19th - Dec. 23rd, 1974

FIG. 8



THE INLAND SEA OIL SPILL - DEC. 23rd at 1100 Hrs.
Spreading of Oil, Dec. 19th - Dec. 23rd, 1974

FIG. 9

The government report and the oil company deny this. According to Professor T. Okaichi of Kagawa University, who was one of the members of the 'General Examining Committee' of the official government report, much oily sludge had sunk to the bottom, mainly in shallow water close to shore. There was therefore even controversy within the agencies taking part in the formulation of the government report.

In January 1975, Mitzubishi Oil Company engineers indicated that the sludge or mousse was an 'oil in water' emulsion, approximately 30 percent oil and 70 percent water, with a considerable amount of fibres and other debris to bind it all together.

Some beaches and shores were hit by oil two and more times. Each oil-polluted island developed twin 'tails' of slicks on the leeward sides, as wind and waves carried oil off their beaches. Not only were the windward sides of the island polluted, for waves and currents tended to 'wrap' the oil around the leeward beaches. Oil became trapped in the fixed nets of the mariculturists, and this oil was also being constantly released by wave and current action. On January 11, helicopters chartered by the Mitsubishi Oil Company spotted narrow, three kilometre long slicks of oil sludge along the Tokushima coast, apparently being kept about five hundred metres off the shore by currents and by 'echoing' waves. Much of this oil was heading and accumulating into Hudé Bay, while other portions were going out to sea.

Tides also carried the oil 600 metres and more up into some rivers. Looking at charts on the walls of various operations centres, one got the impression that the Inland Sea was being attacked by long serpents, as slicks, spotted and photographed from the air, were marked in long streaks of red on the charts. Indeed, the Japanese coined the phrase 'oil attack'.

Many miles of rocky shoreline, jetties and beaches were covered with oil that rose and fell with tides and adhered in three or four foot bands. On beaches, the oil penetrated thirty and more centimetres into the sand. The storms that persisted during the first weeks of clean-up operations deposited sand over one layer of oil, after which more oil was carried in, to be again covered by more sand. Core samples from beaches in Kagawa and Okayama prefectures looked like a layer cake.

In early January, in the whirlpools of Naruto, some oil was recorded as going into emulsion in the water at a concentration of 0.6 ppm. Other samples in Kagawa and Tokushima indicated concentrations of 0.95 ppm. The Japanese press reported that emulsified oil was found to a depth of five metres. It is to be noted that the Japanese government's Fisheries Agency considers that a concentration of 0.01 ppm of oil in water will taint oysters and fish if exposed for 24 hours, and that a concentration of 0.2 ppm in mud for one hour will taint clams, etc. Therefore, due to the very extensive surface and shoreline pollution, all fishing activities and fish marketing in the affected areas were closed down by the Japanese government. This involved about half of the total area of the Inland Sea. A comprehensive picture of the behavior and movement of the oil would fill many more pages than the nature of this discussion warrants.

6 ENVIRONMENTAL EFFECTS

The Mizushima Oil spill is certainly the most intensively studied and controversial spill since the accident of the 'Torrey Canyon' in the English Channel. On January 27, 1975, it was announced that the Japanese government would launch a joint ministerial survey in early February to investigate the degree of sea pollution caused by the Mizushima spill. The survey was spear-headed by the Environmental Agency, with the Maritime Safety Agency, the Fisheries Agency, the Ministry of Health and Welfare, and the Ministry of Construction participating. The survey covers water and bottom analysis, a market inspection of marine products, a long-term investigation to examine the possibility of effects on humans from hydrocarbons taken into the system from oil contaminated marine foods, the degeneration or bio-degradation of oil by bacteria, etc., and the movement and spreading of oil both on and below the water surface. (''General Investigation into the Environmental Influences of the Mizushima Oil Spill of 1974'', a Report by the General Examining Committee.)

The report generally indicates that water quality in the Inland Sea returned to its previous levels within months of the incident, and a superficial reading of the report would tend to minimize the effects of the spill in the water column. However, this report has released a storm of protest from the press, from Fishermen's Cooperatives, and from University research workers.

Professor Okaichi, of Kawaga University, one of the members of the investigative board, claimed that the government's investigation was unscientific. He said that the sampling was done on a grid system, which ignored or missed actual locations of heavy pollution. Fishermen said exactly the same thing, although their position was a very delicate one, for the simple reason that if the public believed the fish taken from the area to be contaminated, they would not be sold. Professor Okaichi and others pointed to poor liaison between investigating departments.

On talking with more than a hundred individuals from the Inland Sea area, it would seem that the ecosystem or life regimes of the area are changing, and that the oil spill may have accelerated these changes. However, it would be impossible to state this as a fact. Certain fish, usually expensive ones like sea bream, seem to be decreasing in areas where fishing has not been excessive but where the oil pollution had been serious. Certain coarse fish, plankton eaters of the anchovy family, have increased. (These fish are used only as fertilizer.) The oil in dispersion or emulsion seems to have seriously reduced the number of sea urchins. The population of swimming crab (Tritodynamia Horvathii) has exploded, in such numbers as to clog the engine intakes of ferry boats.

Professor Okaichi believes that oil spills may very well be the cause of the increased incidence of 'red tide'. He says that during the first period of the spill planktonic diatoms and flaggellates dropped dramatically in numbers in the oil-affected surface waters. Water which would be expected to have 1000 cells per cc had only one or two cells per cc.

Later, when oil levels in the water dropped to 0.1 ppm and less, diatoms and dinoflaggellates bloomed in places, causing the 'red tide' which kills other marine life.

The edible seaweed industry was seriously affected in Okayama and Hyogo prefectures, and in Kagawa and Tokushima prefectures the effect of the spill was catastrophic. The growing season for this type of seaweed culture is October to March, and thus the spill destroyed one year's crop of seaweed in the affected areas. In Kagawa and Tokushima prefectures, the 1975 crop was less than ten percent of what it should have been, and in Kagawa prefecture along, 110,000 of the 120,000 'Nori' nets were so covered with oil as to render the nets useless. The 1975 government report gave the figure of 240,749 sets of nets being destroyed by oil. ''Nori'' is a seaweed that is part of the daily diet of almost every Japanese. It is cultured on nets that are suspended in a flat horizontal plane just below the surface of the water. The nets are ''seeded'' with monospores that are cultured on oyster shells, and then are set fairly close inshore in large banks of buoyed nets. ''Nori'' has a very delicate flavour, and the flavour greatly affects the market price. ''Wakame'' is a seaweed commonly used in Japanese soups and other dishes, and is also cultured on nets.

Marine culture of fish was also seriously affected in the area, especially the coastal fish culture stations of Kagawa and Tokushima. The oil was pushed into bays by wind and current, and the most immediate effect on the fish farms - which are usually net-enclosed compounds open to the seas, was that the thick surface covering of oil prevented the distribution of feed. Oil clogged the nets and fractions of it dissolved in the water.

The principal type of fish cultured in the area are yellowtail ('hamachi' - *Seriola* quinqueradiata) which are marketed in three classes, under three different names, the porgy or red snapper ('madai' - *Chysophyrs* major, family Sparidae), and the black sea bream ('kurodai' - *Mylio* macrocephalus). In Kagawa and Tokushima, this industry was severely damaged. Members of the fishing cooperatives reported that more than 30,000 fish had been killed. The Asahi newspaper, the Mainichi newspaper and several weekly magazines carried pictures of dead and oil-smeared yellowtail. Fish that were neither starved nor poisoned by the oil spill were nevertheless unmarketable. The main food species affected by the spill were: mussels, oysters, short-necked clams, sea bass, black sea bream, red snapper, yellowtail, whelks, octopus and 'hiiragi' (Leiongnathus Nuchalis). The national and local news carried many reports on concentrations of oil in water, as much as 0.95 ppm; however, the conditions of waves, currents and mixing seemed to be so variable, that the picture of the first weeks of the spill is still quite confusing. Certainly, the over-all survey records lower levels of oil in the water column.

In any case, the Japanese government closed all marine ship markets in the affected area, which was almost half of the Inland Sea, and no fishing vessels were allowed to harvest. Fish bait sellers were closed down and no products of mariculture were sold. Depsite the rising Japanese per capita consumption of land-animal products, it is still a basic truth that marine products form a very important part of the Japanese diet, especially of the people outside mammoth cities like Tokyo or Osaka.

In the polluted area of the Inland Sea, common items of diet like the short-necked clams disappeared from the markets. This affected many people, as this food was relatively cheap and used by all strata of the Japanese society.

By the end of January, many intertidal areas had been oil covered for more than three weeks. Oil was deposited on sandy beaches in successive waves, making oil-sand 'layer-cake'. In

November, 1975, some of these beaches were revisited by the author and many dead clams were found in the sand. Local people were still not eating the clams, claiming that when put in water an oil film would appear on the surface of the pot, and that the clams were unpallatable. Researchers reported that small clams were numerous, nevertheless, and suggested that due to the oily taste of the spawning adults, the adults had not been taken, thus leaving more to spawn.

In January of 1975, on the author's first trip to the beaches, oil was observed penetrating to a depth of 20 cms. In November of 1975, in the same location, no oil was found at that depth. Later, according to fishermen digging bait, the oil was at 40 cms. and deeper.

Certainly, in November, eleven months after the spill, fishermen were digging and catching polychaetes (worms) for bait. They were also digging for small octopus which lives in the mud and which is used for human food. They claimed that the numbers were 'far fewer' than before the spill, but no research evidence is available to back this up, mainly because no population studies were done prior to the spill.

Surprisingly, there were practically no accounts of oiled birds. According to the Japanese government's Environmental Protection Agency, only one duck was found dead with oil in its gut. The cleanup efforts were so intensive that north-bound migratory birds, appearing in the Inland Sea in early spring, were not affected. The press carried reports of one porpoise dying in the slicks. In November, previously oiled walls had been recolonized by periwinkles, and barnacles were living except on those walls which had been cleaned by high pressure steam or by flaming. Regrowth of algae (green algae) was sparse, but evident. Crabs were flourishing in crevices previously badly oiled. However, fish previously caught in shallow waters close to shore now had to be netted further out.

It would seem that despite the enormous amount of effort and research put into determining the environmental effects of this spill, the picture is still confusing. Extremists on both sides have taken data and interpreted it to serve their own purposes. Some said that the oil spill was the beginning of the death of the Inland Sea, some said that the oil spill had no effect at all. Obviously, neither side is correct. The tragedy is that the rift becomes wider. The fishermen and residents, people who have tasted (or imagined) oil in their sea food, and who have noticed but not scientifically recorded changes in their environment, have become increasingly distrustful of government and industry. As an impartial observer, with no loyalties to either side, the author was able to observe this conflict and distrust.

7 THE CLEAN-UP OPERATIONS

Press reports in Canada and the USA carried accounts of a 'leak' of oil from the Mizushima refinery. This was a poor choice of works; 'gush', or 'flood' would be more accurate; the oil came out at a great force, and was hot enough to scald. This made containment extremely difficult. The oil got into the canal leading to a separator system, and had it been a much smaller amount, it would have been contained there. However, the oil overflowed the separator and entered Mizushima harbour. Booms were placed, but winds were strong, the water surface choppy, with tidal currents of 1.5 knots experienced in some places. It was also dark. The foremost concern in the minds of the refinery crew was that of fire.

Hot oil had surrounded several other tanks and had covered a total land area in the refinery of 148,300 square metres, so that the danger of fire and explosion was very real. As it was, the 34 ton base of the vertical ladder by the side of tank 270 was moved by the force of the escaping oil a distance of several yards so that it smashed through the dyke. Tank 270 itself was buckled and ripped.

An item worth of note is that during these operations, both the initial period and the months following, nobody was killed or injured by the accident or the clean-up operations, and this, it is felt, is an exceptional mark of competence of the Japanese on-scene commanders, both from industry and from the various governmental agencies.

The principal types of boom used in oil containment were a Bridgestone ocean type boom (designated as Type "B' by the Enforcement Regulations of the Marine Pollution Law) and the Yasunaga harbour type boom (designated Type "A' by the same regulations). The ocean boom has a 40 cm. skirt and float-supported 30 cm. freeboard. In addition, thousands of metres of other regulation booms were used for controlling the spill. In total 25,870 metres of boom were actually used.

The booming of Mizushima harbour was not effective. The accident occurred at night on December 18, 1974, and by 0900 hours on December 19 the oil was well outside the harbour and into the Inland Sea.

After the initial failure of booming operations, the Maritime Safety Agency attempted to emulsify the oil by spraying chemicals from 41 patrol vessels. The chemicals were sprayed from high pressure hoses. This was generally not effective because:

(a) the volume and the thickness of oil would require huge amounts of chemicals and enormous mixing powers (which were not available) and

(b) The temperature of the water and wintry conditions made the Bunker C oil extremely viscous.

Within a few days of the initiation of clean-up operations, the use of chemical dispersants was stopped due to strong protests from fishermen's cooperatives in all four of the badly affected prefectures. In certain incidents (as related by the fishermen involved), the fishermen actually went out to vessels spraying chemicals and stopped them. Despite this, some 1,014,733 litres of dispersant were used (223,216 Imperial gallons).

In Japan there is currently a very strong feeling, both in fishing and scientific communities, against the use of chemicals to handle oil spills, and this feeling was reflected in numerous newspaper, radio and television reports. Fishermen in the Inland Sea were absolutely adamant in their refusal to accept dispersants, maintaining that the dispersed oil was all the more easily available to ocean plankton, and that it was ingested by the plankton and then by fish with the result that fish were tainted. Dispersants were very definitely out of favour in the Inland Sea clean-up.

Due to the division of command and the large area of operations, it was difficult during the first month or so to get accurate figures on the quantity of equipment used and number of personnel mobilized to cope with the spill. However, during the first month, the Sixth Regional Maritime Safety Board announced that the following resources had been utilized:

8,189 workers
738 vessels
153 aircraft
30,000 metres of boom (this boom had been purchased, but not all in fact was used)
Cost of fuel alone for that month was $83,333.

The Maritime Safety Agency, several refineries and port authorities all had vessels in the Inland Sea, and many fishing boats were also used. During the clean-up operations of the first week oil was trapped in booms and recovered by various systems; floating pumps, rollers and hand bailers. Absorbent roller recovery systems were used but had a bad reputation with the oil companies and with the Maritime Safety Agency. Oleophilic belt devices similar to the "Slicklicker' were used to good effect, but the capacity of holding tanks and disposal of recovered oil posed problems, as did mechanical failure due to the weight and thickness of the oil slicks in the harbours.

Absorbents were supplied by the Mitsubishi Petro Chemical Company. The principal type used was a 50 by 50 by 0.5 cm. sheet absorbent called "Attack Ace'. This material looked like thick white cloth and seemed effective, but was not re-usable. Unfortunately in many instances it was used wastefully and indiscriminately, and much of it got loose in the sea and drifted around, and according to fishermen, much sank to the bottom.

As the oil spread, the Mitsubishi Oil Company (MOC) used dozens of trucks to distribute booms and absorbents for the use of local authorities and fishermen's cooperatives.

Equipment and personnel were brought from all over Japan. MOC pulled every available man from branch offices and laboratories all over the country. MOC's first operation centre was in the Mizushima refinery. Normal refinery operations were closed down, and remained so for the duration of the clean-up and of the investigations. The refinery did not start operating until August of 1975, eight months after the accident.

Of the Japanese government departments, the Maritime Safety was certainly the most active and effective. They set up local operation centres, as well as an operations centre in the Ministry of Transport's offices in Tokyo. The Maritime Safety Agency took responsibility for all marine operations, coordinating and controlling the movements of the oil recovery fleet and the oil spotting vessels and aircraft. The Fisheries Agency of the Ministry of Agriculture was also immediately effective. Each prefectural government office in the four prefectures badly hit by oil set up operations centres, and research centres in the Inland Sea. A certain amount of clean-up was coordinated through the prefectural offices and the Fisheries Agency as well as through local fire and public health departments.

The Fishery Agency operations centre in Tokyo had the following main objectives in mind:

(a) Arrange for compensation for the affected fishermen as soon as possible so that they would have enough money to live on,

(b) Coordinate the removal and recovery of oil,

(c) Encourage and conduct research into the long-term or side effects of the accident on the marine environment,

(d) Encourage and direct the reconstruction of the destroyed fishing grounds and mariculture areas.

As of Janaury 6, 1976, the Fisheries Agency were still analysing damage reports to fisheries and connected industries, and had to that date come to a figure of $31,333,333 (Can.) damage. On January 22, 1975, the Fisheries Agency was reported by the Canadian press to have given a damage figure of fifty three million dollars. While the author was in Kagawa and Toskushima, analysis of damage reports were still being carried out, and claims from fishermen, bait sellers, logging companies, etc. were still coming in.

To August of 1975, the Mitsubishi Oil Company advised that they had paid the following sums to this date:

(1) Damage to fisherman, fish markets, hotels, storage, houses, etc.
17 billion yen
($56.7 million Canadian)

(2) Payment for oil recovery and cleaning work of fishermen and other people **excluding** government and military services
13 billion yen
($43.3 million Canadian)

(3) Loss from refinery operation shut down for eight months
17 billion yen
($56.7 million Canadian)

(4) Cost of fuels, booms, dispersants, etc. used by MOC
Not yet calculated

Other damage negotiations were still underway at this time, and complicated court cases were sure to be initiated to settle responsibility for the cause of the accident.

The Maritime Safety Agency advised that they had requested and received 46.8 million yen from MOC to cover the expenses which they had incurred during the clean-up operations, namely: overtime of government employees, fuels for ships, booms, dispersants, etc. Their participation was carried out in the context of the Ocean Contamination Prevention Law. Article 41 of the same require the party responsible for an oil spill to pay the expenses of oil recovery and cleaning measures which the Director-General of the Maritime Safety Agency initiates and pursues at his own discretion.

The Kagawa Prefectural Government advised that:

(1) Mitsubishi paid 15,060,000 yen to Kagawa prefectures to cover overtime of prefectural employees, cost of booms, dispersants, adsorbents, fuels, etc.

(2) Mitsubishi paid 15,679,120 yen to local municipalities in Kagawa prefecture to cover overtime of their employees, and 111,586,719 yen to cover cost of material and fuels used in the recovery operations. Okayama and Tokushima prefectures also received money from MOC, but smaller amounts.

Neither the Fishery Agency nor the Ministry of International Trade and Industry requested payment from MOC, the reason being that the Ocean Contamination Prevention Act is under the administration of the Maritime Safety Agency.

From figures available to date then, the cost of conpensation, expenses and operational shutdown loss is approximately 48 billion yen or 160 million dollars. These figures are not yet complete.

In the official government report ''General Investigation into the Environmental Influences of the Mizushima Oil Spill of 1974', the following figures were quoted:

Oil and water collected from the sea	7,430 kilolitres
45 gallon drums filled with oil and water by shore parties	102,885 drums
Polluted sand and shingles removed from beaches	5,720 tons
Sets of nets destroyed	240,749 sets
Number of persons taking part in the clean-up	232,150
Ships and boats used	38,653
Aircraft used	344
Booms used in operations	24,870 metres
Dispersants used	1,014,733 litres
Absorbents used	830,116 kgs.

The Mitsubishi Oil Company itself was intensely involved in clean-up and recovery. They coordinated the supply of materials as well as the hiring and movement and the organization of cranes, trucks, vacuum trucks, pumps, barges and boats. They chartered aircraft to plot the movement of oil. Their staff worked through the holiday season, putting in extremely long hours, every day.

When the author arrived in Japan on the first study trip (January 6, 1975), operations had already peaked in Okayama and Hyogo prefectures, and were just passing the peak at Kagawa prefectures, with work activity building to a peak by the second week in January at Tokushima. MOC was shifting men and equipment as needed, and working out of three main operations centres.

The author spent five days working out of the Kagawa prefecture operations centre in Takamatsu city. The decision to centre there was based on the fact that: all types and phases of recovery and clean-up were being coordinated there, and that this operations centre had at that time the greatest concentration of skilled and technical MOC personnel.

At the Takamatsu city operations centre, which was situated in a modern hotel, and practically occupied the entire hotel, some 69 people were working from early in the morning until late at night, every day. The Plaza Hotel, Takamatsu, was very conveniently situated, close to the harbour and ferry terminals. Almost every room in the hotel was rented by MOC, and they used two large meeting rooms for their operations. One was principally a communications and administration room, complete with a Xerox, a telecopier, half a dozen phone lines, tables, blackboards and charts. The second large room was on the ground floor, and was a dispatch headquarters for the men going out to supervise operations in the field. It seemed to be a very well-functioning system. Meals, taxis, etc. were arranged by MOC, and taxis were paid for by signed 'chits' which all of the taxi companies honoured without questions. These were marked as to their origin for easier accounting. While working in the centre at Takamatsu, the author was privileged to get a feeling of the teamwork at which the Japanese are particularly good.

On January 8, 1975, in Kagawa prefecture alone, the following equipment was being used:

8,000 metres of boom
15,000 empty 45 gallon drums
19 Marine Safety patrol vessels
56 oil recovery ships
6 barges
1 crane ship
1 oil incinerating ship
Varying numbers (10 to 30) trucks and vacuum trucks were in use.

Apart from the booms supplied by MOC, the fishermen's cooperatives had their own harbour booms.

By this time, having been carried across the Inland Sea, the oil was a heavy sludge. The workers found that skimmers, floating pumps and other specific oil recovery gear was not as effective as removal of the oil by long-handled bailers. It was found that one person could fill a 45 gallon drum in twenty minutes this way. At every harbour and fishing port, fishermen and their families bailed oil into drums that were carried away by trucks or barges. It may appear primitive, but it was effective with minimal equipment costs, and with the kind of manpower available in Japan, it was an excellent solution to the problem.

An example of the amount of oil removed by local fishing families was demonstrated at the tiny harbour of Shimo Kasai, where 120 drums a day were taken for one week - 840 drums, by hand bailing. Most of this was oil, with very little water. The trucks and barges could not keep up with the amount of oil being taken this way. In Shimo Kasai harbour, the oil was so thick on the water that the outboard engines were being stopped by it. There were harbours like this in all four of the badly affected prefectures.

At sea, the oil was trapped in booms, concentrated into a small area, and then pumped or bailed into tanks and drums. The amount of sludge/oil/water/debris recovered was prodigious. By January 13, 1975, in Kagawa prefecture alone, 13,500,000 gallons of oil and muck had been collected, and by no means were operations in that area finished. The recovered oil, etc. was taken to a prefectural site near Banosu refinery, Kagawa. Bulldozers dug pits 1.5 metres deep, and labourers lined the pits with plastic sheeting and built a 40 cm. berm around them. The filled drums were emptied into these pits. This was a temporary arrangement. The whole problem of disposal was one which took immense effort. Eventually, the oil and water, etc. were taken to the Mizushima refinery, to be recycled at great cost. At the Banosu site, an accumulation of 10,000 drums filled in three days, was observed.

There were three main gathering sites set up to handle the recovered oil; one at the refinery in Mizushima, one at Banosu for Kagawa prefecture, and one at Kameura for Tokushima prefecture. At the Tokushima prefectural site, an accumulation of 13,500 full drums was observed.

These figures are confusing, but the important fact to be remembered is that if you spill one gallon of crude oil or Bunker C, you have at least five gallons of oil/sludge/water/debris to recover.

The two most heavily utilized pieces of equipment in this whole operation were the long handled bailer and empty 45 gallon drum. Another piece of simple equipment which MOC found to be particularly good for picking up sludge was a two-metre square of steel mesh, the mesh size being 5 mm., and the ends turned up to form a shallow basket. This mesh basket was manipulated by a crane, either land or ship based. It was dipped under the oil sludge and lifted out. The free water ran out and the sludge dumped.

Personnel of the Japanese Self Defence Forces worked in three and sometimes four teams on land operations. A total of 900 officers and other ranks were employed in oil recovery and beach clean-up. They used their own jeeps, trucks and portable radio equipment, and they controlled traffic on the narrow country roads in their particular areas of operation. The energy and efficiency of these military teams was most impressive.

Beaches were cleaned with heavy and medium equipment where possible, but in most instances the job had to be done by hand. Dirtied sand was removed. Oiled rocks were wiped with 'Attack Ace' absorbent. No peat moss or straw was used. Jetty walls were cleaned with steam, with high pressure hoses, and in places, with chemicals or with flame.

On January 11, 1975, the Tokushima prefecture was visited. MOC had set up its operations centre in the Park Hotel, Tokushima city. They had installed a Xerox, a telecopier and several phones. On that particular day, the following equipment was in use in Tokushima:

30 trucks
10 vacuum trucks
2 oil recovery ships
1 crane ship
5 Maritime Safety Patrol Vessels
30 smaller fishing vessels

10,000 metres of booms

In Tokushima prefecture, four operations centres were working the MOC centre in Tokushima city, a Maritime Safety Agency centre at Komatsu Island, a prefectural centre at Fukuchiji and a city government centre at Naruto city, which had been badly hit by the oil. MOC had established a huge collecting base and equipment and supplies stockpile.

In the second week of January, oil was still moving and collecting in bays along the coast of Shikoku, especially in Hude Bay, where it was 5 to 10 cms. thick - a heavy, reddish brown sludge which was being removed by vacuum trucks.

8 CONCLUSIONS

The Mizushima spill demonstrates the environmental, social and economic damage, that can be caused by a large oil spill even when contingency planning and readiness is excellent, and when equipment and labour are readily available. It highlights the fact that despite advanced technology, an industrialized nation will encounter major difficulties, as did Japan, in handling a major spill in the face of severe wind, wave and current conditions.

It can be argued that the damage to the Island Sea was all the more severe because of the intensive mariculture in the area and that Canada's coasts do not have this kind of concentrated use. Canadian coasts, however, are becoming more and more developed for recreational and food producing uses.

Japan is a highly industrialized nation, with five times Canada's population. Despite the extremely rugged coastline, Japan's access to its shore is generally excellent, labour is readily available, and countermeasures equipment and material can be manufactured in record time. In Canada, we do not have the labour force nor the amount of equipment that Japan has; yet we have a coast which is longer, as rugged and, in many areas, much more difficult to access.

It is concluded, therefore, that Canada (or any other nation) would have even more difficulty than Japan in counteracting a similarly large spill in its waters.

The answer then is to ensure, through dedicated preventative activities, that major spills do not occur.

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NOTE ON THE AUTHOR

The author was born on July 17, 1940 in Neath, South Wales, and became a Canadian citizen in 1967. From 1958 to 1962 he participated in various wildlife studies in Canada's North and was a wintering member of the Devon Island Expedition organized by the Arctic Institute of North America. Also during this period he attended St. Paul's Teacher's Training College in Cheltenham, UK, wrestled professionally, and for a short period was assistant warden of the bird sanctuary of Lundy Island, Bristol Channel, UK. He subsequently journeyed to Japan and for the next three years studied the martial arts there, achieving black belt rank in Karate in 1965. From 1965 to 1966 he was employed by the Fisheries Research Board of Canada at the Arctic Biological Station in Montreal as a marine mammal technician. During this period he spent six weeks aboard a Japanese whale catcher, four months at a whaling plant and took part in and directed several over-ice surveys of seals on the Canadian East coast. For the next two years, he again left Canada and became employed by the Ethiopian Government to develop a new national park in the northern mountains of the Simien region. But Japan once again beckoned and in 1969 he returned there for two years to study language at the Tokyo School of the Japanese Language and fisheries at Nippon University, Japan. He returned to Canada in 1971 and again was employed by the Fisheries Research Board, this time at the Freshwater Institute in Winnipeg. In 1974 he transferred to the Pacific coast where he was employed by the Environmental Protection Service of Environment Canada in their environmental emergency section. It was in this capacity that he was sent to Japan to observe the Mizushima oil spill.

In June 1975 he was seconded to External Affairs to become assistant manager of the Canadian Pavilion at the International Ocean Expo in Okinawa, Japan. It was during this period that he undertook a second research trip to the Inland Sea. In February 1976 he returned to Vancouver to continue his work in environmental emergencies.