3. Enforcement

Background

Management of the new 200-mile U.S. fishery zone will, of necessity, have enforcement of regulations as an integral part if it is to accomplish restoration and conservation of fish stocks and provide the domestic fishing industry with the potential and incentive to grow, as mandated by the Fishery Conservation and Management Act of 1976 (P.L. 94-265).

Management plans to be drawn-up under provisions of the Act will lay the groundwork for the types of regulations which will be required and which must be enforced. However, fish resources are already scarce enough and the demand for fish products high enough that it is logical to conclude that foreign nations can justify the risk of violating these regulations and the United States can justify the effort and expense of enforcing them. In fact, the U.S. Coast Guard, the agency primarily charged with the enforcement task, has concluded in a report on its preparations for increased fisheries duties that "the state of the fish stocks today is too critical to allow for any lapse in enforcement."[20]

A discussion of enforcement problems and opportunities is offered first in this report for two reasons:

1) Clear and timely indication of U.S. intentions to strictly enforce fishery regulations within the 200-mile zone is imperative for gaining foreign cooperation.

2) Even the best of management plans cannot succeed without effective enforcement of its provisions.

Later sections of this report deal with the problems and opportunities of managing the 200-mile fishing zone and with the need for much additional information as Federal agencies and Regional Councils seek to refine and improve management techniques.

Brief History of Fisheries Law Enforcement

The United States began to exercise control over its coastal fisheries soon after it became a country. Until the passage of the Bartlett Act, in the middle 1960's, however, enforcement was essentially confined to the "territorial sea", the area within 3-nautical miles offshore.

The early control activities were generally mild. It wasn't until the late 1800's and early 1900's, that strong legislation was passed to resolve fishery and marine mammal problems in Alaska and the Pacific Northwest, In the early 1900's, foreign fishing vessels were seized and brought to American ports, and fines were successfully levied against the crews and vessels.

The Bartlett Act has been the primary fisheries law. Foreign fishing is not only prohibited within the territorial sea, but also is excluded within a contiguous 9-mile fisheries zone beyond the 3-mile territorial sea. In addition, foreign fishermen cannot retain creatures of the Continental Shelf (shellfish and crustacean). Violations of the Bartlett Act could result in fines, imprisonment, and forfeiture of the vessel, gear, and catch.

There are a number of treaties and international agreements in which the United States and other countries have agreed to manage fishery resources, outside the 12-mile zone. ICNAF (International Convention for the Northwest Atlantic Fisheries) is an example of one important treaty. Here, the 18 member governments prepare the regulations, which for the most part are concerned with quota

allocations. Inspectors may stop, board, and examine member fishing vessels for violations of the regulations, but prosecution and punishment (if any) are carried out by the "flag state", the home country of the particular fishing vessel.

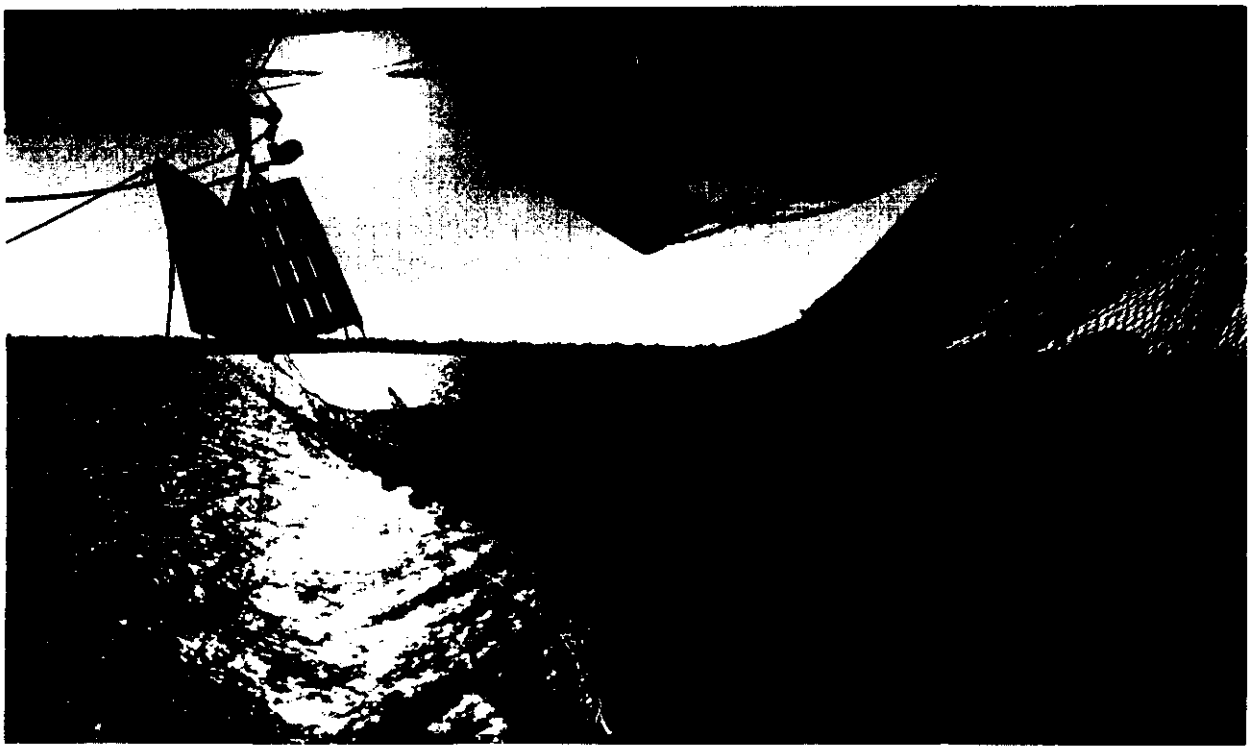
The United States was a member of ICNAF for more than 25 years. However, it withdrew from the convention after Congress passed the Fishery Management and Conservation Act of 1976, unilaterally assuming jurisdiction over most of the east coast waters in which American fishermen work.

The growth in breadth and strength of enforcement of fisheries laws can be traced to two primary interrelated occurrences:

- intense foreign fishing off our coasts, and
- depletion of many fish species due to overfishing.

In 1975, there were 17 foreign nations fishing off our coasts.[21] In June 1975, almost 1,000 foreign fishing vessels were sighted; the year's monthly average was more than 500.[22] The foreign vessels caught about three-quarters of the 3 million metric tons of fish caught in the 200-mile zone that year.

From 1964 through September of 1976, nearly 100 foreign fishing vessels were cited for violation of U.S. fishing laws. The most frequent offenders have been Japan, Canada, Cuba, and the U.S.S.R. Fishermen from these nations account for more than 70 percent of the violations of U.S. law. In addition, approximately 100 treaty violations are documented each year.[23]



OTAI *Photo*

Trawl nets on shrimp boats dry in the sun. Shrimp is one of the largest commercial fisheries in the Gulf of Mexico.

Requirements of the Law

Violations of U.S. law can be classified as:

- geographical intrusion, that is entrance into forbidden areas, such as territorial waters or closed areas; and
- catch and illegal retention of creatures from the continental shelf, such as lobsters and crabs.

Treaty violations take the form of:

- improper fishing gear, which is prohibited in certain areas by regulation;
- illegal retainment of bycatch, that is, catching and keeping prohibited species;
- overfishing of quotas; and
- violating administrative regulations, such as improper keeping of log books or not reporting required scientific data.

In the past, fisheries enforcement responsibility has been vested primarily in the U.S. Coast Guard. The Coast Guard has provided the ships and aircraft and much of the manpower to staff the vehicles, the sensing equipment and the command and control function of operations. The National Marine Fisheries Service, which is primarily concerned with gathering management and scientific data, assisted in enforcement. NMFS provided personnel with expertise on fishing gear, fishing techniques, and fish identification and catch rates. There was close cooperation between the two groups, with personnel from both agencies frequently onboard the same vessels,

The State Department has also played an important role in fisheries law enforcement. The State Department negotiated the various treaties and international agreements, and in the past, any foreign fishing vessel was seized only after coordination with the Secretary of State. A close liaison between the State Department and the Coast Guard was needed since any interference with foreign shipping, warranted or not, could certainly affect U.S. relations with the foreign country.

The purpose and policies set out in Public Law 94-265 have important effects on enforcement. The law vests the responsibility for enforcement in the Secretary of Commerce (NMFS) and in the Secretary of Transportation (Coast Guard). Authorization is given to arrest violators, to seize vessels and cargo, and to issue citations.

In addition a number of specific instructions, which have a major effect on enforcement, are spelled out in the law:

1. No foreign fishing is permitted in the fishery conservation zone except:
   a. under agreements or treaties (new and renegotiated), and
   b. with a permit.
2. In every international agreement:
   a. The foreign country agrees to abide by all U.S. regulations.
   b. The foreign country allows a U.S. officer to:
      (1) board the vessel,
      (2) make arrests and seizures, and
      (3) examine the permit,
   c. The permit must be prominently displayed.
   d. Appropriate position-fixing and identification equipment, such as transponders, if required by the Coast Guard, are to be installed and maintained on each vessel.
   e. U.S. observers will be allowed to board any vessel, the cost to be reimbursed to the United States.
   f. Foreign agents are to be sited in the United States to deal with any legal process.
   g The foreign nation acts in behalf of its individual vessels.

Present Plans for Near-Term Enforcement

3. An allocation of fishing level (fish quotas) will be made to specific foreign countries.
4. If a foreign vessel, with a permit, violates the regulations:
   a. The permit of that vessel could be revoked.
   b. The permit could be suspended.
   c. Additional conditions could be imposed on the foreign nation and on any of its permits,
5. Civil penalties for violations could be as much as $25,000 per violation, where every day may be considered as an additional violation.
6. Criminal penalties for violations could be as much as $100,000 and 10 years in prison.
7. Any vessel, its fishing gear and cargo, could be forfeited to the United States.

Since the passage of the Fishery Management and Conservation Act of 1976, some concern has been voiced by Members of Congress, members of the Regional Councils, and others, that foreign investments in U.S. fishing operations and joint ventures between foreign and domestic fishing and processing companies may provide a means of circumventing controls on foreign fishing interests within the 200-mile zone. Such investments may guarantee foreign firms the almost unlimited access to fish stocks which is intended for domestic fishermen and allow them to operate outside certain regulations-such as gear restrictions—which may be in effect only for foreign fishermen. While such investments may pose problems in enforcing the intent of the Act, they are not, strictly speaking, an enforcement problem to be dealt with by the Coast Guard and NMFS operational divisions.

The problems and benefits of foreign investments are discussed as management concerns in other sections of this report.

Enforcement of regulations in the new 200-mile fishery zone is complicated by the size of the area and the fact that fishing is to be regulated not prohibited. The area encompassed by the 200-mile-wide band surrounding the United States and its possessions adds up to almost 21/Q-million square miles of ocean. According to Coast Guard estimates, major fisheries cover approximately one-fourth of that area. These prime fishing grounds will require concentrated enforcement efforts during certain seasons, In addition, at least some level of enforcement may be required in all parts of the zone at some time during the year. A dense mixture of marine traffic, including merchant vessels, warships, tankers, recreational craft, and both domestic and foreign fishing vessels, is found within the 200-mile zone. From this mix of vessels, foreign fishing craft must be located and identified by nation. Further, in order to enforce any regulation in any fishing area at any given time, fishing vessels must be classified as fishing according to the provisions of their permits and existing regulations or in violation of these controls; violators must be apprehended; and some prosecutor action must be taken.

This detection, identification, and classification of foreign fishing activity must go on under any sea conditions that permit fishing itself. Experienced fishermen have indicated that this means enforcement activities may be

necessary through at least sea state 7 (28- to 40-knot winds and 22- to 40-foot waves).

In addition, for each enforcement step, different vehicles and equipment are useful. For example, an aircraft flying at 200 knots, at 15,000 feet in clear weather will cover a greater area, using sight and radar, and detect more fishing vessels than will a cutter at sea doing 15 knots. On the other hand, the aircraft cannot put a boarding party on fishing vessels, while a cutter can accomplish this mission.

It is not now possible to project explicitly what enforcement will be necessary to detect and deter violations because the Regional Councils, which are charged with creating the regulations for fishery management, have not yet formalized final plans which will include the regulations which are to be enforced. Regulations which have been drawn-up by the National Marine Fisheries Service for implementation as of March 1, 1977, are merely interim rules which will be supplanted once the councils formulate regulations specific to

U.S. Coast Guard Photo

Under the new law, Coast Guard enforcement officers may board foreign fishing vessels to inspect the catch and fishing gear

their fisheries. The interim regulations are not too different from those contained in the international agreements which have, in the past, been the only means of controlling fishing activity. The major immediate changes will be that the United States has taken on the responsibility for enforcement, will board and inspect foreign vessels for compliance with U.S. regulations, and will prosecute offenders itself instead of leaving that task to flag states. But as experience with the fishery zone grows, new types of regulations and enforcement techniques will be needed and used.

Nevertheless, certain basic types of violations can be anticipated, such as illegal fishing by foreign vessels which do not have permits; overfishing of quotas allowed for each species; violation of permit stipulations such as gear-, area-, or time-restrictions; and failure to comply with data-reporting requirements.

The specific regulations to be enforced and violations expected will affect the type of enforcement strategies and equipment to be used, Figure 4 is a matrix of likely enforcement needs and techniques.

Figure 4
Summary of Fisheries Regulations, Where Proposed, Effectiveness of Selected Surveillance Techniques (Regulations Are Taken From Preliminary Management Plans, Techniques From USCG Plan, OTA Working Paper and Others)

		Effectiveness in Detecting Violations			
Typical Fishery Regulations—(to date)	Selected Fishery Applications	Electronic Surveillance	Ship Patrols and Insp. by Boardings	Aircraft Patrols	Observers
Total Allowable Catch (per country)	All Foreign Fisheries	Low	Moderate	Low	High
Time and Area Allocation (per vessel)	Wash/Ore/Calif Trawl Fishery	Moderate	Low	High	N/A
Season and Area Restrictions	Most Foreign Fisheries	Moderate	Low	Moderate	N/A
No Fishing for Certain Species	West Coast and Alaska Trawl Fisheries	N/A	Low	N/A	Moderate
No Retention of Certain Species	Crab Fisheries	N/A	Low	Low	High
Specified Allowable Gear	Only Pots for Crabs Specified Trawls—East and West Coast	N/A	Low	Low	High
Minimum Mesh Size and Other Gear Restrictions	Wash/Ore/Calif Trawl Fishery	N/A	Low	Low	High
Reports of Catch and Bycatch by Species	All Foreign Fisheries				
Exclusion Areas	Most Foreign Fisheries				

NOTE: The techniques above are judged on capabilities of existing technology and present plans for numbers of ships and aircraft.

Source. OTA

Level of Enforcement

Just as important in determining what enforcement capabilities will be necessary is determination of the desired level of enforcement. In other words, should enforcement agencies mobilize to catch 50 percent of the violators, 75 percent, or 100 percent—in which case the costs could prove to be astronomical. Without a quantified level of enforcement, the allocation of enforcement resources becomes a matter of intuition rather than one of reasoned judgment.

Currently, the Coast Guard simulation model used for costing purposes indicates that the agency assumes it can catch or deter approximately 95 percent of the 2,150 expected annual violators within the budget appropriation level requested.[24] That percentage, however, does not appear to have been set as an enforcement goal based on any policy decision as to what level of enforcement is desirable. In addition, the percentage shown may be much too high, depending on what types of violations (over quota, use of prohibited gear, fishing in closed areas) are being counted, A middle-ground approach is probably required and a specific definition of that approach would be desirable. This should be followed by regular assessment of changing enforcement needs as well as the actual level of enforcement compared to the desired level. Determination of the level of enforcement could also be enhanced by asking Regional Councils to make a projection of desired enforcement actions in their areas, possible compliance inducements for fisheries in their areas, and potential domestic-enforcement plans.

A major shortcoming of the Coast Guard's analysis of the appropriate level of enforcement is the lack of an adequate method for assessing the benefits that can be expected from various enforcement strategies. Since significant resources may be required to operate an effective enforcement system, the Coast Guard's current inability to systematically estimate the expected value of enforcement is a serious flaw. However, since the determination of appropriate enforcement strategies is only one part of the broader process of fisheries management, what is probably needed is a more general analytical system which could provide quantitative estimates of the impacts of alternative management techniques, including—but not limited to—the enforcement strategies, on the catch and profits of commercial fishermen, the quantities and prices of fish available to the domestic consumer, the state of recreational fishing, and other measures of the benefits of management.

One such general analytical system is currently being developed for NOAA by the Center for Technology Assessment and Resource Policy at Stanford University. This system is based on a generalized computer systems model which can integrate the best available scientific information about any particular fishery in order to assess the quantitative impacts of various management techniques on the fishery. Since even the initial approach to enforcement is expected to cost nearly $100 million per year, benefits should be clearly identified and quantified to the extent useful. Some of the benefits may include:

- A future increase in stocks and yields due to tighter controls to prevent overfishing.
- Less pressure on stocks caught as bycatch due to better controls on gear and areas fished,
- Less conflict among fishermen for certain grounds and reduced gear conflict.

- Assurance of proper allocation of quotas among foreign and U.S. fishermen.

An enforcement component is not presently planned for the Stanford model. Such a component, which would translate various enforcement strategies into impacts on foreign fishing activities, should be developed by the Coast Guard. The Coast Guard could then use its enforcement model in conjunction with the Stanford model, or any similar one adopted by NOAA, in order to determine the costs and benefits of various levels or enforcement or specific enforcement strategies.

The primary objective of the Coast Guard simulation should be to evaluate the effectiveness and the cost of a mix of vehicles, sensors, and personnel as they enforce the regulations applicable to the 200-mile fishery zone. Among other factors, the model should include:

- existing capabilities and possible future systems of sensors, vehicles, and personnel;
- short- and long-range enforcement needs;
- possible multipurpose use of systems and equipment by the Coast Guard for accomplishment of several of its missions;
- . likely levels of assistance from the Navy, NASA, the Air Force, and NMFS;
- relative importance of various components of enforcement, such as surveillance, boarding, etc.;
- the effects of various types and levels of penalties, such as fines and seizures;
- . likely regulations of all types;
- explicit yardsticks of effectiveness, such as percent of captured violators, amount of protection given to stocks, value of fines collected, value of regulation on foreign relations, comparability with other Coast Guard duties, etc.;
- . behavior patterns of foreign and domestic fishermen in reaction to regulations; and
- monetary cost of programs.

A model which does a more adequate job of making cost-benefit estimates than the existing Coast Guard model will be exceedingly difficult to prepare since the efficiency of enforcement involves intangible as well as tangible costs and results. For example, how does the value of protecting and restoring a depleted stock compare with the value of improved international relations which may result in some specific sought-after agreement in another field? However, the model could present possible scenarios, impacts, and tradeoffs which may result from various levels of enforcement or differing amounts of expenditures.

Although the analytical models to be used by NOAA and the Coast Guard in fisheries management and enforcement are an important tool, there is considerable feeling among members of the Regional Councils and other interested parties that modeling techniques have already outstripped available data. The results of the OTA study also indicate that existing models have already identified large areas where there is insufficient information. Therefore, immediate emphasis should be on a program for long-term collection of consistent basic information. Models and modeling techniques can be improved while this basic data is being gathered.

Existing Capabilities

The existing capabilities for enforcing Public Law 94-265 include three primary groups, within the executive branch, which would or could be involved in the future:

1. The Coast Guard has the primary responsibility for enforcement and exercises almost complete jurisdiction over activities in the foreign fisheries.
2. The National Marine Fisheries Service shares the enforcement function with the Coast Guard by providing personnel with scientific and biological expertise to aid in planning and carrying out enforcement strategies in the domestic fisheries.
3. The Department of Defense normally will have no enforcement function at all, except in the unlikely event that foreign warships should appear within the 200-mile zone to contest U.S. regulations. In that case, U.S. military forces would be called upon under the terms of a memorandum of understanding between the Coast Guard and the Department of Defense. The memorandum and contingency plan for such a situation has been worked out by the Joint Chiefs of Staff and the highest levels of the Coast Guard and is classified information,

The Department of State, which has been involved in enforcement of fishery agreements in the past because of their international nature, has been given a limited role under the new law.

The Department of State's primary function is to negotiate the Governing International Fisheries Agreement, by which, foreign nations agree to accept the U.S. jurisdiction in the 200-mile zone. The State Department is also to exercise an advisory role, keeping the Coast Guard, the National Marine Fisheries Service, and the Regional Councils informed on foreign policy implications of fishery management.

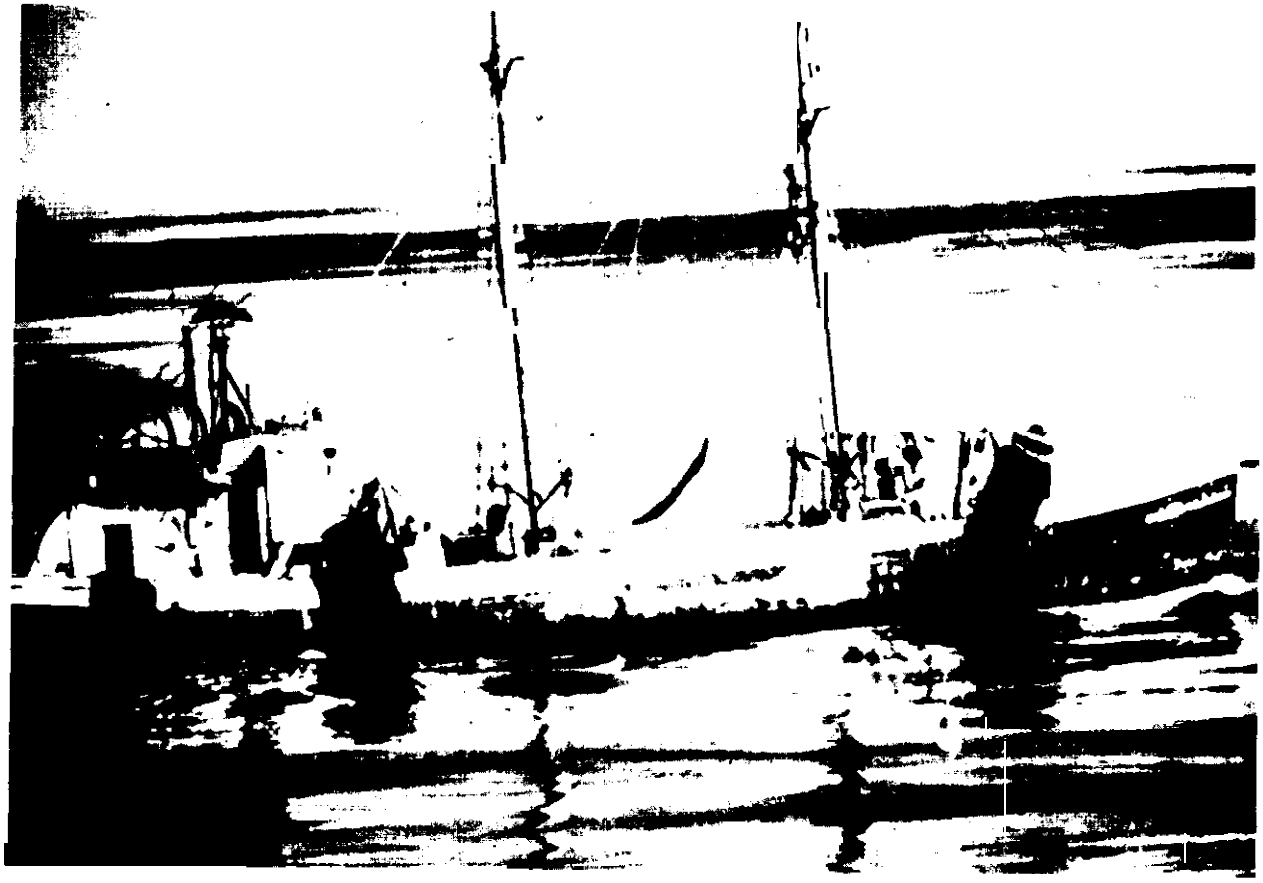
Under the new law, as in the past, the State Department is consulted by the Coast Guard before any foreign fishing vessel is seized for violation of U.S. regulations. There are undoubtedly legitimate instances when the foreign policy or diplomatic implications of some action should take precedence over the fishery implications. However, the Coast Guard routinely allows the State Department's desire to avoid unpleasant diplomatic incidents to influence enforcement actions. There appears to be no formal mechanism to assure that State Department decisions to intervene in a fishery action are made at an appropriate policy level and that the Coast Guard exercises its statutory responsiblitity to make final enforcement decisions, with advice from the State Department being only one of many factors to be considered. There is obvious need for a clear and simple procedure which quickly leads to a decision-and review of that decision by the Chief Executive when necessary--on whether or not to seize a foreign vessel which is violating U.S. law or regulations.

The following discussion of the work of these agencies in regard to enforcement is not intended as a specific description of their planned operations. Rather, it is an overview and a critique of likely enforcement.

In its routine enforcement role, the Coast Guard provides personnel, vehicles, and sensing equipment. Its enforcement capability during 1975 came from its fleet of 39 aircraft, 39 ships, 94 helicopters, and various support facilities. These facilities were not dedicated

solely to fishery enforcement, but were used also for other Coast Guard duties such as investigating oil spills, sea search and rescue, and general law enforcement. Approximately 2,500 days of ship time and 6,000 hours of aircraft time were devoted to enforcing fishery laws, regulations, and treaties during 1975, about one-haIf million square miles were patrolled, at a cost of $46 million for the year. The Coast Guard spent about 5 percent of its total annual operational budget on fisheries enforcement [25]

The Coast Guard's original plan for enforcement under the new law called for increasing ship time by 951 days to provide 2,616 patrol days inside active fishing areas and 823 patrol days in other areas; increasing aircraft time by 7,553 hours to provide 8,446 hours of patrol in active fishing areas and 3,068 hours of patrol in other areas.[26]



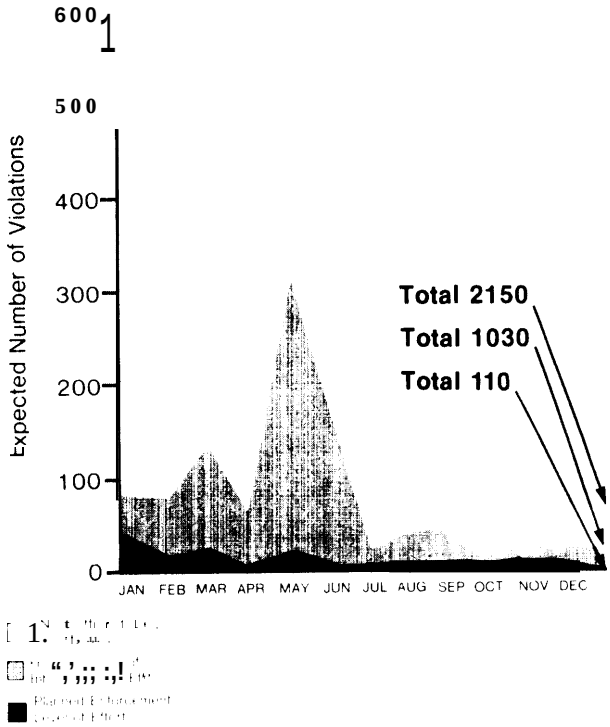
Trawlers operating out of New England ports work in the ground fisheries of Georges Bank, U.S. Navy *Photo*

According to the Coast Guard plan, this, theoretically, would reduce the number of violations per year from the expected 2,150 to about 110, based on the assumption that detection and identification constitute enforcement (see figure 5). However, there is some question about the wisdom of this assumption since simple detection of a violation by an aircraft or other means does not guarantee that the violation will cease and that the violator will be penalized.

The Coast Guard plan would necessitate the addition of 10 fixed-wing aircraft, 5 helicopters, and 6 high-endurance cutters. Procurement and operation of these new craft was estimated at $275.4 million through fiscal Year 1978, After appropriation of the fiscal year 1977 budget, this strategy was reassessed and it was determined that budget constraints dictated that initial enforcement focus on the active fishing areas only. For maximum effect in that area with appropriated funds, the Coast Guard revised procurement plans to include purchase of four C-130s and reactivation of four C-131s; reactivation of its last five spare, short-range shipboard helicopters, and temporary overscheduling of the crews of five others; and reactivation of one cutter—all of which could be in operation close to the March 1, 1977, effective date of the law. The package, with necessary support facilities, was estimated to cost $64.3 million.[27]

Most of the projected new vehicles are scheduled for use where the new U.S. jurisdiction now takes in more extensive fishing grounds, that is, in the Pacific Council area and off the Alaskan coast. Since these areas contain about 16 species of fish which have been overexploited in the past, the allocation of more vehicles to enforce regulations there will also aid in the conservation and recovery of these stocks. (See figures 6 through 10.)

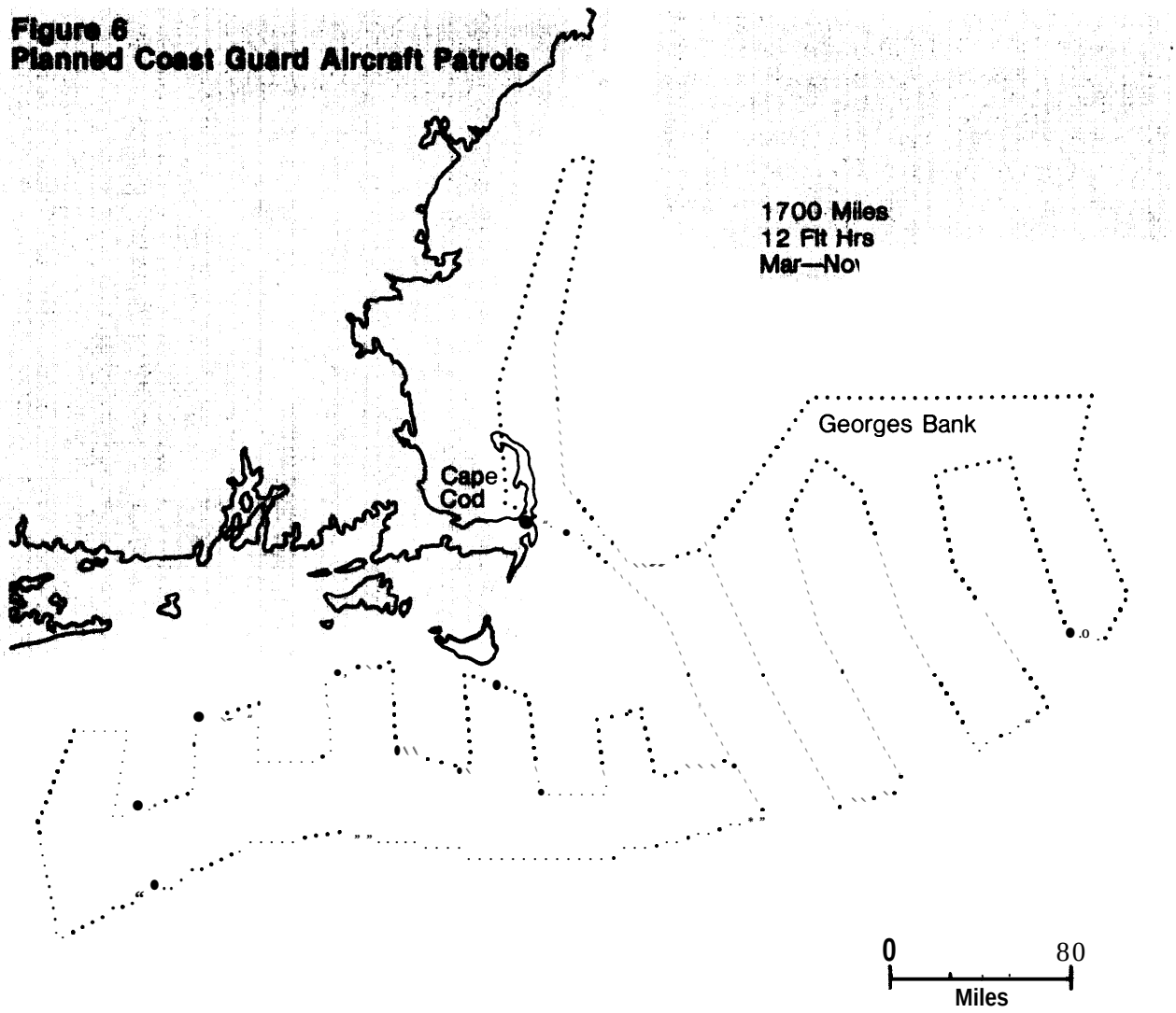
Figure 5
Expected Number of Undetected Violations by Month Under "No Effort", FY 75 Level, and Planned Enforcement



Source U S Department of Transportation Coast Guard

New England

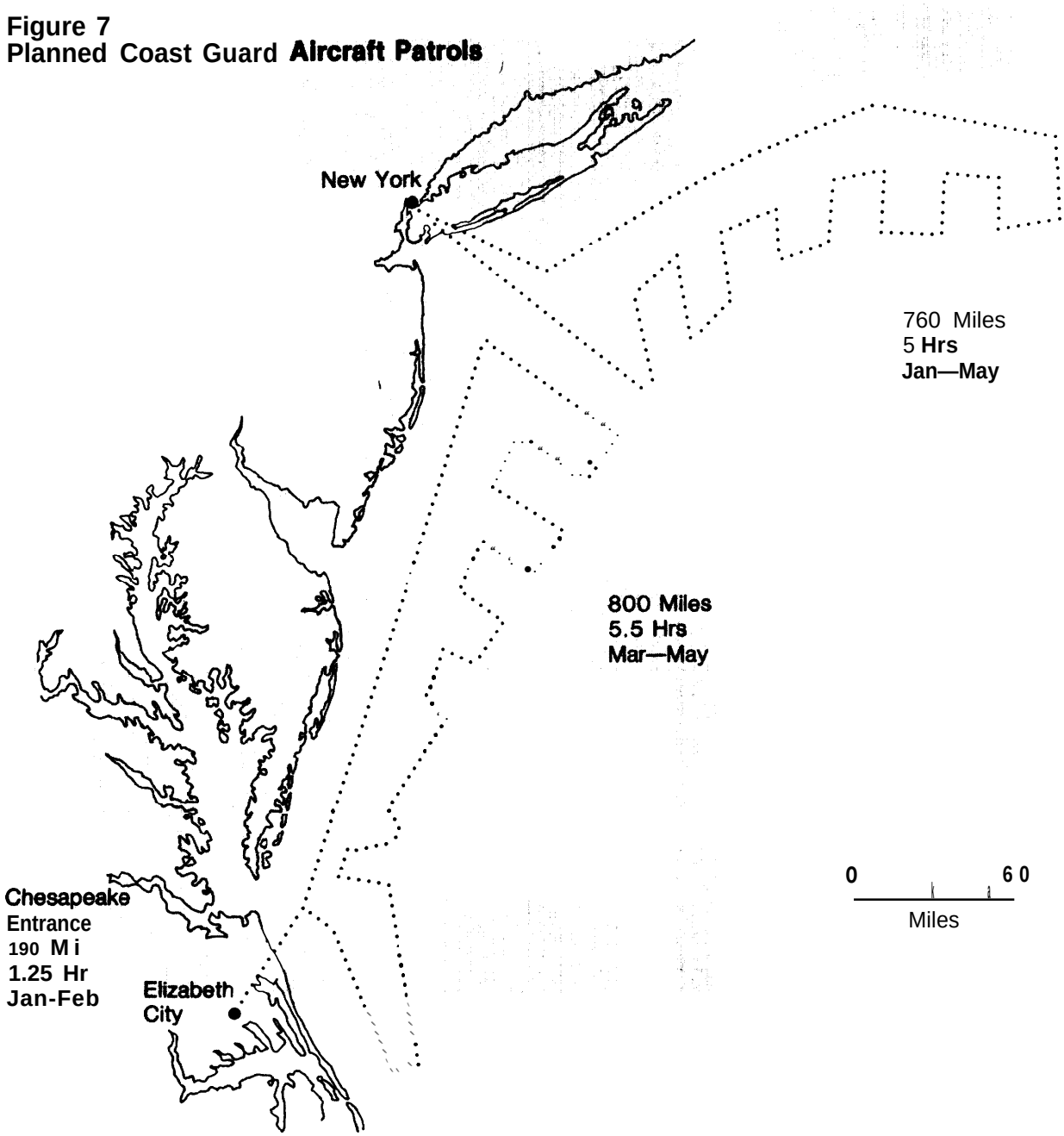
Figure 6
Planned Coast Guard Aircraft Patrols



Source: U.S. Department of Transportation, Coast Guard

Mid Atlantic

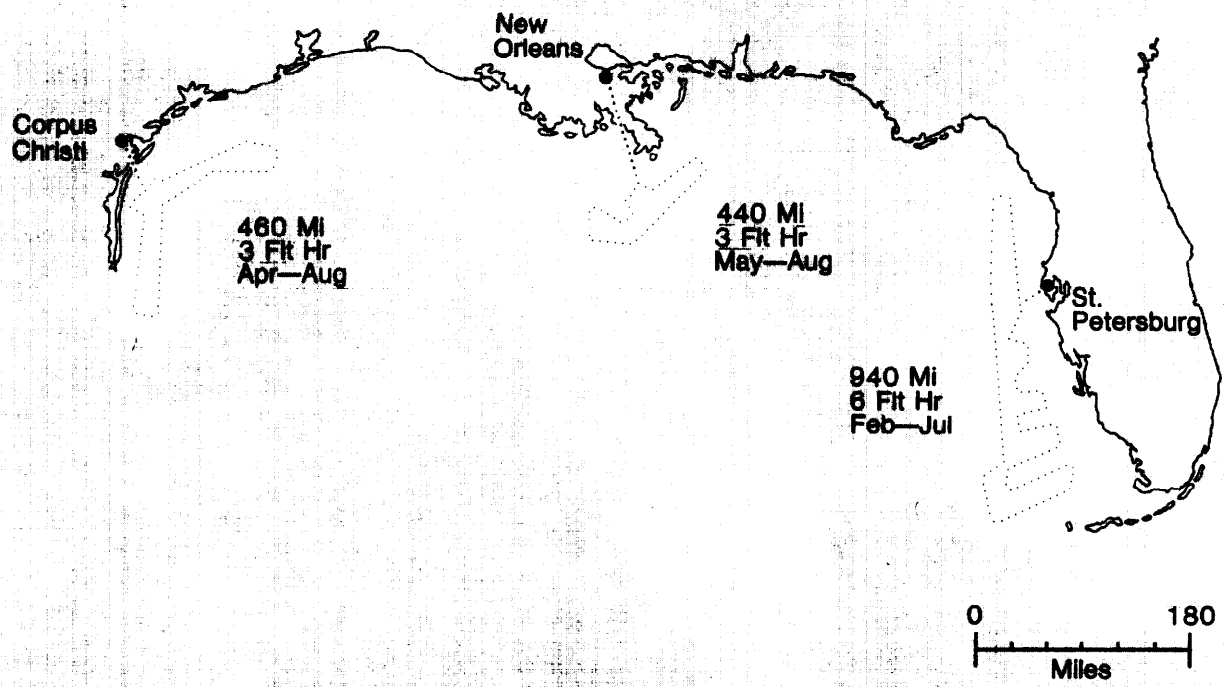
Figure 7
Planned Coast Guard Aircraft Patrols



Source: U.S. Department of Transportation, Coast Guard

Gulf of Mexico

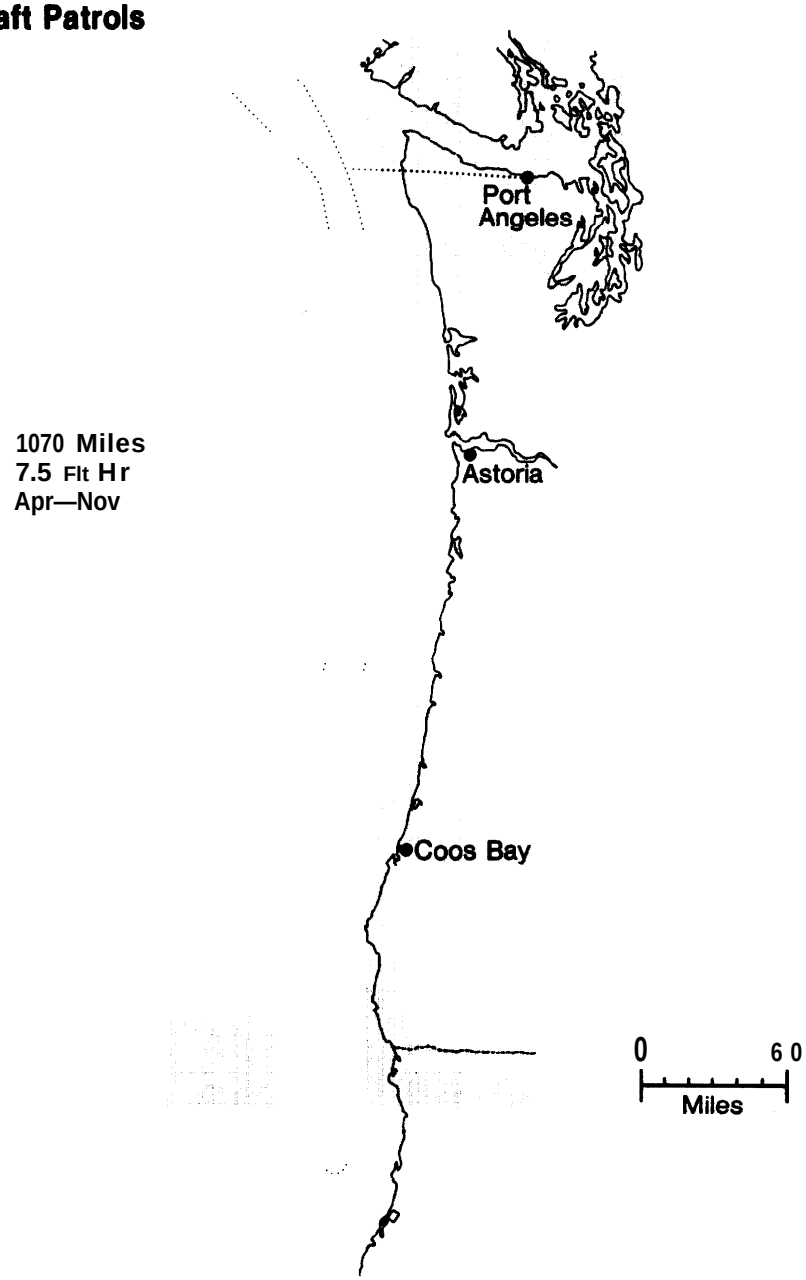
Figure 8
Planned Coast Guard Aircraft Patrols



Source: U.S. Department of Transportation, Coast Guard

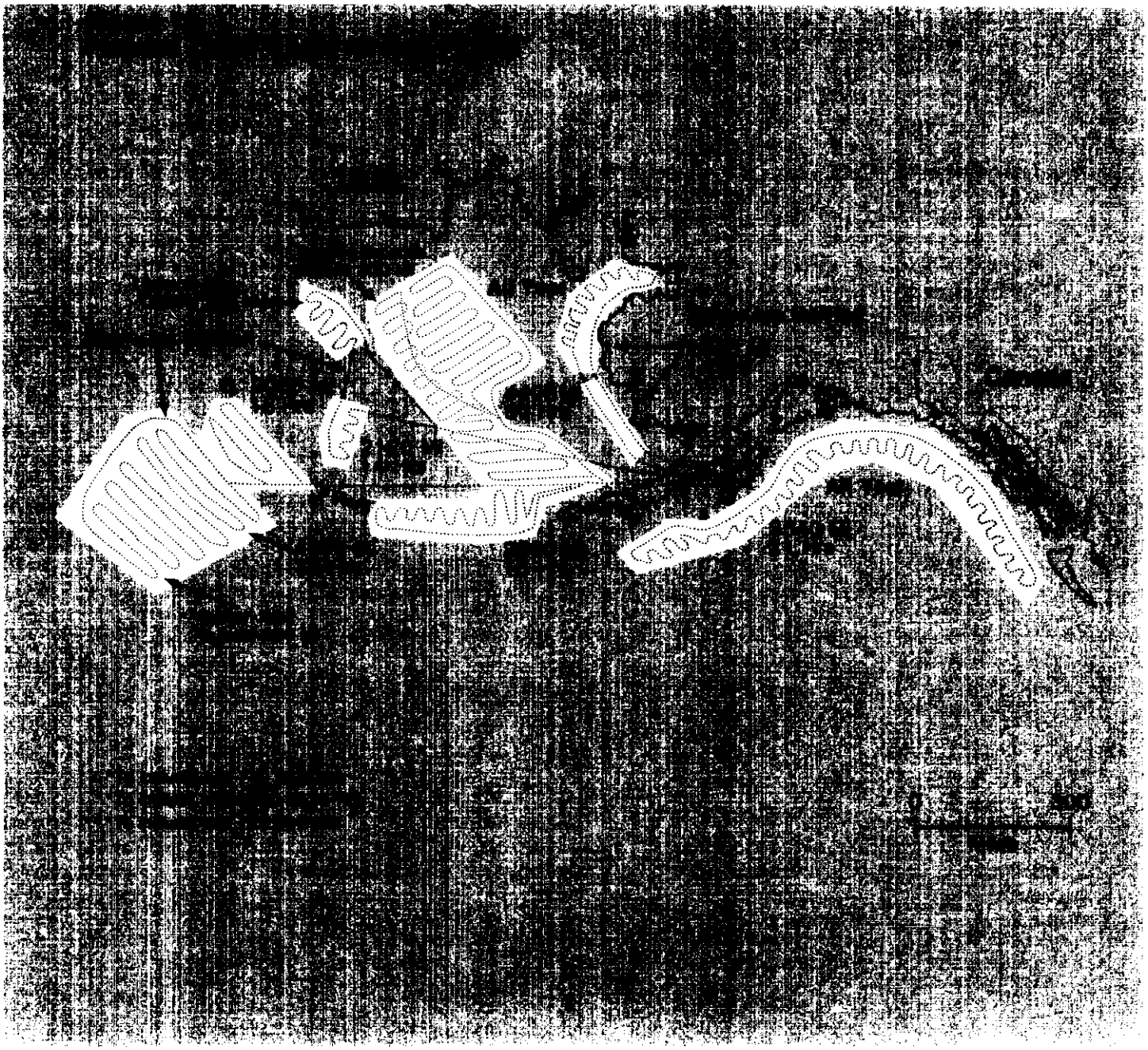
West Coast

Figure 9
Pianned Coast Guard Aircraft Patrols



Source: U.S. Department of Transportation, Coast Guard

Alaska



Source: U.S. Department of Transportation, Coast Guard

On the other hand, there are also many species in danger in the east coast and gulf fisheries. Three new aircraft have been assigned to the New England area and one to the Gulf of Mexico, but it seems reasonable that additional vehicles may be desirable on the east coast in the future even though fishery areas there are concentrated and not greatly increased by the move to the 200-mile jurisdiction.

As outlined by the Coast Guard, the planned enforcement strategy of increasing present capabilities is a reasonable first step. It is flexible in that enforcement resources will be added over a period of time and at a moderate first cost. As experience is gained, additional resources can be curtailed or accelerated if original assumptions do not prove out.

The Coast Guard enforcement strategy is, however, limited to preventing violations by foreign fishermen. Presently, there is no planning within the Coast Guard to deal with possible at-sea violations of the domestic fishery regulations. Only two domestic management plans have been drawn-up so far, but other plans will be a major order-of-business facing the Regional Councils in the future.

In the past, enforcement in the domestic fishery has been carried out by NMFS from shore, where officials observe offloading, weigh and inspect fish, and identify bycatch. NMFS will continue its enforcement of domestic fisheries from shore under the new law. If this dockside effort were to be combined with a program of boarding domestic vessels for inspections, it would probably be sufficient in most situations.

However, if regulations for domestic fisheries duplicate many of the gear and operational controls used in foreign regulations, some at-sea capability will be needed.

In the event an at-sea capability is needed for enforcement in domestic fisheries, the Coast Guard could use the same types of equipment and techniques planned for foreign fisheries, but would need additional facilities in order to cover the different areas used by domestic fishermen and the many additional fishing vessels of a greater variety of sizes and types.

Available information indicates that about 7,000 domestic vessels may spend most of their fishing time in the 3- to 200-mile zone.[28] Although the domestic vessels catch far less than the foreign vessels, domestic fisheries enforcement—in terms of fishing units to be dealt with—is on a larger scale than foreign enforcement. The cost of any deterrence gained by domestic enforcement will also be higher than for foreign enforcement.

The Coast Guard has rightly given priority status to planning for enforcement in foreign fisheries. However, this OTA assessment indicates that at-sea enforcement will also be necessary in domestic fisheries in the near future and planning for such a job should be started as soon as possible." This will be a particularly sensitive enforcement job because fishermen, a politically powerful group, have traditionally enjoyed a great deal of freedom in how they conduct their activities.

Other Possibilities for Near-Term Enforcement

The OTA study of enforcement strategies seems to indicate that several fairly simple techniques which could be activated almost immediately have not been given favorable consideration by the Coast Guard or the National Marine Fisheries Service.

Among these are:

1) the establishment of an efficient reporting system which would allow domestic fishermen to aid in observing foreign fishing vessels,
2) extensive use of observers onboard foreign fishing vessels, and
3) formulation of specific guidelines to be followed in granting annual permits and renewing the Governing International Fisheries Agreements.

The lesser of these strategies is the reporting system, which could be simply a well-defined and published procedure, which domestic fishermen could follow in notifying the Coast Guard by radio with information on the location of foreign vessels or on suspected violations of fisheries regulations.

The Coast Guard is not now planning a reporting system because of concern that it will increase the number of bogus complaints of violations and tax the already limited manpower and facilities of Coast Guard in the area. The Coast Guard argues that if fishermen suspect serious violations, they will-and already do—report these to the nearest Coast Guard facility,

Extensive use of a reporting system may not be likely because many domestic fishermen maintain radio silence in order to protect the location of their fishing areas. Still, it is likely that the lack of formal procedures for reporting may, in the future, cause the same kind of gap in coverage that was demonstrated when fishermen testified to congressional committees that some recent oil spills might have been prevented if fisherman had some system for reporting on the location of foreign tankers which are sited outside of established traffic lanes.[29]

Another minor improvement in enforcement could probably be gained by formulating a detailed list of specific criteria which will be taken into account in renewal of the Governing International Fisheries Agreements (GIFAs) with foreign governments and in annually granting fishery permits to the vessels.

The National Marine and Fisheries Service is now drafting civil procedure regulations which outline the sanctions, such as permit revocation, suspension, or modification, which may be used against violators or

U.S. Navy Photo

Much of the fishing activity is still conducted by hand, such as the job of emptying large nets.

against those countries which have not paid fines and assessments. However, these procedures are not expected to include specific numbers or types of violations which would mandate nonrenewal of GIFAs or nonissuance of permits.

The Coast Guard has indicated that recording violations on the permits of individual fishing vessels may constitute one of the most potent regulatory tools available.[30] A system which works much like the points system used in revocation of drivers licenses and setting insurance rates is probably worth investigating in connection with fisheries permits. Such a system could be used initially in foreign fisheries, but would be equally useful in the domestic fisheries should some form of limited entry be adopted.

Under the law, GIFAs are negotiated by the State Department. However, the State Department has been given no regulatory functions. Therefore, the law may have to be amended in order to charge the State Department with preparing such guidelines for its negotiations or these guidelines could be prepared by NMFS along with guidelines to be considered in granting permits. Without these specific guidelines as to what violations constitute grounds for nonissuance of permits or GIFAs, it is likely that uneven and inefficient use of this potential tool will result.

It appears that the second strategy, the extensive use of observers onboard foreign fishing vessels, could be vital to the success of enforcement in the 200-mile zone.

Current plans call for placing observers onboard 10 to 20 percent of the foreign vessels granted permits to fish in U.S. waters. These observers will be NMFS personnel who will have no enforcement duties. They will be assigned randomly to vessels of foreign nations which in the past have been suspected of giving NMFS incomplete or inaccurate reports on their fishing activity.

The present plan is to place about 20 observers on vessels in the Georges Bank area of the Northeast fisheries and slightly fewer in the Northwest fisheries, primarily Alaska. The National Marine and Fisheries Service has estimated the annual cost of the program at approximately $750,000, The cost per ship, with an observer onboard, may be as high as $15,00031 for a cruise of several weeks. Under the terms of Public Law 94-265, which requires that foreign fishing vessels pay reasonable fees to compensate the United States for expenses incurred in the course of fishery conservation, management, research, administration, and enforcement, costs for observers will be billed to the individual ship carrying the observers. [32]

The cost will probably make little difference to vessels from countries which subsidize their fishermen, However, such a charge may not be taken lightly by fishermen who are independent operators. Since the vessels to carry observers will be chosen randomly within any particular country, levying the charge against the individual vessels may strain relations between foreign fishermen and the observer who must live onboard their vessel for extended lengths of time and make it much more difficult for the observer to gather accurate data. In the interests of easing this relationship, OTA suggests that charges for observers be spread evenly among all the ships in the fishing fleet of a particular nation. The law requires that the fee schedule which sets out charges to foreign fishermen be determined by the Secretary of Commerce in consultation with the Secretary of State.ss Therefore, a revised billing procedure for observer costs could be recommended to Commerce by State based on its negotiations with foreign nations.

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NMFS has used some observers for the past 2 years, primarily on Japanese vessels, and has termed the experience very successful as a tool for collecting information.

From the NMFS viewpoint, the observers are ideal for gathering scientific and management data, The observers could visually examine the rate of fish catch, effectiveness of fishing gear, and types and sizes of fish caught. This is information which will be vital to NMFS and the Regional Councils for use in the formulation of management plans for the foreign fisheries. Yet, none of these jobs can be adequately carried out by surveillance vessels or any of the remote-sensing devices which will be discussed later in this section. For these reasons, much more extensive use should be made of observers, in a dual role:

1) to collect data needed for management of the fisheries and

2) to observe operations for enforcement functions.

Observers could be utilized by the Coast Guard as part of its enforcement network. Among other enforcement-related duties, the observers could:

- verify proper use of specific fishing gear;
- check on bycatch or fish caught incidental to the species sought (In some fisheries more than half of a typical landing is not used and is dumped overboard.);
- communicate actual practices and fishing information quickly to a control center; and
- note violations, notify the Coast Guard, and even personally collect fines.

National Oceanic and Atmospheric Administration Photo

Observers on board fishing vessels may be in the best position to inspect catch for illegally retained species

The Coast Guard has stressed the need for easily enforceable regulations as an important factor in successful enforcement. Aiming toward that goal, the Coast Guard favors a NMFS proposal to reduce most regulations to limitations on the amount of effort expended fishing or the number of days spent in a certain area. Such limitations are next to meaningless, however, because there is no dependable equation for measuring catch rates based on vessel time in an area. Past data used in such calculations haven't been verified. In addition, new technology and improvements in fishing techniques make any equation subject to constant change. Shipboard observers would be in the best position to provide analysis of the relationships between vessel time, fishing effort, and catch rate.

Foreign fishermen will realize that from their view the observer is primarily a policeman. The potential penalties for violations noted by the observer could be high, but the value of an illegal catch may be even higher. Therefore, foreign fishermen may attempt to bribe, harm, or deceive the observers, frustrating their scientific and enforcement functions.

Present thinking at the Coast Guard is that such drawbacks exceed the enforcement value of onboard observers although the observers would be very useful for collecting scientific and management data for NMFS.[34]

OTA research suggests otherwise: a near-blanket program of mandatory shipboard observers may be the simplest way to obtain the detailed information about fishing activities and response to fisheries regulations which will be necessary in developing a dependable, cost-effective enforcement program.

In addition, the Federal Government's failure to implement an extensive observer program will remove from the Regional Councils the option of charging a fee for illegal bycatch. Some council members feel that such a fee, based on actual bycatch figures provided by observers, would be more successful than gear restrictions in reducing the actual amount of bycatch because it would force fishermen to find their own means of not catching fish which cut into their profit. [35]

The observer program is an area in which there are a wide range of opinions among the many parties interested in enforcement of fisheries regulations. However, the limited use of observers to date provides no basis for resolving these differences. A pilot project would offer actual experience on which to evaluate the cost and usefulness of observers in a combined enforcement - information gathering role.

Recommended Pilot Project

The Office of Technology Assessment's analysis suggests that much could be learned from a pilot project in which a foreign fishery is nearly blanketed with shipboard observers who have both management and enforcement duties,

The New England region would be most suitable for such a pilot project for the following reasons:

- The fishing grounds are concentrated and foreign fishing practices are well known.
- Many of the foreign vessels fish in groups which could simplify the arrangement of vessels with observers and control vessels without observers.
- The stocks in that region are generally depleted and information for use in restoring stocks is badly needed.
- Questions about bycatch are most significant in the area.
- There are important problems with gear restrictions and gear conflicts in the area.

About 150 foreign vessels, on the average, have traditionally fished within the 200-mile zone off New England. At this writing, the number of permit applications which had been received suggested that this number will probably go down because of the 1977 catch allocations. Therefore, it appears that a total of about 100 shipboard observers would be suitable for the pilot project. These observers should be selected on the basis of experience in fishing practice and knowledge of fishery matters. If they are given enforcement duties, they should be Coast Guard personnel, instead of NMFS personnel. However, they should receive some training from NMFS in observing, collecting, and reporting information of value. Some familiarity with the nation on whose vessel the observer serves would also be helpful.

Based on NMFS estimates for their limited-observer program, the cost of a 100-man pilot program would be roughly $2 million plus funds for an accurate evaluation of the pilot.[36]

Under the law, this cost is passed on to the foreign vessels. However, other fees and charges are also levied, under the law, to reimburse the United States for management and enforcement activities in the 200-mile zone. Since the observer program would presumably make some other expenditures covered by these levies unnecessary, the gross tonnage-fee or tax on ex-vessel value of the catch could be reduced accordingly.

Possibilities for Long-Range Enforcement

It is likely that the proposed near-term enforcement capabilities described earlier will not be adequate for long-range demands. Factors like the following may contribute to the need for more sophisticated enforcement tools:

- Individual Regional Fishery Management Councils are likely to develop some unique regulations which demand more knowledge of vessel locations;
- Developments in technology may result in more efficient and effective equipment, for instance, land-based electronics systems could supplant some aircraft flights;
- There may be pressures for increased foreign fishing off our shores, such that the value of illegal fish could exceed the cost of being apprehended;
- Scientific data might reveal a greater danger to fishery resources than is presently realized or danger to resources in new areas not now covered;
- The costs of traditional enforcement may grow to a level that could not be easily justified in terms of resources conserved.

Such factors as these lead to the conclusion that plans should be made for further improvements in enforcement capabilities by use of remote-sensing devices and other advanced technology.

It is probably in the national interest to actively plan and pursue interagency use of some of these new technologies, especially those in which there already has been significant investment in development. However, it is unlikely that military agencies which now have such advanced technology will volunteer or be receptive to suggestions that they share their capabilities for use in enforcing fishery regulations.

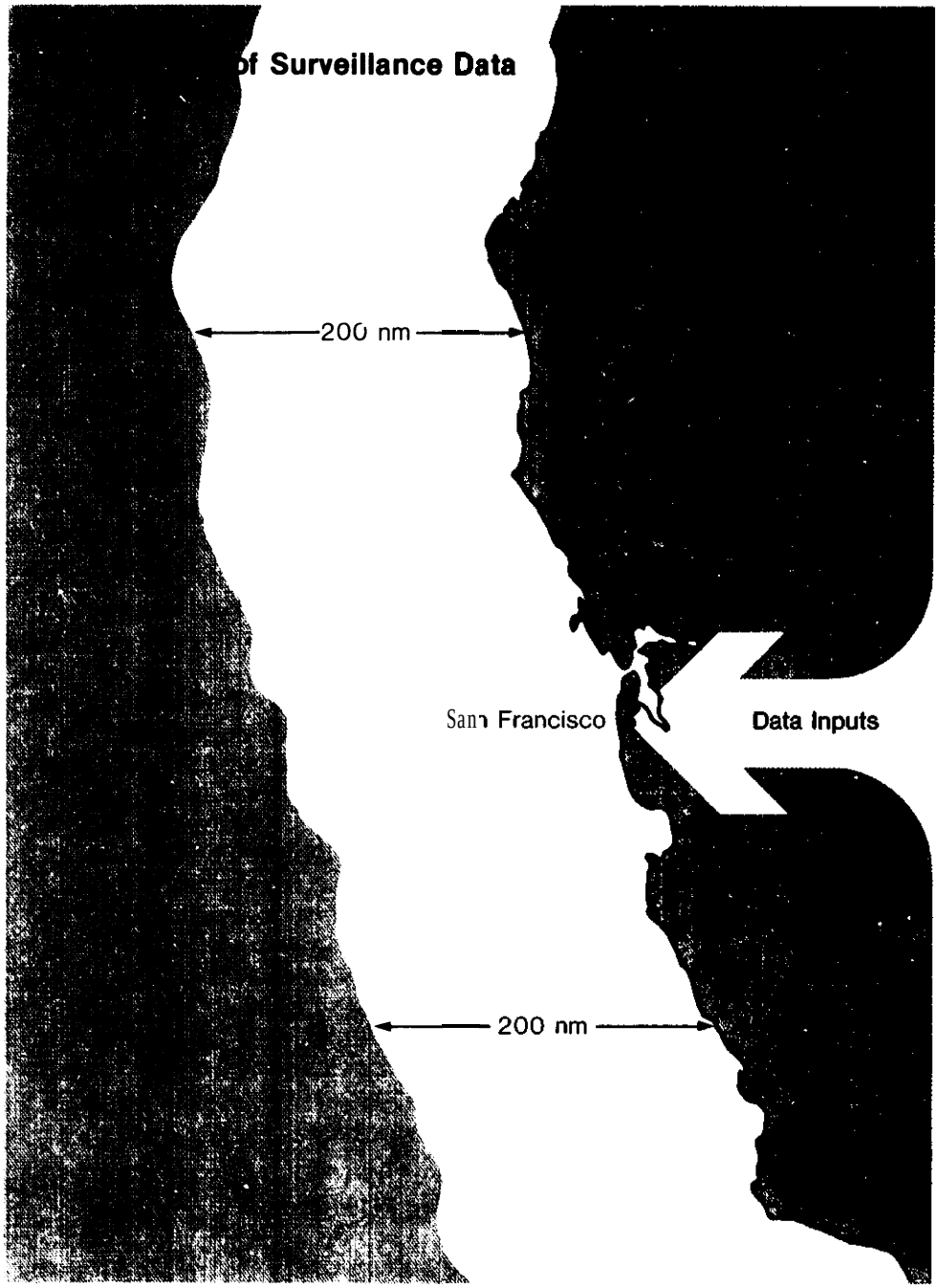
In addition to the fact that such equipment is dedicated to military application and reportedly already heavily used, it would be necessary to develop a fast and efficient clearinghouse for processing and distributing information from the sensors before joint use of sensing equipment would be possible. The military has already developed specialized systems for correlating information from many sensors; however, these systems are crowded and translation of fisheries data would receive low-priority treatment.

It may be desirable to pursue the development of new facilities which could receive data from many sources, including such groups as the military, Bureau of Customs, NMFS, Coast Guard, and State and Federal law enforcement networks. This facility could correlate data, protecting classified or privileged information if necessary, and display all maritime activity, including that of fishing vessels[37] (see figure 11).

Such a data correlation and display center for coverage of the complete fishing zone would be costly, but it could also provide information on oil tankers, commercial cargo carriers, surveillance for search and rescue missions, and other similar activities. The Office of Technology Assessment's Working Paper No. 5, which discusses such a facility, estimates the initial set-up cost at $1.5 million for a correlation facility to receive the information. Computer time would cost at least $14,000 a month for operation of the facility. Expense to the Coast Guard for installation of hardware compatible with the correlation facility and operation of Coast Guard functions would be an additional cost which has not been determined.

Recommended Pilot Project

OTA proposes a pilot program utilizing one of the existing military systems for the collec-



Routine

- **Amver**
- **Fit. Weather**
- **Port Data, VTS**
- **USCG Ships, Aircraft**

Special

- **NOSIC (Naval Ocean Surveillance Information Center)**
- **HF/DF (High Frequency/Direction Finding)**
- **Dept. of Motor Vehicles Computer**
- **U.S. Customs Computer**
- **U.S. Treasury Dept. Computer**
- **Federal/State Law Enforcement Networks**

Source: Lockheed Corp.

tion and transfer of available surveillance data for one specific region. Some precedent for such a project already exists at the Naval Ocean Surveillance Information Center where the Coast Guard has recently detailed one officer to work on data which are of interest to the Coast Guard and have not, in the past, been processed by Navy personnel.[38]

The Office of Technology Assessment has not investigated the feasibility of using a specific system in any region, but it appears that the Navy's west coast network could be a likely pilot region. Any pilot project should begin with an indepth investigation of the Navy's existing system and its ability to provide information needed for fisheries enforcement.

Some funding would be necessary to add personnel who would coordinate the transfer of fisheries-related data from the Navy to the Coast Guard district in charge of fisheries enforcement in that zone.

After a period of operation, the pilot project should be evaluated with special attention to determining the completeness of coverage provided, the cost, the timeliness and usefulness of data provided, and a comparison of this method with other methods of surveillance.

On one hand, there may be difficulties in working with and protecting classified information and there may be a danger that this extra task might not receive adequate attention in a facility oriented to an existing military mission. However, such an information-sharing program could ultimately cut costs substantially by reducing duplication of effort and facilities. It could also provide cooperative experience which might lead to sharing of other services and resources needed for enforcement and the opportunity to evaluate new technology which may be of use in fisheries enforcement.

Use of new technology, particularly remote-sensing devices, may make it possible to improve enforcement of fisheries regulations in the future by better coverage, better performance, and a reduction of the need for expanding conventional ship and aircraft patrols. Although it may be possible for several agencies (such as the Coast Guard, the military, and NASA) to share the cost of new remote-sensing devices, these systems are extremely expensive and their use should be thoroughly evaluated before any one system is adopted. Any analysis of benefits and costs of remote-sensing systems should not *ignore* the argument that national security could be compromised by making some of these systems available for other than military missions. Most of the security risks and financial costs of remote-sensing systems could be considered now; however, a clear analysis of the benefits or improvements that could result from the use of such new technology is not possible until overall strategies of enforcement and specific regulations are defined. When these strategies and regulations have been drawn up, it will be desirable to prepare a long-range plan; for example, a 5- to 10-year plan that would include specific analysis of the introduction of new technologies and techniques into enforcement plans.

The Coast Guard is presently in the process of formulating a research and development program for future enforcement of fisheries laws.[39] Such a program could make good use of an improved version of the existing computer model or a new model such as the one suggested in an earlier section for joint preparation by NOAA and the Coast Guard. The research program is expected to include plans for studying hardware and procedures for improving monitoring and surveillance, communications, data integration and analysis, and general operations.

At present, the research and development program is directed toward bringing new enforcement technology into use in 10 years or more. It could be possible, however, to accelerate the applied development of new technology for which most of the research has already been completed by others so that it could meet some Coast Guard needs in about 5 years.

Because the budget for fisheries enforcement is only a small part of the overall Coast Guard budget (about $50 million out of $1.2 billion), the agency has determined that research funds in support of such enforcement can best be spent for technology transfer and for additions to related research contracts in other agencies.[40]

The Coast Guard is also following developments in the Department of Defense where much of the work on technology which may be applicable to long-term fisheries enforcement is classified.

If conservation and management of the 200-mile fisheries zone is judged to have value to the United States beyond the present monetary value of fisheries-related products and employment, support for increased research at the Coast Guard level may be warranted. Further research should include determination of the best methods of utilizing classified systems for other than defense purposes.

It appears that a pilot project for cooperation and joint research could bring together the Coast Guard, DOD, and NASA to develop new systems and find efficient ways of using technology in a multimission context. Such a pilot project could include joint preparation of long-range plans for determining the most appropriate research and development strategy for new technologies, identifying the needs of all potential users of such technology, and analyzing the costs and benefits of developing and utilizing new technology, especially remote-sensing devices.

Remote-Sensing Devices

Since it appears that remote sensing will be an important enforcement tool as fisheries management develops, OTA commissioned a study of the technology of such systems. The following is a brief summary of the OTA study of remote-sensing devices and findings relative to the remote-sensing techniques which were analyzed for potential usefulness in fisheries enforcement. Figure 12 compares the various techniques for usefulness and cost.

Of the seven devices studied, microwave radar appears to have the best potential for use in fisheries enforcement. High-frequency, over-the-horizon radar was also judged to have good potential, but is not as highly developed for commercial application as microwave radar. Other remote-sensing systems in this group appear to have only limited fisheries application at this time.

Because of the sensitive nature of much of the remote-sensing technology, OTA has also prepared a separate classified document on these systems.

By definition, remote sensing includes any method of obtaining information about an object from a distance without any physical connection to the object. It must be remembered that remote sensing is a detection and identification tool only; it is not useful in apprehension.

For purposes of this study, research personnel with broad knowledge and experience in remote sensing have analyzed potential techniques for use in fishery enforcement and have determined that some of these techniques can be applied to fishery enforcement without resorting to the kind of high-priority, high-cost research and development used in defense and space exploration programs.

Based on past experience and based on Navy and Coast Guard ocean surveillance functions, it is likely that a combination of sensors may be required to maintain an adequate picture of activity. When properly correlated and analyzed, information from visual, radio, and radar sensors can provide a picture that is much more complete and of greater validity than could be provided by any one or a few sensor systems. Ultimately, the problems of patrolling a 200-mile fishing zone may require the acquisition, correlation, and analysis of multisensory data.

The Department of Defense is the principal developer and user of most of the remote-sensing technology which may be applicable to the fisheries enforcement problem. To a lesser extent, the National Aeronautics and Space Administration and the Federal Aviation Administration are also developers and users of new sensing technology. The Coast Guard is now working with these other agencies to determine what technologies would be suitable and how they could be utilized in fisheries enforcement.

Transponders

A transponder is an active beacon which can be used in conjunction with radar or other electronic transmission system to enhance the detection and location of foreign fishing vessels. The transponder transmits energy on the same frequency as the radar signal, but at a level several times higher than that which would result from unaided reflection of the signal.

Some transponders can be hooked into Loran–C receivers. Loran–C is a navigational aid by which the location of a vessel is automatically pinpointed by triangulation, using continuous signals from two shorebased stations at known locations. After the location is identified by Loran–C, the information is passed to the transponder which retransmits it, along with the vessel's identification, to a control station. These systems have good future potential for use in fisheries enforcement as an extension of patrols by cutters and aircraft.

Transponders can be built that emit a standard, preset signal or that respond to interrogation by a remote-sensing device by transmitting a wide variety of identification and fishing status information. The sophistication of transponders is limited primarily by cost considerations. However, the state-of-the-art in transponders is advancing rapidly, due largely to advances in digital storage and processing technology, so that improved performance at lower cost is possible in the future. From a fisheries enforcement standpoint, the major drawback of most transponders is that cooperation on the part of the vessel fitted with the transponder is required. A transponder that simply enhances detection or supplies a preprogrammed identification and location signal can operate independently on any input from the target, but to supply additional information such as fishing status or catch data the vessel must provide the information to be transmitted. Guaranteeing that such input would be provided or that input would be accurate could prove to be a serious problem, In addition, since such transponders could only be placed aboard vessels which had permits to fish, they would do nothing in identifying vessels which had illegally entered an area without permit status.

It has been suggested that in lieu of requiring transponders on foreign fishing vessels, such devices could be supplied to domestic fishing craft to emit a signal that would immediately identify them as ships with which the enforcement agency need not be concerned.

Figure 12
Summary of the Potential of Remote-Sensing Technology To Support Enforcement of the 200-nmi Fishing Zone

Technology	Overall Potential	Detection of Design Target	
		Unaided	Beacon-Assisted
Microwave Radar	Excellent	Detection to 200 nmi from Aircraft; Some Sea Clutter Limitations; Position Accuracy<5 nmi	Detection to>200 nmi from Aircraft; No Sea Clutter Limitations; Position Accuracy Accuracy<2 nmi
HF Over-the-Horizon Radar	Good	Classified	
Microwave Radiometry	Limited	Detection to ~10 kft; all weather Except in Extremely Heavy Rain; Position Accuracy, Relative to Platform, 1 to 10 ft	Beacon Detection to Line of Sight
Optics and Electro-optices	Limited	Line of Sight Limited; Subject to Cloud and Fog Obscuration (Day Visual/ Night LWIR.) Data Subject to Excessive Clutter and Ambiguity Due to Cloud and Sea State; Beacon Assist Gives Only Marginal Improvement	
Electromagnetic Intercept	Limited	Method Inherently Uses Target Transmissions as Beacon. Detection Limited Only by Propagation and Interference Conditions. Bearing Accuracy ~1°; Position Accuracy by Triangulation Limited by Hearing Accuracy and GDOP to Errors ≥ a Few Miles.	
Magnetic	Negligible	Extremely Short Range	Not Applicable
Acoustic	Limited	Classified	

Source: Stanford Research Institute

The Coast Guard has a research program underway to develop prototype transponder equipment. The Loran–C system is one of several alternatives being considered.[41] The Coast Guard is also following related hardware-development projects within other agencies, such as the Navy, and has added some of its needs to research contracts already underway in other agencies. [42]

As the lead agency in developing transponder technology for use in fisheries enforcement, the Coast Guard is seeking to determine the specific contributions that can be made by existing equipment and to develop small, tamper-proof packaging for transponders to be placed on foreign vessels.

Estimates are that a minimum of 2-years work will be necessary before a suitable

Figure 12 (continued)
Summary of the Potentiai of Remote-sensing Technology To Support Enforcement of the 200 nmi Fishing Zone

Classification Capability					Rough Cost Estimates ($ thousands)	
Fishing Vessel?	Foreign Fishing Vessel'	Fishing?	Permit?	Catch?	Initial	Yearly Operating
Beacon Required	Coded Beacon Required	Cooperative Transponder Required			250-500 Per Aircraft*	Principality Aircraft Operating Costs (1 ,000-1,600 per A/C)
Beacon Required	*Coded* Beacon Required	Cooperative Transponder Required			48,000 for Complete Coverage*	1,800 for Complete Coverage
Beacon Required	Coded Beacon Required	No Capability	No Capability	No Capability	100-200 Per Aircraft*	10% of Aircraft Operating Costs
Good; Requires low- to Medium-Altitude Approach	Fair; Requires Very Low-Altitude Approach	Good, with Direct Tele-Photo Inspection	Cooperative Transponder Required	Fair, if Catch Visible on Deck	10-500 Per Aircraft	10% of Aircraft Operating Costs
Limited; Requires Target Cooperation	Limited; Requires Target Cooperation	Cooperative Transmission Required			125 Per Station	110 Per Station
No Capability	No Capability	No Capability	No Capability	No Capability	N/A	N/A
Beacon Required	Coded Beacon Required	Cooperative Transmission Required			Classified	Classified

● NOTE: Beacons or transponders on each fishing vessel would be in addition to the above and cost $500 to $2,500 per vessel.

Source: OTA

system can be put onboard foreign vessels and that as much as 7 years may be required before an ideal system with the best long-term application is devised.[43]

Recommended Pilot Program. —The Office of Technology Assessment suggests early implementation of a pilot program utilizing transponders in two specific regions—the Bering Sea off the coast of Alaska and Georges Bank off the New England coast. Since each of these areas is a traditional fishing ground, but with very different prevailing conditions, the usefulness of transponders could be evaluated for a broad range of applications by this pilot program.

The pilot programs would require the design and manufacture of Loran–C transponder equipment specifically for this pur-

pose. The Loran–C network is now planned or in operation in the regions proposed. A licensing arrangement and installation technique for fitting transponders on each foreign fishing vessel entitled to fish in the region would need to be devised, Control stations and receivers on patrol ships or aircraft would need to be installed.

It is estimated that the transponder which would go onboard each foreign vessel would cost less than $2,500. Once the system were installed, operational costs would be roughly equivalent to the operational cost of the aircraft carrying each control station, $1 million to $1.6 million annually. Funds for evaluating the pilot project would be in addition to these costs.

The Georges Bank pilot program would require about 150 transponder units and a control station most likely at a Coast Guard shore base in New England. Each vessel entering the 200-mile zone at Georges Bank for fishing would be required to activate its transponder which would automatically transmit identification and location to the shore base. The shore base would keep plots of all foreign fishing activity on the banks and give this to patrol craft. Regular patrols of the region would use this information to check on any fishing activity that wasn't reported by this system. At the end of one season, an evaluation of the usefulness of this system could be made.

In the Bering Sea region a similar network of transponders could be required aboard foreign fishing vessels, In this region it may be desirable to combine the transponder network with microwave radar systems already used aboard Coast Guard patrol aircraft and receiving stations. In this way a specific region could be covered by regular overflight, all vessels operating in the region located by radar, each vessel interrogated to determine whether an approved transponder is aboard stating ID and location, and any vessels without transponders investigated.[44] There are several advantages to a system thus described, especially in Alaska where long distances and large areas can best be covered by aircraft and where frequent cloud cover makes visual observation difficult or impossible. After a season of operations with such a system a comparative evaluation of its usefulness would determine whether it could be beneficial to expand use or coverage.

Microwave Radar[45]

Microwave radar has been used for ocean surveillance by aircraft and ships for almost 40 years. The technology is highly developed and the design principles are so well known that it is possible to predict with high confidence the performance of any given design chosen for use. Microwave radar has better potential for large area coverage than any other system now in use.

Microwave radar operates by transmitting pulses of energy from a directional antenna, The pulses are reflected by any material object encountered. The reflected energy is subsequently received and analyzed to determine the position and characteristics of the reflecting objects. The direction of the objects can be determined by tracking the reflected signals and the distance is determined by measuring the time delay from pulse transmission to reception of the reflected signal.

The basic information for fisheries enforcement which can be supplied by microwave radar is:

- the presence or absence of a vessel in a given area;

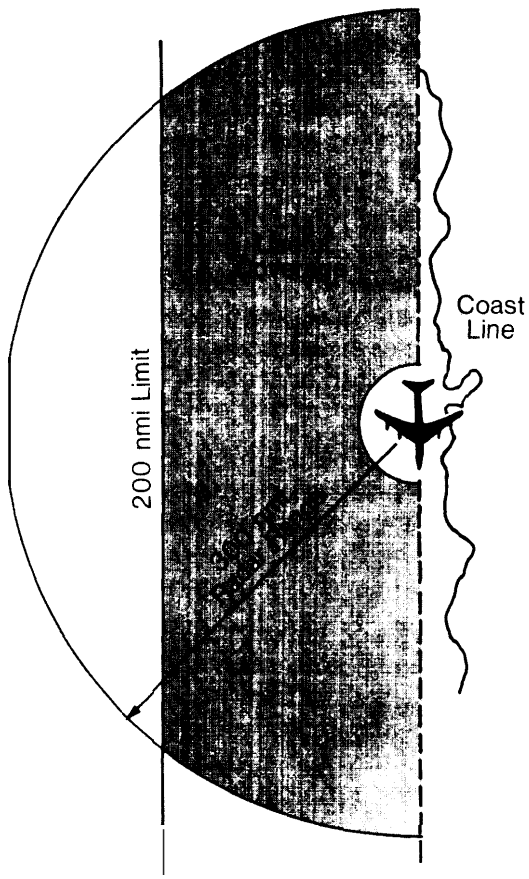
- the position of a detected ship at a given point in time;
- course and speed of a vessel when a series of position updates are available; and
- estimates of gross shape and size.

However, microwave radar by itself has almost no potential to classify vessels by type, nationality, or operation. Some classification may be possible by continuous tracking to establish movement patterns, but microwave radar's primary contribution to classification is in guiding patrol ships or aircraft to a position where identification can be made by visual means. Detection of fishing vessels by radar is enhanced, and identification and classification made possible, by adding transponders onboard permitted foreign fishing vessels.

Any modern commercial or military shipboard radar can easily detect fishing boats at a distance of up to 12- to 18-nautical miles (nmi), Existing ground-based, surface-search radars, such as the sea surveillance radars developed for the Pacific Missile Test Center by the Navy Electronics Laboratory Center, can detect fishing vessels at a distance of up to 40 nmi from the land base. These systems are already in use by the Coast Guard which has some of the best available equipment.

The opportunities for improving the use of microwave radar lay in the use of more advanced radar systems from aircraft or satellites and the addition of transponders onboard fishing vessels in order to exploit the information-gathering potential of the combination. It is estimated that a single aircraft with radar could patrol the west coast out to and beyond the 200-mile fishing zone once every 4 hours (see figure 13), For satellite surveillance, the National Aeronautics and Space Administration (NASA) has estimated that twice daily imaging of the entire U.S. fishery zone could be provided by eight satellites.

Figure 13
Useful Surveillance Coverage by a State-of-the-Art Microwave Radar on a 70-kft Altitude Aircraft



Source: Stanford Research Institute

Microwave radar technology operated from satellites is being developed by the Department of Defense and NASA and mav be available within 10 years, The system has the potential to supplement or supplant airborne

radar, but the cost would be high and probably would have to be shared by several agencies.

Over-the-Horizon Radar[46]

Use of over-the-horizon radar (OTHR) techniques would allow detection of fishing boats at much greater distances and would allow coverage of much larger areas than those covered by microwave radar.

This is because remote sensing using signals in the microwave and other very high frequency ranges is constrained by the essentially line-of-sight nature of the signal. For all practical purposes, this means that the sensors must be elevated in order to operate over significant distances.

The use of over-the-horizon radar reduces this constraint by making use of signals in the high frequency range in which energy waves are refracted by the atmosphere or ionosphere to follow the curvature of the earth.

High frequency energy has been used for communications since the earliest days of radio. The technology for generation, transmission, and reception of high frequency energy is well developed and the effects of the atmosphere and ionosphere on the signals are well understood. However, some aspects of using high frequency signals are not so well understood. Among these are the reflection characteristics of material objects at high frequency, Means of concentrating and coding high frequency transmissions to enhance radar operation and the processing of radar returns in order to extract more information about the object detected also are still being developed.

OTHR has been developed primarily for military use and several experimental systems, capable of performing a number of useful functions, have been built by the Naval Research Laboratory, the National Oceanic and Atmospheric Administration, and other groups.

Two types of OTHR might be useful in fishcries enforcement, a skywave mode and a groundwave mode:

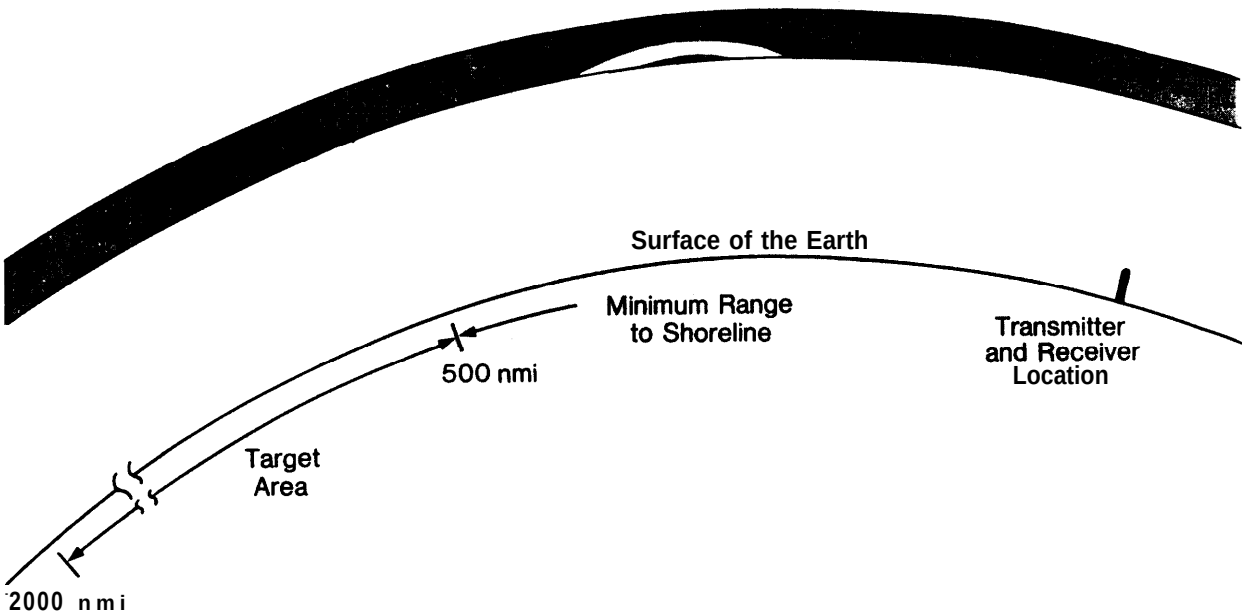
Skywave OTHR takes advantage of the refractive property of the ionosphere, which causes the radar to curve back to earth at distances ranging from 500 to 2,000 nmi (see figure 14). Thus wide area coverage is possible from a single site. For instance, a single skywave OTHR located in Utah could provide surveillance coverage over the entire Pacific Coast (see figure 15).

Groundwave OTHR, in which radio energy travels along the curved earth surface, provides much more limited coverage, but may be useful in specific regions. Groundwave OTHR has an operational radius of a few hundred miles. Thus, while ships out to and beyond the 200-mile zone could be detected from a shore station, many stations would be required to cover the entire coast.

Both systems can provide continuous surveillance of very large areas so that the general location of all fishing boats of at least a certain minimum size can be monitored on a full-time basis. If transponders are installed on the boats, detection can be enhanced and other useful information can be obtained,

Because of their capability to cover greater distances and larger areas, OTHR techniques have good potential for use in fisheries enforcement. However, due to both the classified

Figure 14
Over-the-Horizon Radar



Source: Stanford Research Institute

nature of most of the military work in the field and the high cost of OTHR, use of this system will be contingent upon close cooperation between the Department of Defense (DOD) and the Coast Guard,

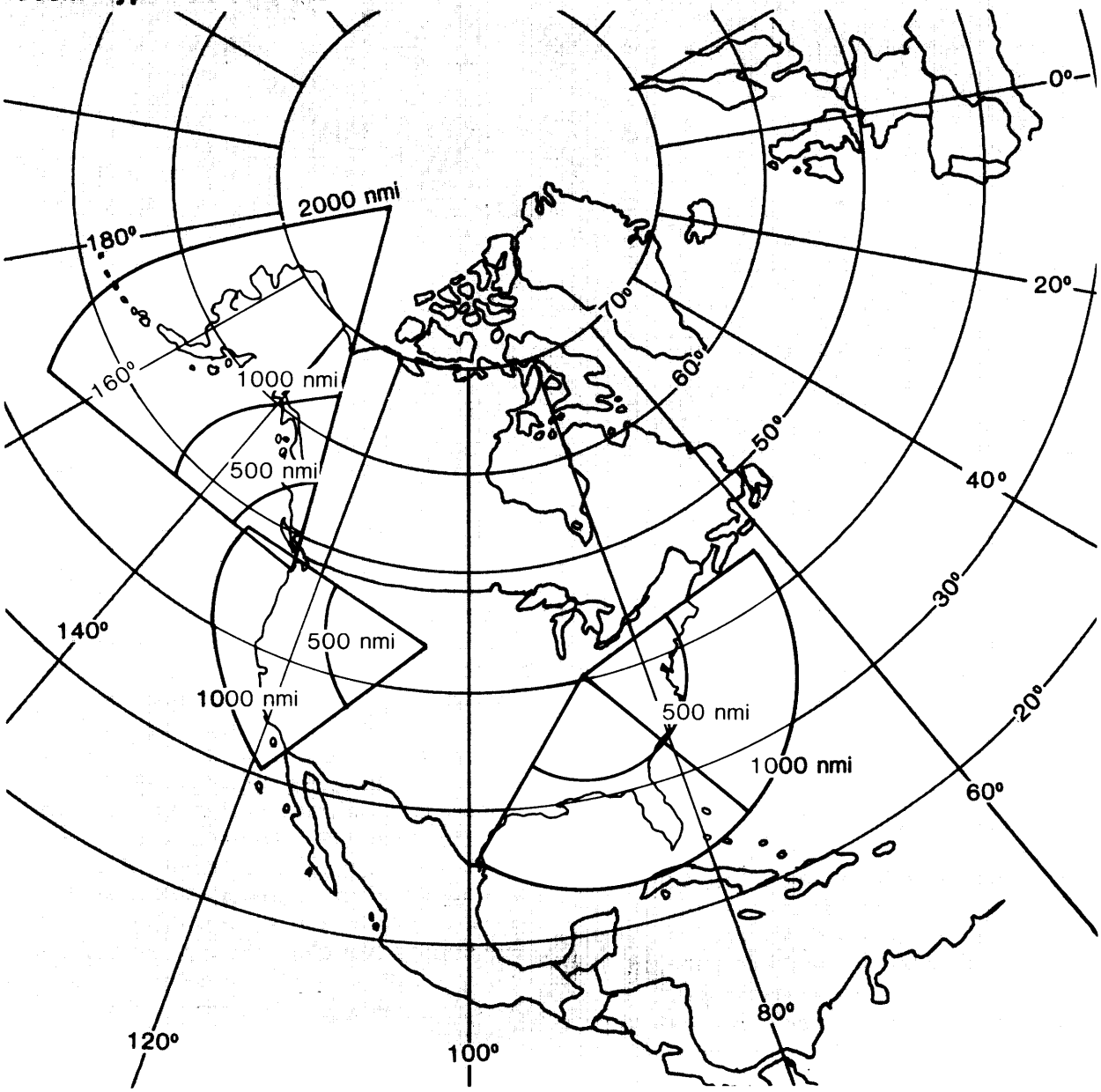
Microwave Radiometry[47]

Microwave radiometers operating alone offer very little promise as a means of identifying fishing vessels or their catch. However, if combined with transponders onboard ship, they are a promising system which would locate, identify, and classify ships in almost any weather, day or night and provide other data on sea state, sea ice, and rainfall rates as well.

A radiometer is merely a sensitive detector which receives and measures the brightness temperature of microwave energy naturally emitted and reflected by surfaces. Detection of a ship is possible because the microwave energy thus reflected by a ship is different than that of the surrounding ocean. A wooden ship appears radiometrically "warmer" and a steel ship "cooler" than the ocean. It is an entirely passive system, as opposed to active techniques which measure the reflection of signals which have been transmitted by radar. One of the advantages of the passive system is that it allows surveillance without radiation, therefore, the target does not know it is being observed.

Microwave radiometers have been used routinely in satellites to measure whether con-

Figure 15
Over-the-Horizon Radar Coverage
From Hypothetical Stations



Source: Stanford Research Institute

ditions and airborne radiometers have been successful in mapping weather fronts and sea states. Radiometric measurement of oil spills have been made with limited success and radiometers have been frequently suggested for use in missile terminal guidance systems.

Although there do not appear to be any operational systems at present that are specifically designed for detection of ships, such systems have been studied and prototypes have been tested. The existing technology is more than adequate for the detection of fishing vessels.

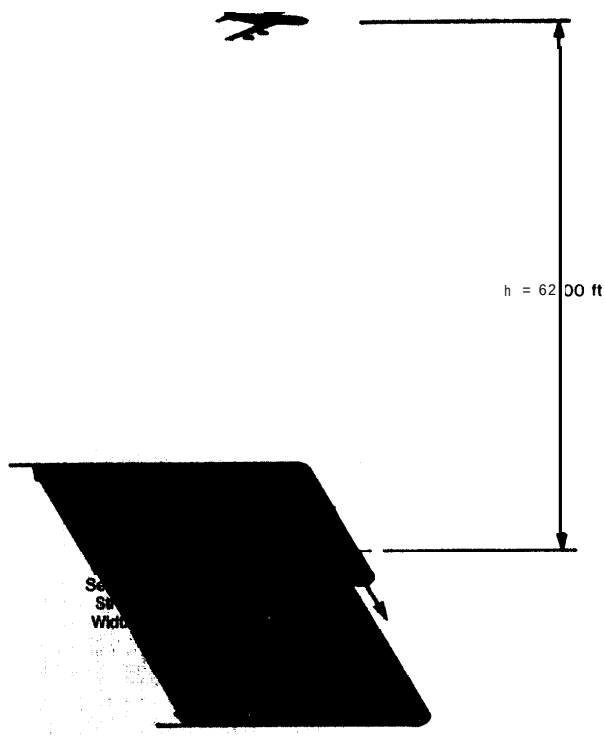
However, constraints on maximum frequency and the detectability of relatively small ships severely restrict the height from which a radiometer can effectively operate. Satellites could not be used for radiometer detection of fishing vessels, and aircraft would be limited at altitudes of about 6,000 feet. At that altitude fishing vessels could be located to within 2,000 feet in range and 2 degrees in bearing (see figure 16).

Optical and Electro-Optical Techniques[48]

With existing technology a variety of optical and electro-optical sensors can be built which could perform many useful functions in enforcement of the 200-mile fishery zone.

This category of sensors includes the traditional visual, aided visual, and photographic techniques—ranging from the human eye to electronically augmented viewing systems and film cameras--and the more sophisticated, recently developed methods of electro-optics such as low-light-level television and infrared or thermal mapping systems. These systems are likely to play supporting or auxiliary, rather than primary roles, in enforcement.

Figure 16
Airborne Scanning Microwave Radiometer



Source: Stanford Research Institute

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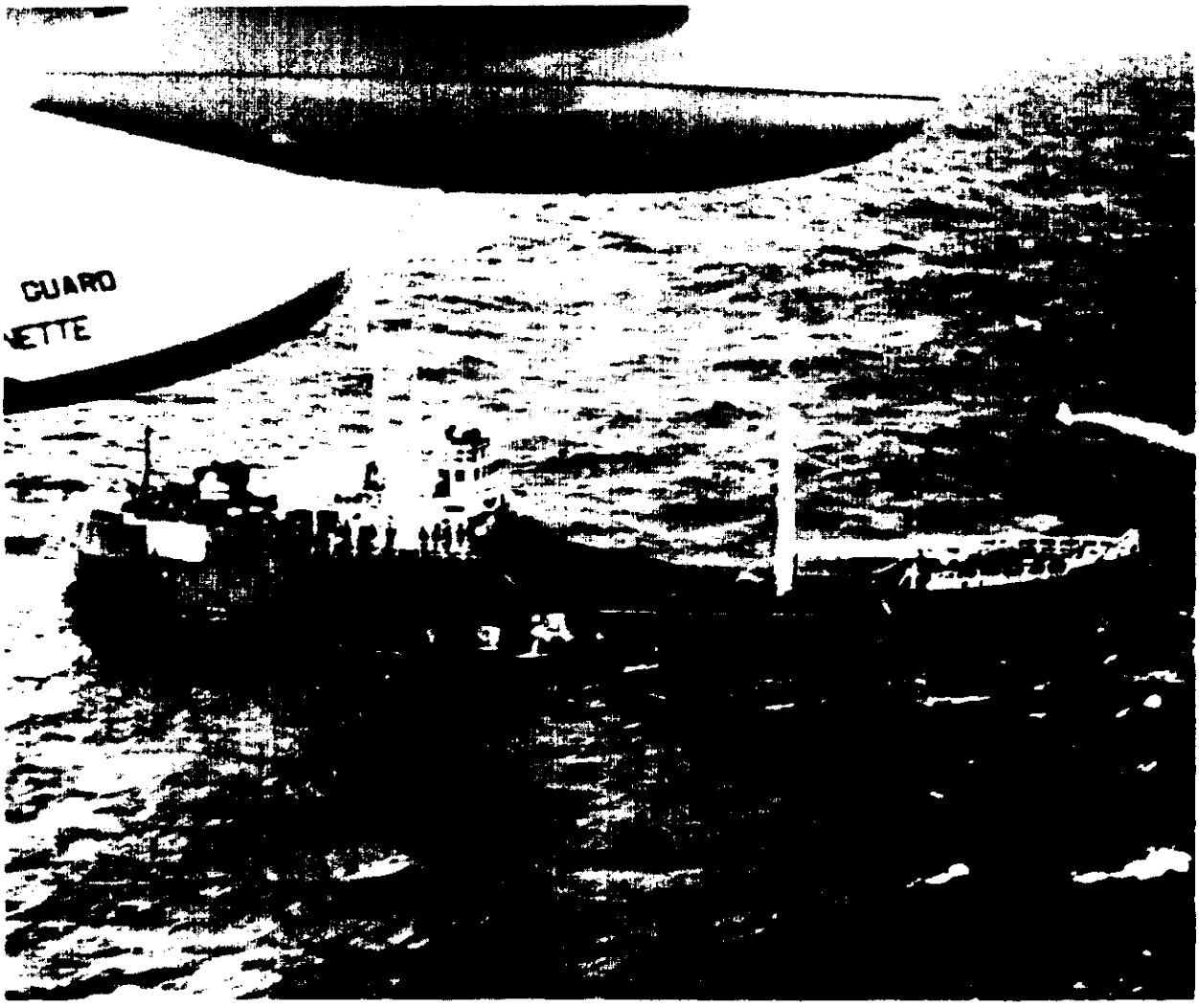
Optical detection and surveillance systems can be operated from satellites, aircraft, or ships. The combination of timeliness of coverage and operational economics makes aircraft seem the most useful surveillance craft for the near future, with some data being derived from existing or projected satellites, and with final follow-up performed by surface vessel.

One of the major problems of optical sensors is the processing and handling of raw-data output. Photographic film requires chemical development, usually at the end of a reconnaissance mission (that is, when the aircraft lands or ejected film capsules have been retrieved from satellites). In some cases, film from aircraft can be rapid processed in flight to allow for examination or data



U.S. Coast Guard Photo

Coast Guard surveillance aircraft can be used for visual observation of the fishing grounds, facilitating detection and identification of foreign vessels

transmission within minutes, for immediate interpretation of close-up photography. But images from long-range, high-altitude satellites need more extensive and detailed examination, often requiring several hours or even days by expert photo-interpreters before useful, specific data are developed. Most of the electro-optical systems can provide realtime outputs capable of immediate display and examination in the form of electrical signals readily amenable to interpretation or transmission to a shore-based facility.

Optical and electro-optical techniques vary widely and the choice of specific systems would depend on the enforcement strategies chosen.

Electromagnetic Intercept Techniques[49]

Because all ocean-going vessels are already equipped with radio equipment and most with navigational radar, it is possible to detect and classify foreign fishing vessels by intercepting and analyzing their radio or radar emissions.

Two techniques have potential in fisheries enforcement activities: the use of direction finding equipment to determine the position of detected vessels and the use of information from the intercepted transmissions to identify and classify the vessel.

The technology for both direction-finding and communications interception and analysis is highly developed and numerous systems have been developed for both military and civilian use. These systems can be operated from shore bases, ships, aircraft, or satellites. At high frequencies intercept is not limited to, but does work best, within line-of-sight of the detected vessel. An aircraft moving at 300 knots could have line-of-sight access to 200,000 square miles of sea surface per hour.

In the past, direction-finding equipment was used primarily for location of aircraft and ships in distress. Currently, however, it is in use largely for monitoring and surveillance. The Federal Communications Commission maintains a network to locate illegal radio transmitters and sources of radio interference; the Department of Defense operates several networks for surveillance and intelligence data collection.

It is possible that some signal intercept information from DOD files can be made available to the Coast Guard for fishery enforcement, However, most of the DOD operations are mission-oriented and are flown in areas of military interest, therefore it is unlikely much time is spent tracking fishing fleets. The feasibility of assigning military aircraft for fishery patrols would be expensive and would have to be worked out with DOD.

The Coast Guard could supply personnel to sort out fishery information collected by DOD or an entire direction-finding station could be dedicated to Coast Guard fisheries work. Because of the security implications of much of the data handled by DOD facilities, such coordination may prove difficult.

Magnetic Techniques[50]

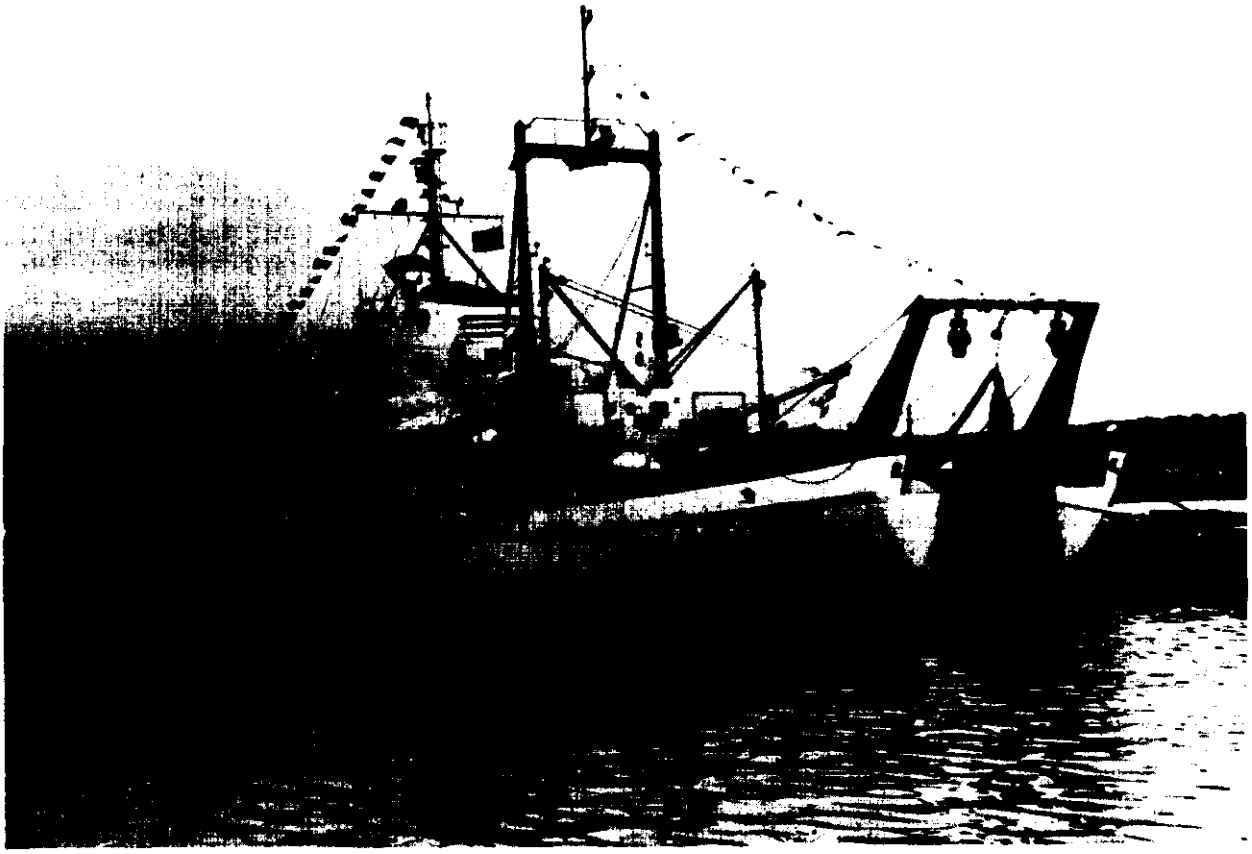
Magnetic anomaly detector systems have been built and used for the detection of submarines and there is no reason why they would not be equally successful in detecting fishing vessels. The systems operate by detecting local changes in the direction and strength of the earth's magnetic field caused by any object, such as a steel-hulled vessel, with mag-

netic properties. However, because detection is possible only at a much shorter range than with radar or visual systems and because no classification of vessels is possible, magnetic techniques presently have little potential for use in fisheries enforcement.

Acoustic Techniques[51]

Detection and classification of fishing vessels by use of acoustic techniques is possible because the technology for the generation, transmission, and reception of acoustic energy is well established and the factors that influence acoustics in the ocean and atmosphere are well known.

The use of acoustic techniques for the detection of fishing vessels can be extrapolated from the Navy's experience in submarine detection. However, new equipment and new methods of use would have to be developed. Since most of the existing acoustic systems are highly classified it is not possible to describe them, except to say the equipment is very complex and costly to operate. Much development would be needed to determine the usefulness of these systems for fisheries law enforcement.



OTA Photo

Oceanographic vessels, such as the Albatross II of Woods Hole, will be used in some fisheries research