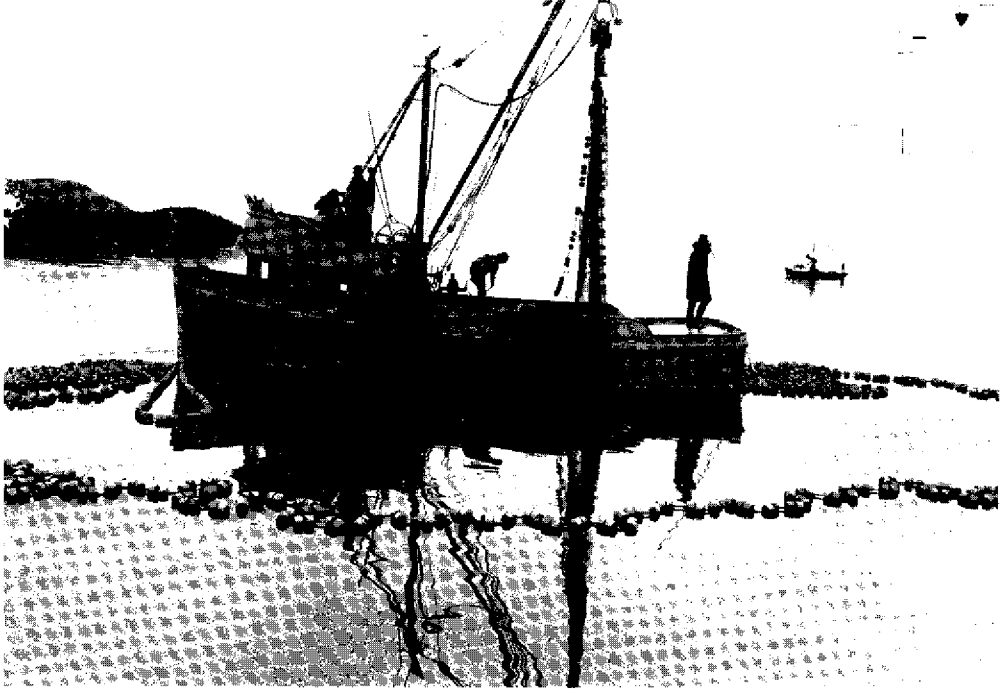

Proceedings of the Cordova Fisheries Institute

April 1 - 3, 1977

Oil and Aquatic Ecosystems, Tanker Safety and Oil Pollution Liability

SEA GRANT REPORT 77-8

AUGUST 1977

Alaska Sea Grant Program
University of Alaska
Fairbanks, Alaska 99701

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Brenda Melteff,
Editor

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ACKNOWLEDGEMENT

We wish to thank the people and industry of Cordova for the effort put into the Cordova Fisheries Institute

Contributors to the Institute were:

Cordova District Fisheries Union
Alaska Packers Association
Morpac, Inc.
New England Fish Company
North Pacific Processors
St. Elias Ocean Products
Whitney Fidalgo Seafoods

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The Cordova Fisheries Institute was sponsored by the Alaska Sea Grant Program, cooperatively supported by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 04-7-158-44006 and by the University of Alaska with funds appropriated by the State of Alaska. Additional support was provided for the preparation and printing of these proceedings by the National Endowment for the Humanities and the Alaska Humanities Forum.

Cover photo of the tanker ARCO FAIRBANKS courtesy of Atlantic Richfield Company. Seiner and fisherman photos courtesy of Mr. Bill Englert.

INTRODUCTION

Ross Mullins
Cordova Fisherman
Cordova, Alaska

We are fortunate in that the Alaska Sea Grant Program has made available the funds for this gathering, and we hope this will be the first of many meetings to come in the future.

The topic chosen for this particular institute is oil impact and renewable aquatic resources. This is a topic that all of us who were responsible for determining the subject matter felt was particulary appropriate in view of the Cordova community's past and continuing involvement with the forthcoming marine transport of oil through Prince William Sound, which we think of as our backyard. Large-scale oil developments are now beginning to occur in the Gulf of Alaska, which we think of as our front yard.

The community of Cordova is primarily and fundamentally oriented to the fishery resources surrounding it in Prince William Sound and the central Gulf of Alaska. Granted, the early growth of the community was stimulated by the copper mining activities in the Interior. Cordova was once the shipping terminus for ore brought by rail to the coast from the Kennecott mines. However, when the mines were closed, the fishing industry continued to provide the economic base that has continued to sustain the area to the present day and most indications point to a growing future for the fishing industry. A growing future if--and in my mind it is still an unresolved question--the large-scale oil developments that are becoming a reality both offshore and on, do not create an ecological situation that removes from this fishing community the option to pursue a lifestyle that many of us find appealing. There are those in this state, and in this community, who are eager for the industrial growth that will surely follow in the wake of the developing petroleum and gas industries. It does seem true that where there are oil and gas feedstocks, there will also be associated petrochemical industries, particularly where developing markets for the final products exist. These markets are represented by the Orient today. The direction that many of these developments will take in the future is not yet clear. It is possible that the interactions of a gathering such as this one today will help to sensitize us to the options available.

It is important for us to attempt to determine our future course and to define the necessary steps that must be taken to avoid an eco-catastrophe, as well as to allow ourselves to make intelligent decisions as citizens concerning the priorities affecting our chosen way of life.

It is my hope that meetings such as this one will serve to stimulate public awareness and involvement to point out the need for coastal zone management initiatives to emanate from the people. If the meeting can provide a catalyst to motivate people to participate

actively and to make known their views regarding the direction the development of the region in which we live should take, then it will have been successful.

The present Alaskan administration seems eager for people to provide input that will assist in molding future policy and we should not let this opportunity slip away. It was only a couple of years ago that any open debate concerning oil resource development was emotionally-loaded. There was no real public dialog. I recall incidents in the past where the Alaska media and other interest groups maligned the fishermen's valid concerns that the resources which they cherished be adequately protected from disruption. Only recently have catastrophic world events focused national attention upon the risks inherent in the marine transportation of oil and the effects upon fisheries and coastal resources.

I hope this gathering will give us all a broader perspective with which we can plan a more rational path to the future.

OIL AND AQUATIC ECOSYSTEMS

THE OCS IN ALASKA

Edward J. Hoffmann
Manager, Alaska OCS Office
Anchorage, Alaska

At the moment, the only certain characteristic about the OCS program, and most energy programs, is uncertainty. I'm not saying this in a disparaging way; one would expect a new administration to take a close look at something as vital to the nation's well-being as energy policy.

There are three events forthcoming which will have major implications on the OCS program nationwide, and certainly for Alaska.

The first is President Carter's energy message scheduled for April 20. Certain bits and pieces of its content are being released. It will call for a close look at the OCS schedule with particular emphasis on Alaska because of its unique environment. It also will provide for the cooperative establishment of marine sanctuaries by the Secretary of Commerce and the Secretary of the Interior. It's too early to assess the full implications of such proposals.

The second major item is the Department of Energy proposal. This proposal appears to take policy and some of the regulatory responsibilities concerning OCS away from the Secretary of the Interior and transfers them to the secretary of the new department. The traditional leasing role of the Interior Department apparently would remain. The precise effect such changes will have on my operations is unknown.

The third major item which will influence the operations in the OCS is Senate Bill 9 which amends the Outer Continental Shelf Lands Act. Among the provisions are:

1. Authority for on-structure exploratory drilling would be given to the Secretary of the Interior.

2. Alternative bidding systems included with the current bonus bid system would be mandatory.

3. Greater consultation with coastal states in the OCS process.

4. Separation of exploration and development.

5. Cancellation of leases.

6. Environmental studies would go to Commerce rather than remaining in the Interior.

7. The development of a five-year leasing schedule subject to annual review.

8. Establishment of an Offshore Oil Spill Pollution Fund. This is an interesting provision. The holder of a lease or right-of-way (pipeline) would be responsible for the first $35 million in damages from a spill. Damages in excess would be picked up by the Fund which is supported by a fee of three cents per barrel of oil produced.

I mentioned at the outset that the OCS program is controversial. The major and most difficult area of contention has been between the Department of the Interior and the State of Alaska. The state felt that the Department of the Interior was insensitive and unresponsive to state needs. I am detecting changes in attitude. Certainly the three major items discussed earlier: (1) development of the President's energy message; (2) the Department of Energy proposal; and (3) the changes in the OCS Leasing Act, will all better serve state interests. Even with sweeping changes in the offing, I suspect that the national interest vs. state interest issue will persist but hopefully with less acrimony. There are other sources of conflict. Some advocate "Damn the torpedoes -- full speed ahead." Develop at any cost. Others categorically oppose development.

The existing planning document published in January of 1977 calls for nine offshore sales by 1980. Secretary Andrus has stated that the OCS sales schedule will be looked at carefully, with particular attention to Alaska. Exploratory action in the Northern Gulf of Alaska continues. Beyond that I cannot predict. The Lower Cook Inlet sale, originally scheduled for February, is still held in abeyance. It's anticipated that Secretary Andrus will make a determination in May whether or not this sale will be held this year. Scheduled to follow Lower Cook Inlet is a sale off Kodiak in November of this year. We've been working toward that and we anticipate that the Draft Environmental Statement will be issued soon.

Next on the horizon is a possible joint federal-state sale in the nearshore waters of the Beaufort Sea. Because of jurisdictional problems between the state and the feds, such a sale will require an agreement between Interior and Alaska to permit the sale to proceed pending the resolution of the jurisdictional issue. There have been overtures toward such an agreement over the past year between the state and the Interior. I cannot predict when such an agreement may be reached.

Further down the line are proposals for an additional sale in the Beaufort Sea; a second generation sale in the Northern Gulf of Alaska; two sales in the Bering Sea (Norton and St. George's Basin); a second generation sale in Cook Inlet; and one sale west of Kodiak.

The Secretary of the Interior has pledged his Department to meet its commitment to an environmentally sound OCS program. He also recognizes the contribution that the OCS program makes to the Nation's economic health. He places safe and efficient development of the OCS resources as a high priority matter. I believe the OCS program in Alaska will move forward but with more deliberate speed than previously planned.

CONTENT OF THE NOAA/BLM ALASKAN OCS RESEARCH EFFORT

Rudolf J. Engelmann
Director, OCS Program Office, NOAA
Boulder, Colorado

Good morning, everybody. The OCSEA program, that is to say the marine program around Alaska, is most unusual for this country. To the best of my knowledge this environmental program for Alaska is the largest that our nation has ever had. I guess that would make it the largest in the world. It also has another unique feature. As far as I know it's the only significant environmental program that has any kind of lead time with regard to development.

Despite the lead time, we still find many of the present leasing decisions being made more because of a lack of environmental information, than because of information we do have. Tracts have been deleted from sales, and the entire order of sales has been changed in recognition of unknowns. Despite this fact we still do have some lead time of a year or two, and I think this is a fine sign and I wish that the country could keep it up. I think that the Department of the Interior should be recognized for having initiated such a program.

The program is big, not only in terms of dollars--BLM puts in about $22 million, and NOAA puts in $5 million worth of ship time annually--but it's also big in terms of the people that are involved. The research institutions that have experience in Alaska are pretty well saturated. It's really questionable whether they have enough qualified people and the wherewithal to take on much more research. The report flow is very heavy. The annual report last year consisted of 14 volumes that occupy 18 inches on your book shelf. In fact, in the program office at Boulder where we do the program planning, publication and reporting, they're joking about going into competition with Doubleday. The data flow is most impressive. There's certainly a lag between when the research is done and when the data are in the computer and available for everyone back in the Environmental Data Service in Washington, D.C., but it's on the way and is high quality stuff. And furthermore, our staff is very much oriented towards getting products back out of that data base in addition to those products that the Principal Investigators have already gotten from the data.

Twenty-seven or twenty-eight million dollars sounds like a lot of money, but it really is a very small amount compared to the investment that exists in the oil and gas development in the offshore region. Therefore, the cost benefit for an environmental program of this nature is very high. Now something that's not realized by most people that haven't had a chance to think about it is that if

you don't have the environmental answers then you're going to either over-design, underdesign, or misregulate, and either way it's going to cost you. If you overdesign it costs you construction and operation money, and even though all this is oil company money, it's really your money. If you underdesign, it's going to lessen your environmental quality and have other adverse effects. So the investment that you make in environmental studies is really a small investment that allows you to narrow down that zone of uncertainty that you have when you design your industry, make regulations, set stipulations, etc.

The OCS program around Alaska is a very fast-moving program. It's pretty tough on our staff to try to get the fast turn-around we want between the information that the Principal Investigators develop and the decision-making. But we sure do our best. We call our effort the Outer Continental Shelf Environmental Assessment Program (OCSEAP). Many of you have heard of that. I have a number of figures. This first (Figure 1) is what I call the "research-assessment wheel." In the design of the research program, if you intend to make an assessment, you certainly need to have an understanding of how that assessment is achieved so that you can design the research accordingly. So, one of the steps one wants to take very early is to study the assessment, or predictions that have already been made. One should then use some sensitivity analysis on these predictions. This involves changing something that affects the prediction or changing something that you know about the level of impact on some organism. From your results you can decide what the most sensitive needs are for the research program. Conduct the research and synthesize the results to get the revised models and data to make the next assessment. Do another assessment, and around you go. There is thus a continual feedback into the research program. This is what takes place in the Alaska program.

The word assessment can be a little bit inflammatory. By the way, I don't mean by assessments any value judgment. I really mean, in this case, a prediction of what's going to happen. That should always be separated from the decision as to whether or not it's something that you want to accept or allow. The latter is a value judgment and goes beyond environmental research.

What I'm going to try to do this morning is to take you through the process of making a prediction for assessment in most environmental situations (Figure 2). This process is not limited to the evaluation of a release of oil or drilling muds into the environment--it applies to radioactivity, or pesticides, and so on. Whenever you want to make a prediction, you're really talking about some kind of a source. Now the source might be radioactivity or it might be hydrocarbons; it might also be noise; it might be a lot of people moving around in boats and so on, but at any rate it's a source of the insult and leads to a possible effect. In the case of petroleum, it calls for quite an extensive chemistry program. After defining what the source is--its characteristics, intensity, location, etc., you have

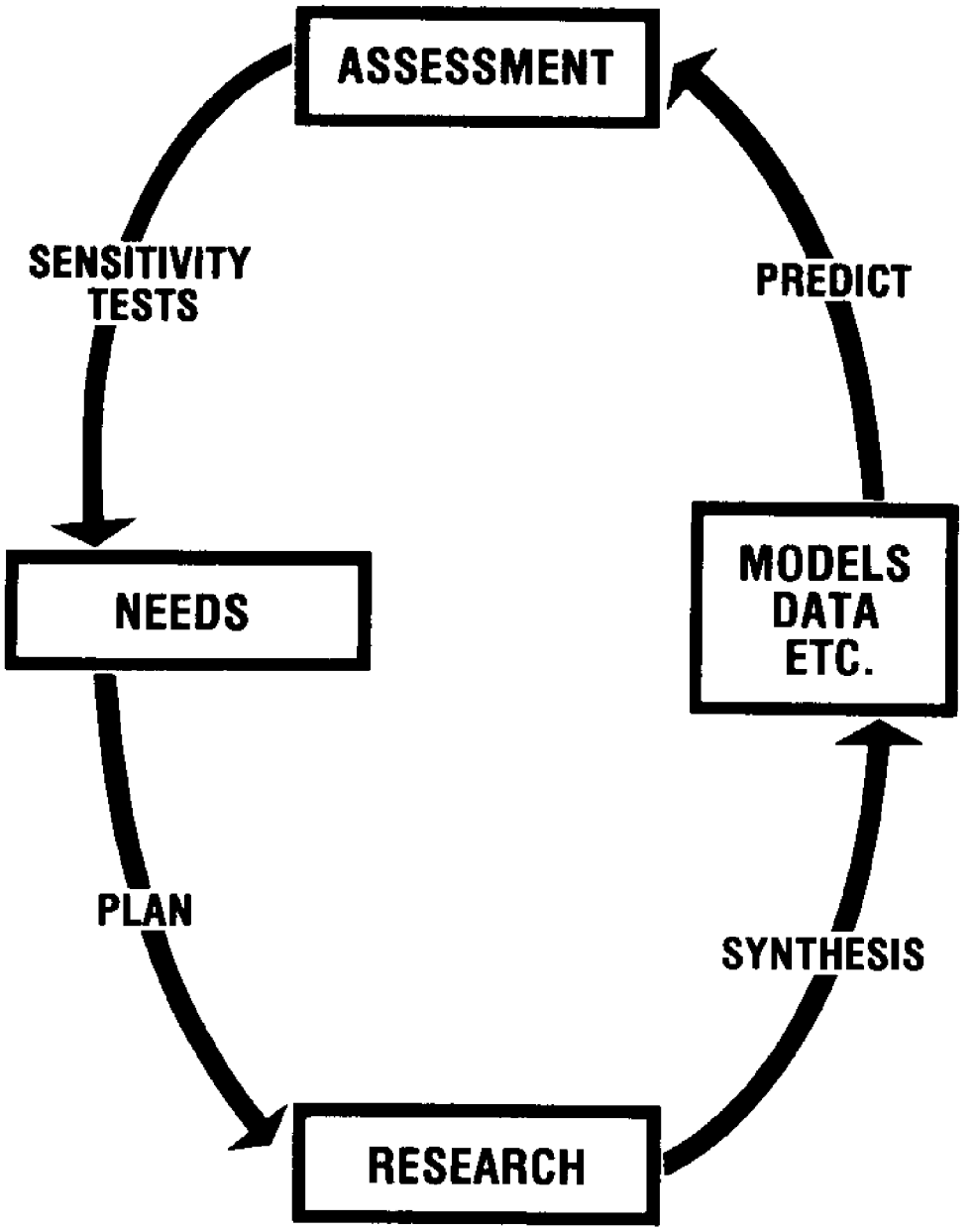
ASSESSMENT
SENSITIVITY TESTS
PREDICT
NEEDS
MODELS DATA ETC.
PLAN
SYNTHESIS
RESEARCH

Figure 1.

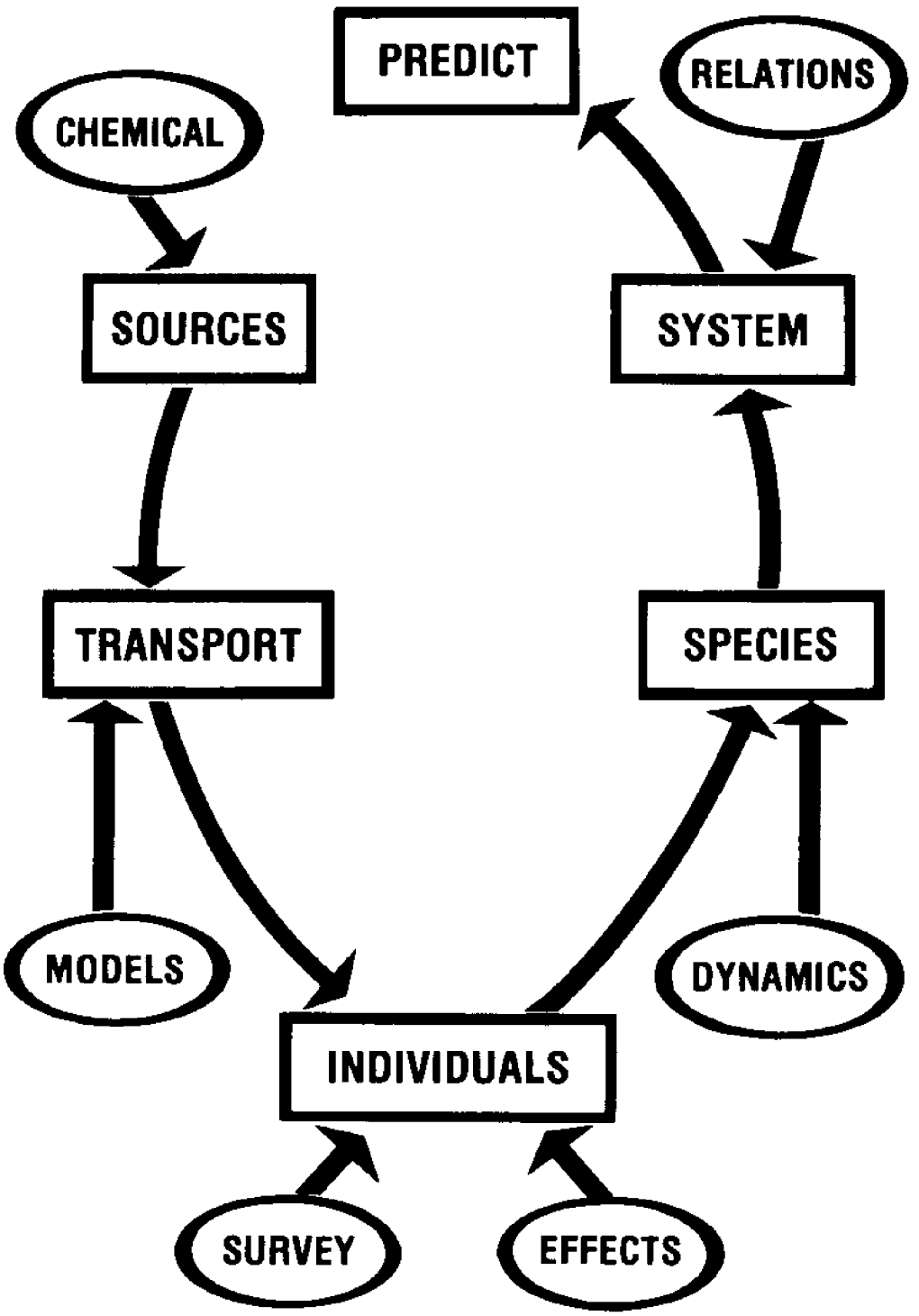
PREDICT
RELATIONS
CHEMICAL
SOURCES
SYSTEM
TRANSPORT
SPECIES
MODELS
DYNAMICS
INDIVIDUALS
SURVEY
EFFECTS

Figure 2.

to deliver it to the biota through a transport term. The transport term is one of those things that you can get pretty objective about; it obeys physical laws. In the case of oil, its movement is a result of a combination of wind and surface currents. Usually transport can be modeled mathematically and can be simulated on a computer if you have the necessary input data.

Thus you "deliver" the insult to an individual, that is to say, to a particular fish, bird, or sea otter. Now you need to know where that individual is. In the Alaska program you have a survey program stating where the creatures are located. After you know what the level of concentration is and what degree of insult is coming from the sources, you need to state what the effect is on that individual and what kind of effect it is. You will find there's an effects program in your Alaskan research.

Now the individual isn't all that important. Of course, in the case of people we have a conviction that an individual is important. But in terms of the ecosystem, just as mankind survives and moves forward despite the loss of a certain number of people to drownings and lightning and wars and automobile accidents and so on, it's certainly true in the environment that any numerous species can sustain some loss of individuals. But what the relationship is between the effects on the individual and the effect on the total species population requires the knowledge of the dynamics of the species, population, productivity, etc. Of course, the species isn't the whole story. There is an ecosystem out there. If you eliminate a species from or add one to it, there is still an ecosystem. And it may or may not be an improvement over what you have now--improved in terms of its usefulness to man or in terms of what kind you like. The current environmental vogue prefers everything in *status quo*, but many of the ecosystems that are here now aren't as they were even a hundred years ago. Therefore, if you really want to make a good prediction of the effects of a source term, you need to understand the relationship between the species and its entire system. If by chance a species is eliminated or added or multiplied or something, what really happens to the system? Then a prediction of what the new system is going to be and for how long--given a particular source and variations of that source--allows someone to make a value judgment. So all of these things, then, are necessary in the Alaskan research program.

Now, I'd like to go around this arc of Figure 2 one item at a time, and elaborate on each aspect in turn. We begin with sources (Figure 3). There is, of course, a chemistry program. This is a program looking at the hydrocarbons, trace metals, and nutrients in the biological systems around Alaska. As you might expect, Alaska is a rather pristine environment. If you're receiving no measure of something, there's not much point in continuing to try to measure it or in attempting to get a statistical baseline. The word baseline means to some people a statistically valid set of data you can look at years later and say "this is what was there and what should be there now if it had not been changed by man's oil and gas development or by something

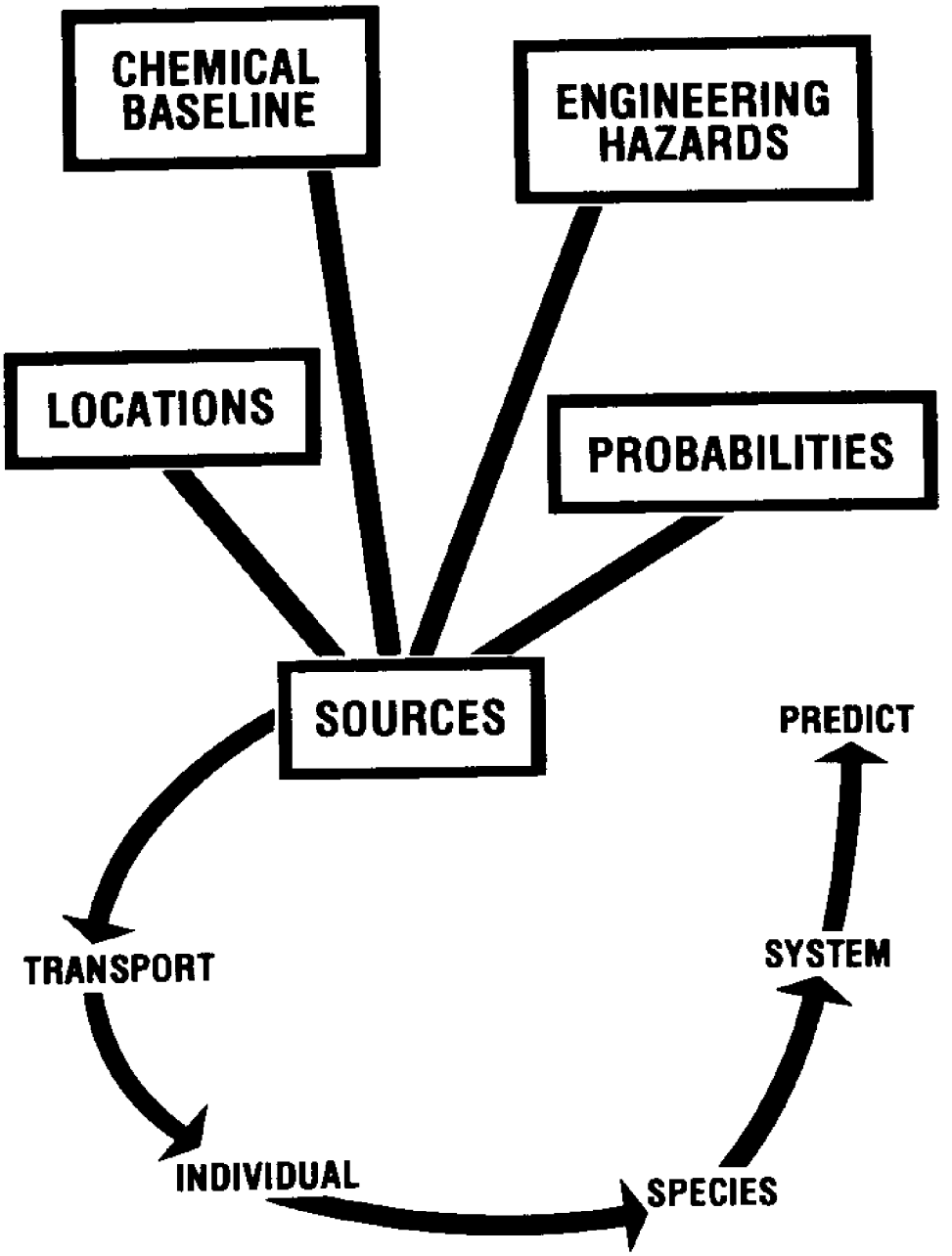
CHEMICAL BASELINE
ENGINEERING HAZARDS
LOCATIONS
PROBABILITIES
SOURCES
PREDICT
TRANSPORT
SYSTEM
INDIVIDUAL
SPECIES

Figure 3.

else." That kind of baseline is a very expensive thing to achieve. It's also not practical in terms of time, because of natural variability you may need 10 or 20 years to obtain any kind of statistical validity. Fortunately, with the relatively pure Alaskan waters we have our chemical baseline right in the very beginning.

When you make your predictions, you want to be able to say "Hey, what if the sources are in different locations, and have different characteristics?" So, one of the things needed in the program is an early decision as to where those sources might be and what the alternative locations are. You need that also because it helps you to design a particular site-located study later on. In order to make the predictions, you also need to know something about the probabilities of any particular kind of release, accident, earthquake, etc. These probabilities are presently obtained for the Alaska situation through analysis of statistics from the North Sea and worldwide oil and gas development.

Finally one would like to be able to control the sources so as to minimize insults, and that means one has to know something about the environmental hazards for the industry (Figure 4). You'll find in this program there is a substantial effort expended on studying engineering hazards. These engineering hazards include extreme wave heights and a program we're trying to get started on tsunamis that might happen in Kodiak, Lower Cook Inlet, and the Gulf of Alaska. They include a permafrost research effort in the Beaufort and Chukchi Seas. That program involves the depth of permafrost, its location and engineering characteristics. There is a substantial geology program. The results of the geology program, which is conducted mostly by USGS in a joint OCSEAP/USGS effort, are used in tract selection in advance of impact statements and sales. In the geology program we study those things you might expect--location of faults and seismicity, the likelihood of earthquakes, sediment depths that would present problems to the structures, previous slumps and potential slumps. Slumps are thick sediment which has the capability of rolling downhill on the ocean bottom if it is disturbed. In addition to the geological program we have a significant ice program. This deals with the location of ice with respect to season, how it moves and how fast, the depth to which it gouges the ocean bottom, the strength of it, the stresses and so on. This can be used by regulatory agencies to judge the adequacy of engineering design to prevent accidents.

Now we move on to the next phase in the prediction arc, which is transport (Figure 5). There are two methods of transporting oil in aquatic ecosystems around Alaska; one is by means of ice, and the other by means of water. Now ice, because of its characteristics, does take the oil with it almost independently of current underneath. Because ice is moved mostly by the wind, knowing the currents under the ice is only part of the answer. One also needs to know the morphology of the underside of the ice. This is because oil is trapped in irregularities on the ice bottom. (There's another purpose of morphology, by the way, and that's the big ice keels that extend to great depths below the ice pack in the arctic and are capable of

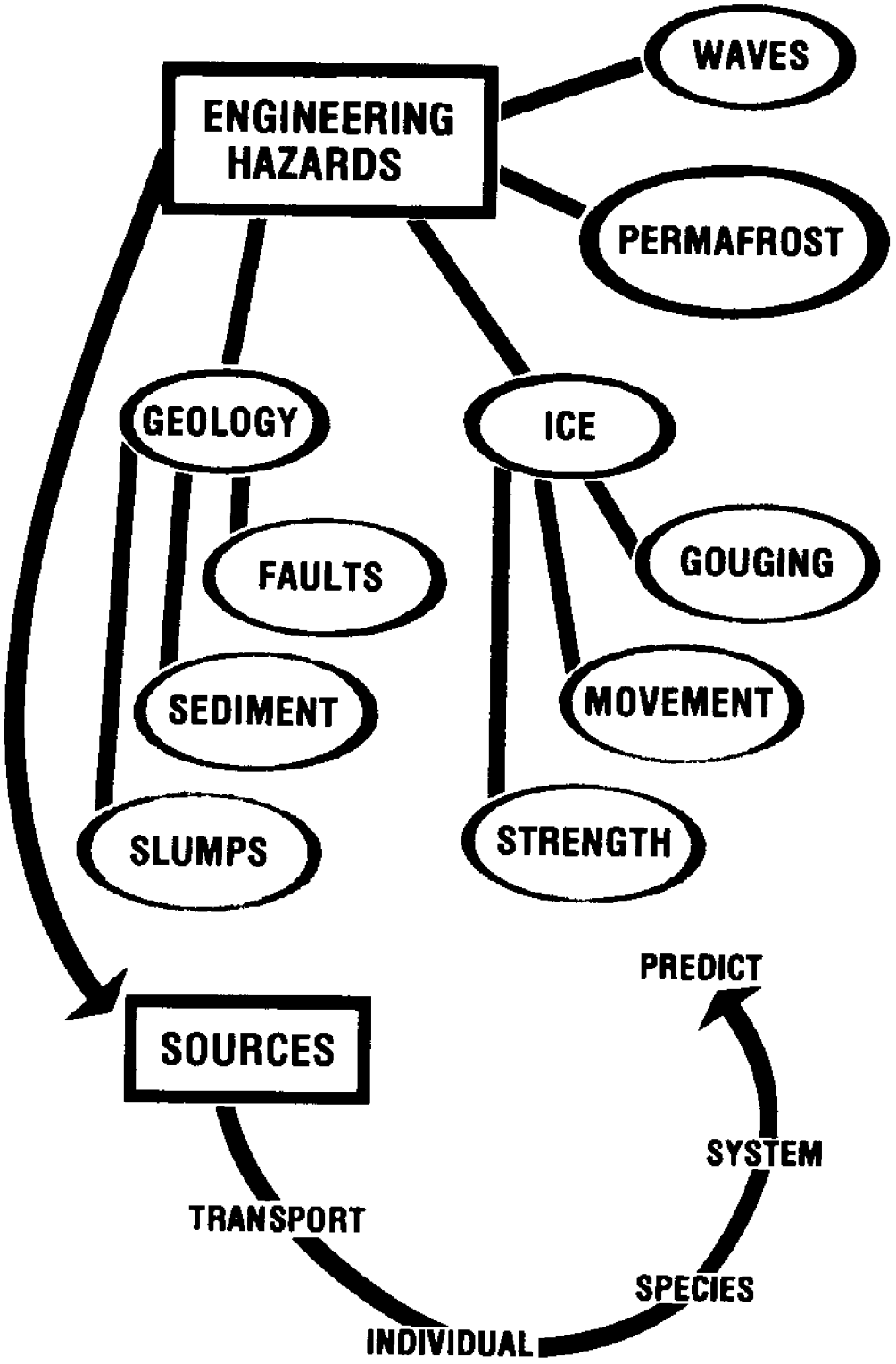
ENGINEERING HAZARDS
WAVES
PERMAFROST
GEOLOGY
ICE
FAULTS
GOUGING
SEDIMENT
MOVEMENT
SLUMPS
STRENGTH
SOURCES
PREDICT
SYSTEM
TRANSPORT
SPECIES
INDIVIDUAL

Figure 4.

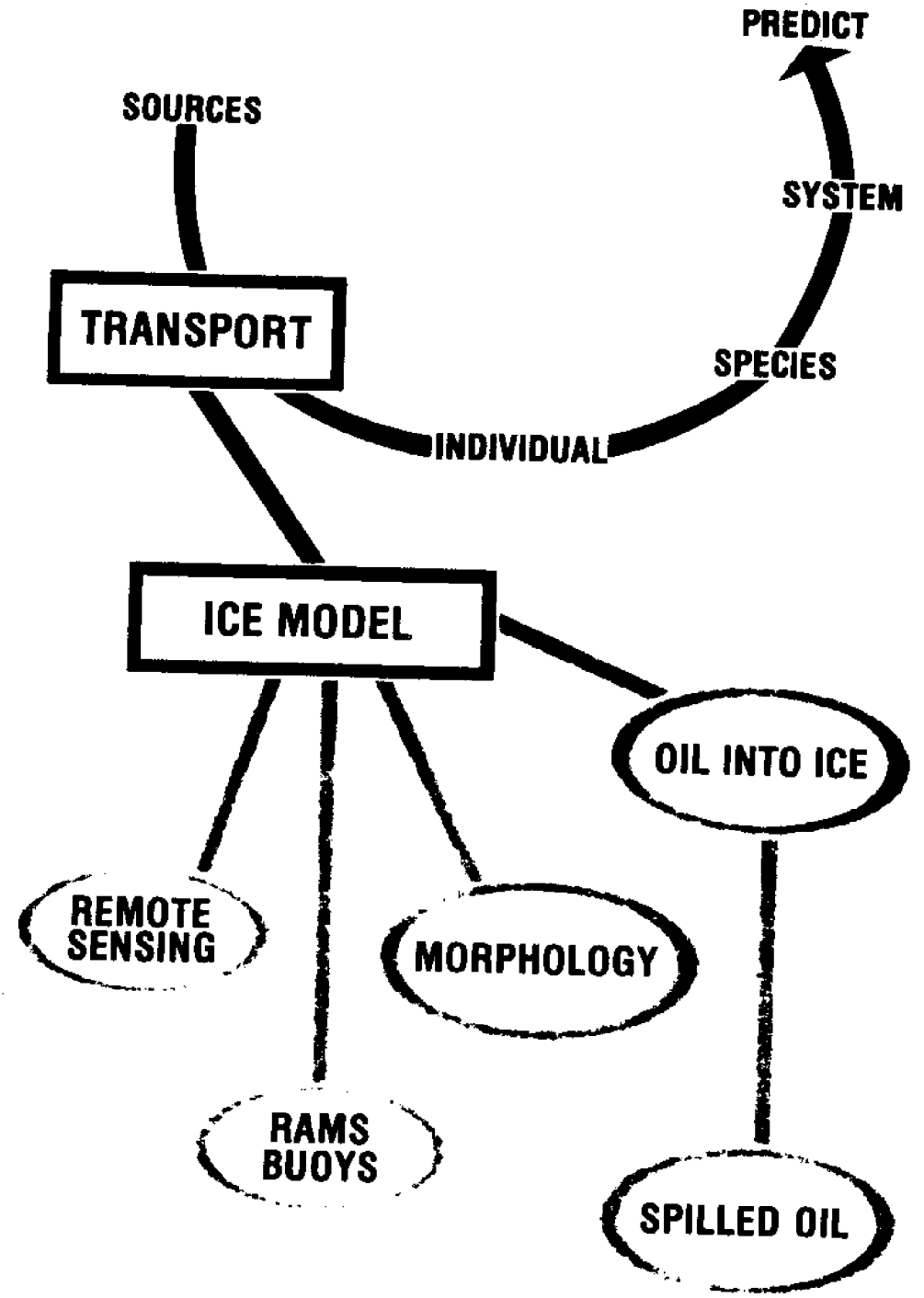
PREDICT
SOURCES
SYSTEM
TRANSPORT
SPECIES
INDIVIDUAL
ICE MODEL
OIL INTO ICE
REMOTE SENSING
MORPHOLOGY
RAMS BUOYS
SPILLED OIL

Figure 5.

gouging out really deep trenches in the ocean bottom, and must be considered in placing the pipelines that are going to be bringing the oil to shore.) In the development of the model of the movement of oil by ice, one uses remote sensing, things like radar (we have a large radar set on the Seward Peninsula), sensors from aircraft and satellites. The aircraft program includes side-looking airboard radar (SLAR) and infrared and laser profiling. Ice buoys have been developed which are dropped from aircraft and are tracked by satellite. We have maybe a dozen or so of these up in the arctic which we drop out on the Beaufort ice. The ice buoy movement is tracked for months at a time from a satellite.

Concerning ice, there are also the problems of how does the oil get incorporated into it, how does it move upward through it in the cracks and leads, and how is it incorporated when the ice is forming? Besides laboratory work on that, we recently had one of those unusual opportunities to make first-hand observations in the Buzzard's Bay oil spill. A barge went aground back east in severe weather and there was enough ice around that we felt it important to send out a couple of investigators. We got probably the best and first significant data on how oil is incorporated into ice and how it behaves in ice. (I'll tell you a little more about those Spill Oil Response teams which BLM/NOAA has for Alaska in a little bit.)

Now we come to the transportation of oil by water (Figure 6). This is your usual mode of transportation. The movement of oil on water is indeed by combination of wind and surface current if the oil is not incorporated into the water column. The biology of the surface concerns mammals and birds. As far as the fish go, they're in the water column. The problem consists of knowing where the oil is going, but also there is how the oil is mixed into the lower depths, how much of which components evaporates, and whether it is incorporated into suspended and bottom sediments. A whole set of submodels (Figure 7) have to be developed in order to determine these things. To get the data for these submodels we have organized Spill Oil Response teams. These teams have NOAA, Coast Guard, BLM, and State of Alaska people on them. When a spill occurs, as in the case of the Argo Merchant, they go to it and take measurements of wind, currents, and how the oil behaves, mixes and changes. We're quite proud of these teams because they are the first of their kind.

In the wind program we are measuring winds in special locations along the Alaska coast and at buoys out at sea that otherwise wouldn't be measured. There is a problem in the northern Gulf of Alaska, because the winds onshore aren't like they are offshore. Because much of the important biology is located right up on the coastal zone, right up on the beach itself, it's not accurate to use the winds off the coast to say where the oil would go ashore if there was a spill. There's also the problem--is it even going to move ashore? You know, it could travel parallel to the coast for a substantial distance, and whether it comes ashore or not depends a lot on the wind right next to the shore.

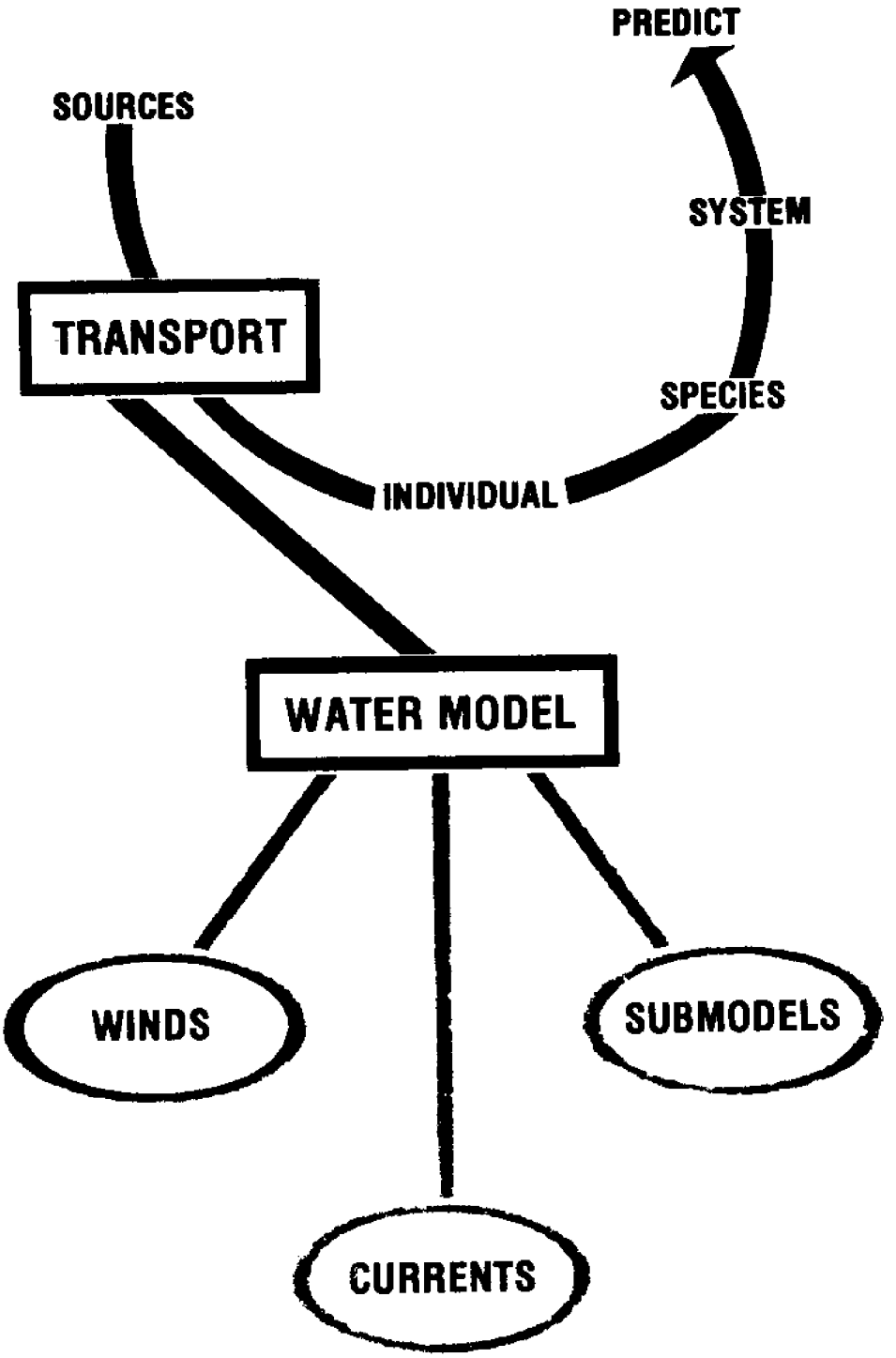
PREDICT
SOURCES
SYSTEM
TRANSPORT
SPECIES
INDIVIDUAL
WATER MODEL
WINDS
SUBMODELS
CURRENTS

Figure 6.

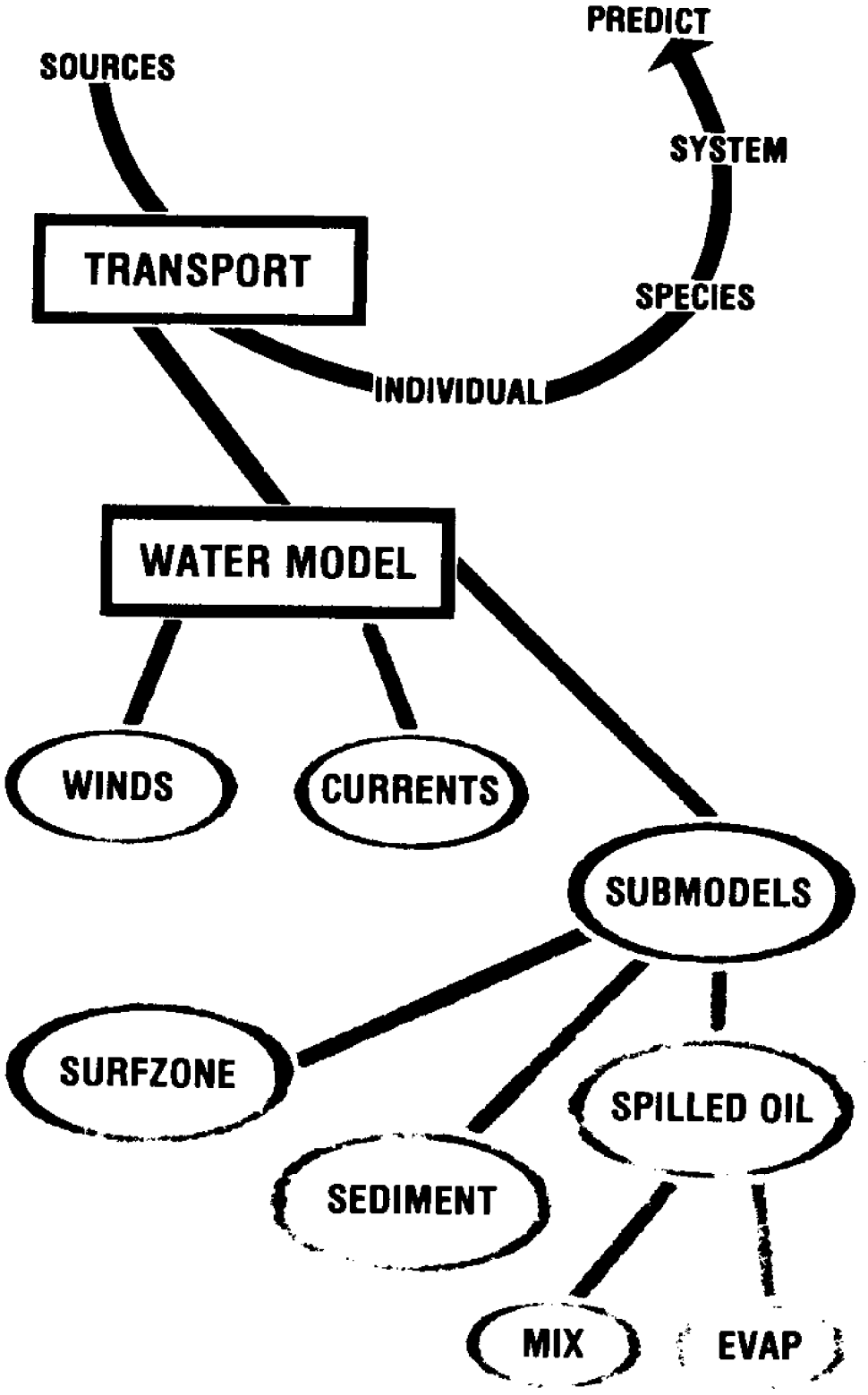
PREDICT
SOURCES
SYSTEM
TRANSPORT
SPECIES
INDIVIDUAL
WATER MODEL
WINDS
CURRENTS
SUBMODELS
SURFZONE
SPILLED OIL
SEDIMENT
MIX
EVAP

Figure 7.

Now in the measurement or the modeling of the currents you have about six thousand miles of Alaska coast, and a good part of it has the potential for being exposed to oil spills sometime in the future. That means that there's an almost impossible task of defining the current along all that coastline, and yet you must define it or at least be able to make an estimate of what you think it might be. Well, of course, what we're trying to do is develop a model of currents that can be applied to different coasts. That requires the measurement of currents, (Figure 8) and we use the best and latest technology in measurement of currents in Alaska. For instance, we have under development a radar capability for remotely measuring surface currents. This uses the Doppler effect from the wave motions. By processing the return signal one is able to pull out the surface currents and produce a vector of both components of the surface motion to a distance of about 50 miles offshore. This is currently being calibrated and if it works it will be up here in the Lower Cook in about June or July. There are also, as I mentioned before, buoys off the coast. We have current meters at several depths beneath the water surface and wind and wave measurements at the surface. There are about six of them as I recall. There's also a drifter program. These drifters are tracked by satellite. There have been quite a few of them released in the vicinity of Yakutat, and they make some interesting tracks. Some of them come right into Prince William Sound, which I think shows that there is a transport of surface waters into the Sound from the Gulf at least during some seasons. These drifters also demonstrate the existence of the gyre to the west of Kayak Island. We may be using some drifters in the Lower Cook Inlet this coming summer. Currents can also be determined from satellite photos in the spring time when there's a significantly different colored water runoff which is turbid and dirty. From good satellite photos you can identify the major headings and currents, and then you can insist that the fellow who's doing the modeling take the real world into account. The satellite photos, for instance, did indeed verify the existence of the gyre west of Kayak Island, and they proved to everyone's satisfaction that the model was right in predicting what was there.

Well, after you have the ability to predict transport to somewhere, you have to know where an individual is in order to say whether the insult will reach him. We're making substantial surveys of mammals, birds, fish, and the like to discover where they exist, what their habitats are, and where they are on a seasonal basis and at different life stages (Figure 9). There's a lot of ship time involved, and a lot of Principal Investigators (PIs) needed in order to be able to make this general kind of survey. But after you've made that survey, you still don't have the understanding you need in order to make the prediction. You only know where those things were in the particular year you made the measurements. You also have to be able to say what the effects are of the particular exposure to drilling mud or oil or whatever. So, we have several

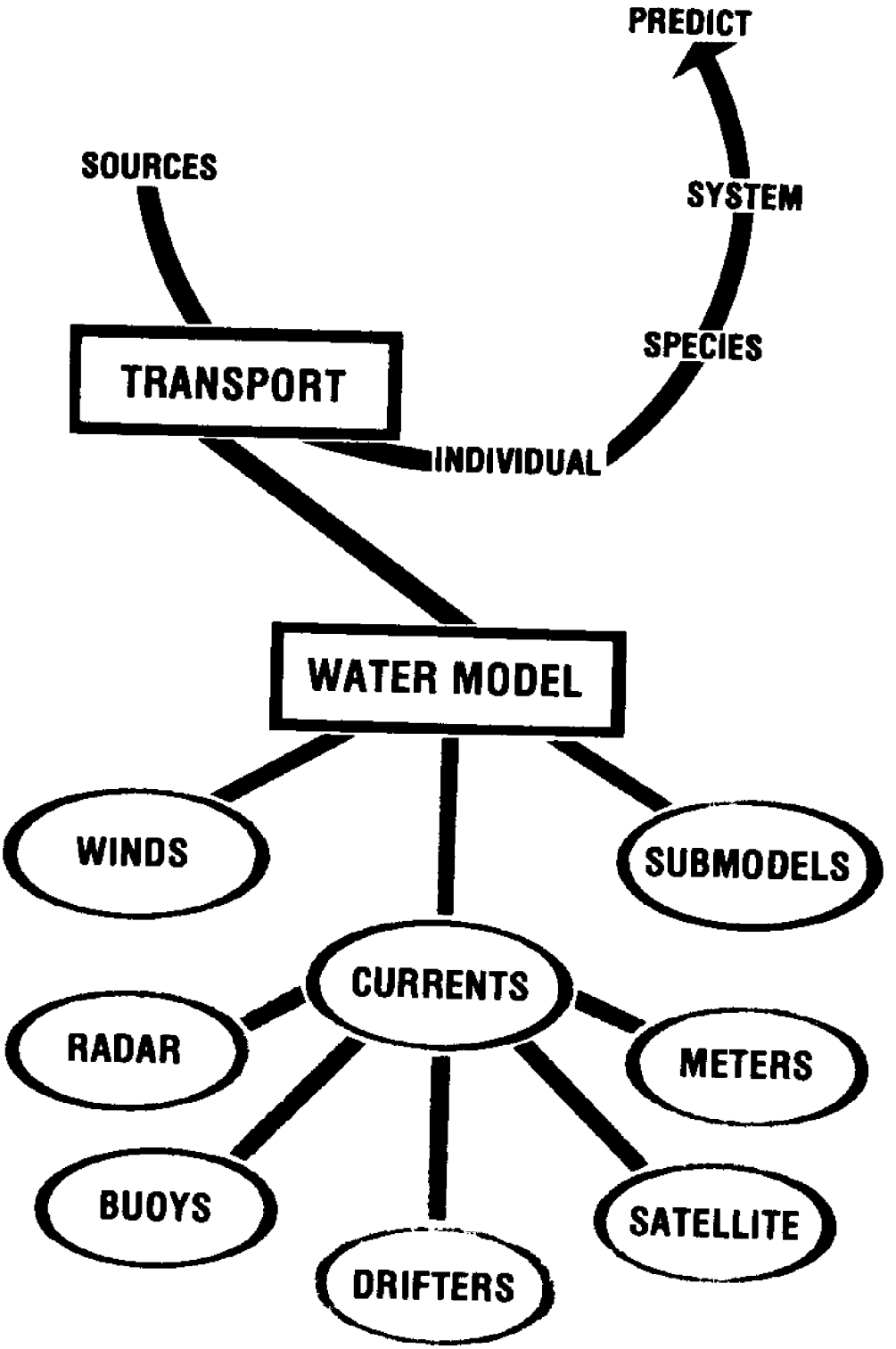
PREDICT
SOURCES
SYSTEM
TRANSPORT
SPECIES
INDIVIDUAL
WATER MODEL
WINDS
SUBMODELS
CURRENTS
RADAR
METERS
BUOYS
SATELLITE
DRIFTERS

Figure 8.

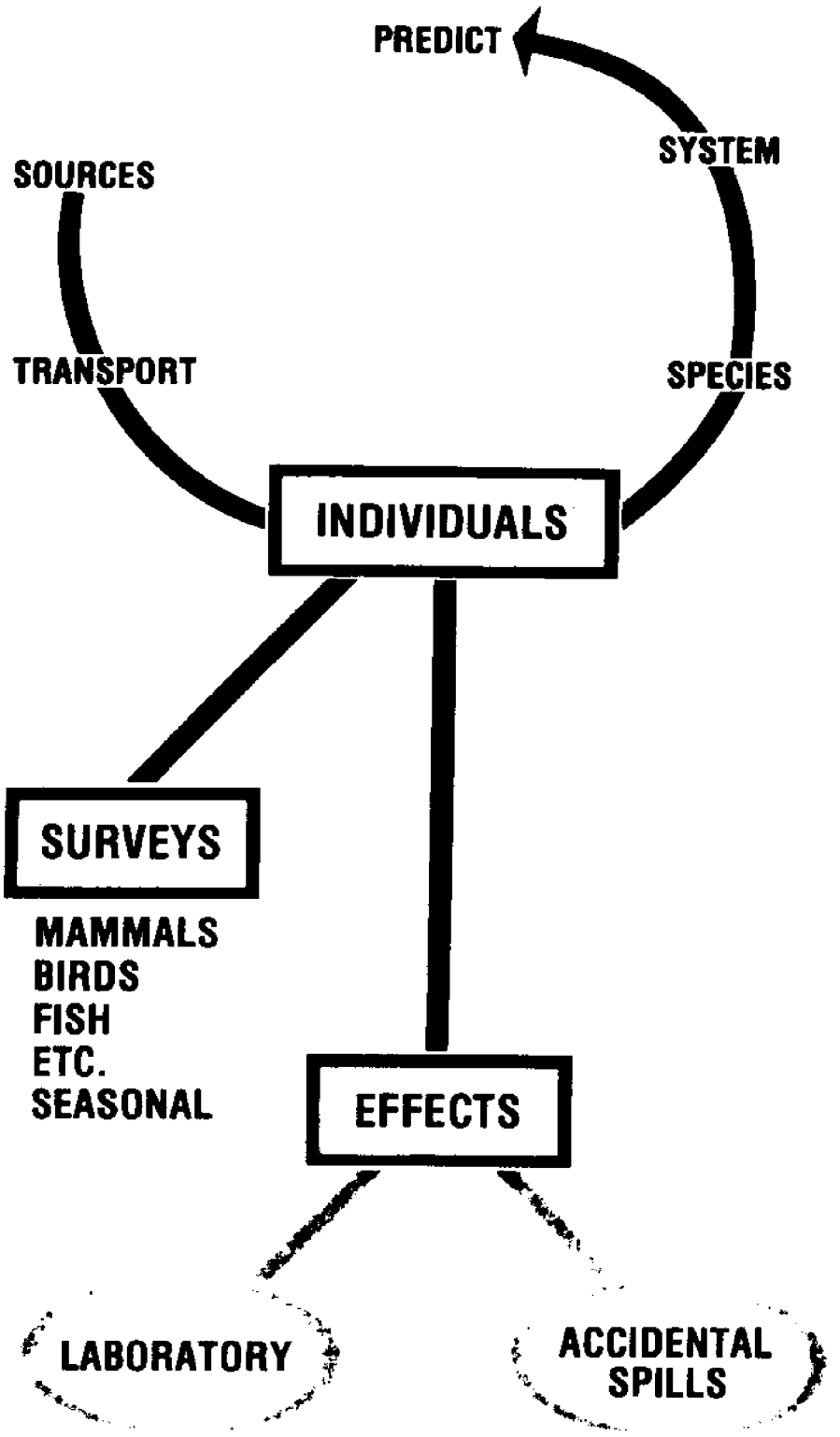
PREDICT
SYSTEM
SOURCES
TRANSPORT
SPECIES
INDIVIDUALS
SURVEYS
MAMMALS
BIRDS
FISH
ETC.
SEASONAL
EFFECTS
LABORATORY
ACCIDENTAL SPILLS

Figure 9.

laboratory studies going, located in Auke Bay, in Seattle, and some in California. I should say these are screening programs. We hold the creatures in tanks and give them rather high concentrations and high exposures of the contaminant and look for lethalities and sensitivities. Although this isn't the real world, it helps us to speculate on which may be key species and how to design longer term experiments at lower exposure levels and at more realistic operational exposures. We'd like to get such data from spills of opportunity, or accidental spills, but so far the biologists haven't come up with a plan that doesn't require measurements in advance of the accidental spill.

As I said earlier, one individual doesn't count, although we must recognize a certain emotional attachment to the individual feathery or furry creature. The question of survival of the species--given damage or loss of a number of individuals--requires understanding of the population dynamics, of recruitment from outside, and of reproduction at the site (Figure 10). If you have that understanding you can predict what will happen to a species in a system if his population is changed, providing you know something about his competition.

One must also consider the Critical Habitat of a species. I don't think it's necessary to define this term. We all have ideas of what it means and I expect if somebody thinks a certain habitat is critical he is probably right. Examples of these are the Copper River Delta which would be critical because there are such enormous populations there, or a particular patch of eel grass somewhere along the coast if it happens to be a good place for fish to spawn, or gravel beds in the rivers. To me a critical habitat is something that, if eliminated or damaged, would have a cascading effect back to the species itself and affect the population. You don't have to be very sophisticated to realize that when you've identified a critical habitat you don't really need a great understanding of an ecosystem to make a judgment as to whether you should protect that habitat. Sometimes, of course, you need an understanding of the ecosystem to be able to determine which <u>are</u> critical habitats. There are also the behavioral studies one needs to do, but those are tied back into things like productivity and recruitment. What is the general behavior of the creatures of the environment? Where do they go and how do they mate and what influences their productivity?

Now we come to the relationship of the species to the entire system (Figure 11). Let me give you an example of a key species--a hypothetical example that was presented to us in a proposal. There's a lowly starfish which may very well have a higher sensitivity to petroleum than almost anything else around it. Just a few parts per X would destroy the population. This starfish hypothetically feeds on sea urchins and the sea urchins eat the eel grass. Of course the sea otter competes with the starfish to eat the sea urchins. The eel grass, however, is a nursery for commercial and other kinds of fish, so it's really a critical habitat. If you knew something

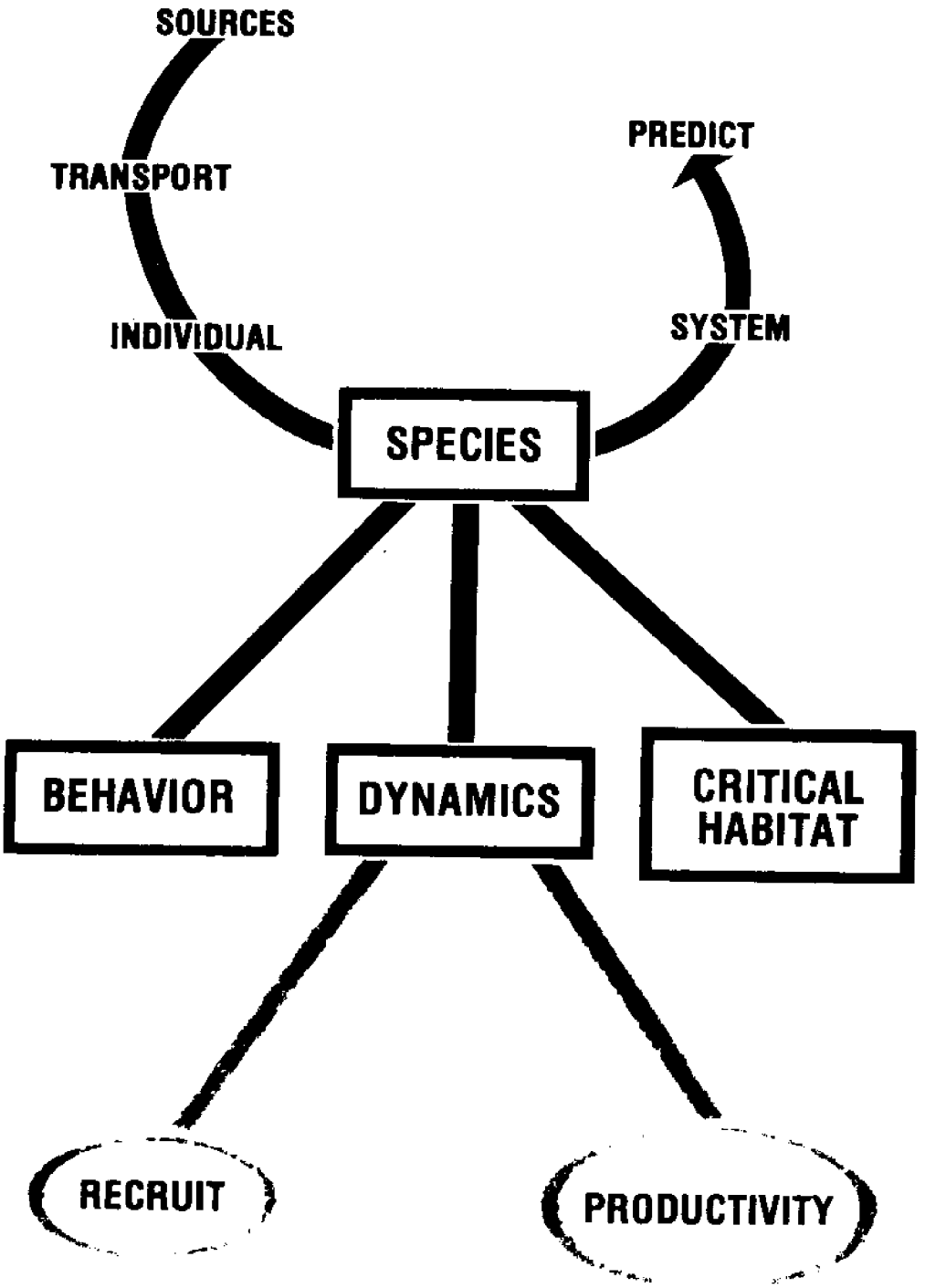
SOURCES
TRANSPORT
INDIVIDUAL
PREDICT
SYSTEM
SPECIES
BEHAVIOR
DYNAMICS
CRITICAL HABITAT
RECRUIT
PRODUCTIVITY

Figure 10.

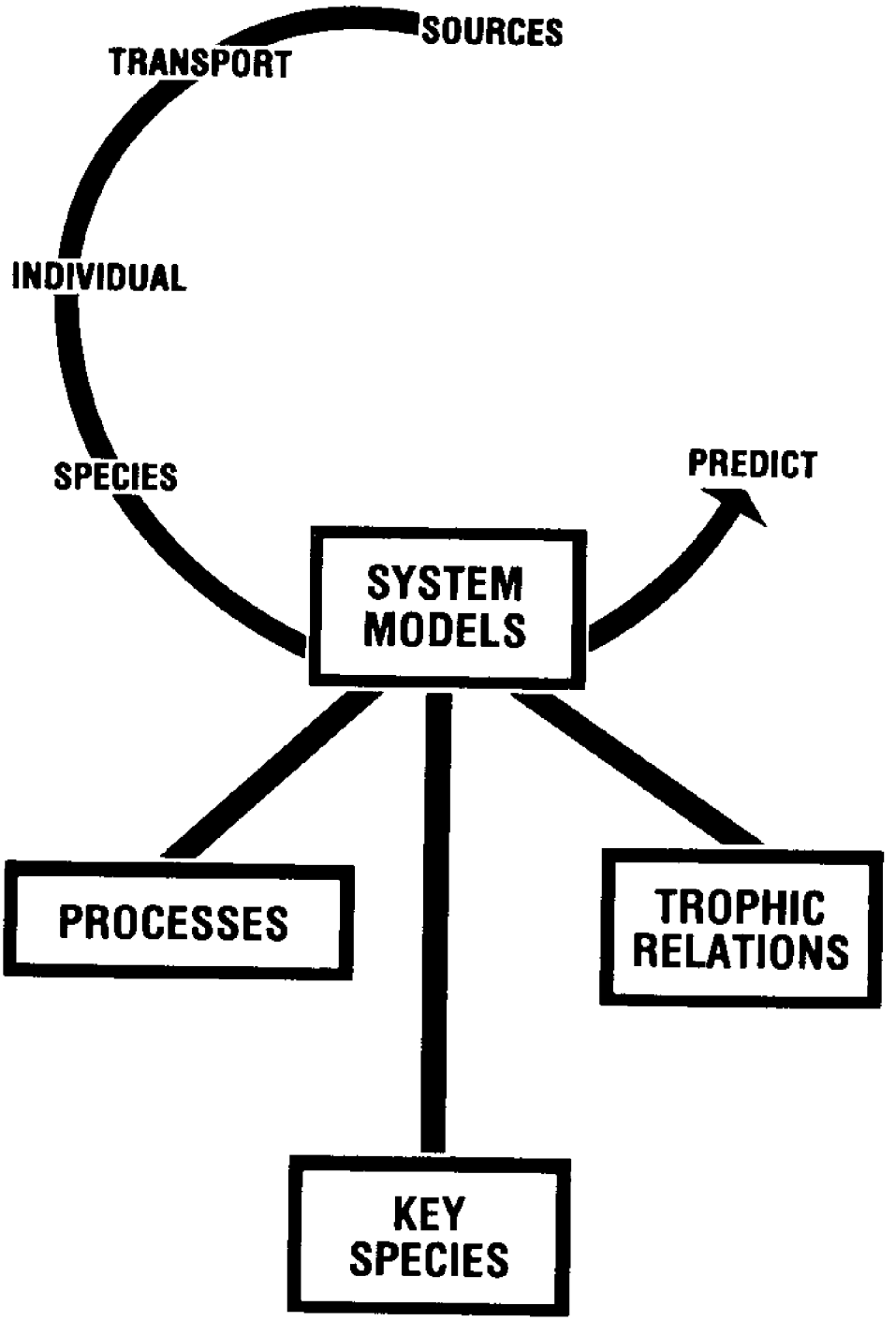
SOURCES
TRANSPORT
INDIVIDUAL
SPECIES
PREDICT
SYSTEM MODELS
PROCESSES
KEY SPECIES
TROPHIC RELATIONS

Figure 11.

about that starfish and about that ecosystem, you might deduce that the key species of that ecosystem is that starfish, because if he's eliminated then those sea urchins with their fast breeding rate would eliminate that eel grass before the sea otters with their slower reproduction would be able to bring the sea urchins under control. Once that eel grass goes, there goes your habitat.

It's the kind of argument which has yet to be proven but for which many examples can be postulated that really make the hair on the back of my neck stand up. Quite frankly, I don't think it's possible to design a program that's going to anticipate all of these things in a reasonable amount of time, but one sure ought to give it a try. From the example we see a need for system understanding--an understanding that goes beyond how hydrocarbon exposure affects the particular commercial fish that you're interested in for your livelihood. There are a lot of other creatures in that system that are important to you, even though they may be very lowly and you may never see them. It's a question of who eats whom, and who competes for the same food. One must know these trophic relations in order to know what's going to happen to the ecosystem if you heavily fish a particular species, or if a species is heavily damaged by oil or something else. And then there are key processes in the system, things like where the nutrients come from, and how nutrients and larvae are transferred by water currents, and so on. There may be some particular processes that have to be identified for man to design his development activities so as not to interfere with certain species to an undesirable extent.

Okay, let's say we think we're real smart. We've done our research, and we think we have an understanding of the entire system. Well, we probably don't have everyone else satisfied that we've obtained a sufficient understanding. We're certainly going to have controversy until we test the hypothesized understanding and prediction. This test has to be done in the field; it can't be done in the lab because the lab situations are unreal. Now every time one designs a lab experiment he runs into wall effects; you keep making the wall bigger, but it seems you eventually have to get to a situation where you don't have a wall. I call these tests "controlled perturbation experiments", (Figure 12), but no matter what name you put on the rose it really comes out to be deliberately delivering an insult to the environment in a controlled situation in a manner that helps you to understand the system better. This controlled perturbation could very well be a controlled oil spill, a deliberate release of foxes on a barrier island, or a deliberate creation of noise on a regular basis in a bird habitat. But before you do any of these things, of course, you study until you think you have an understanding of the system; then you're able to pick out a good site as well as a control site. You run a baseline there for a couple of years to see whether you can get a good idea of how it is behaving. I can imagine using two small bays, one subjected to the perturbation, and the other one to be used as the control. Using your models with your best input you can state that you are positive that the system will recover quite successfully. That's to say, it will go back into its original

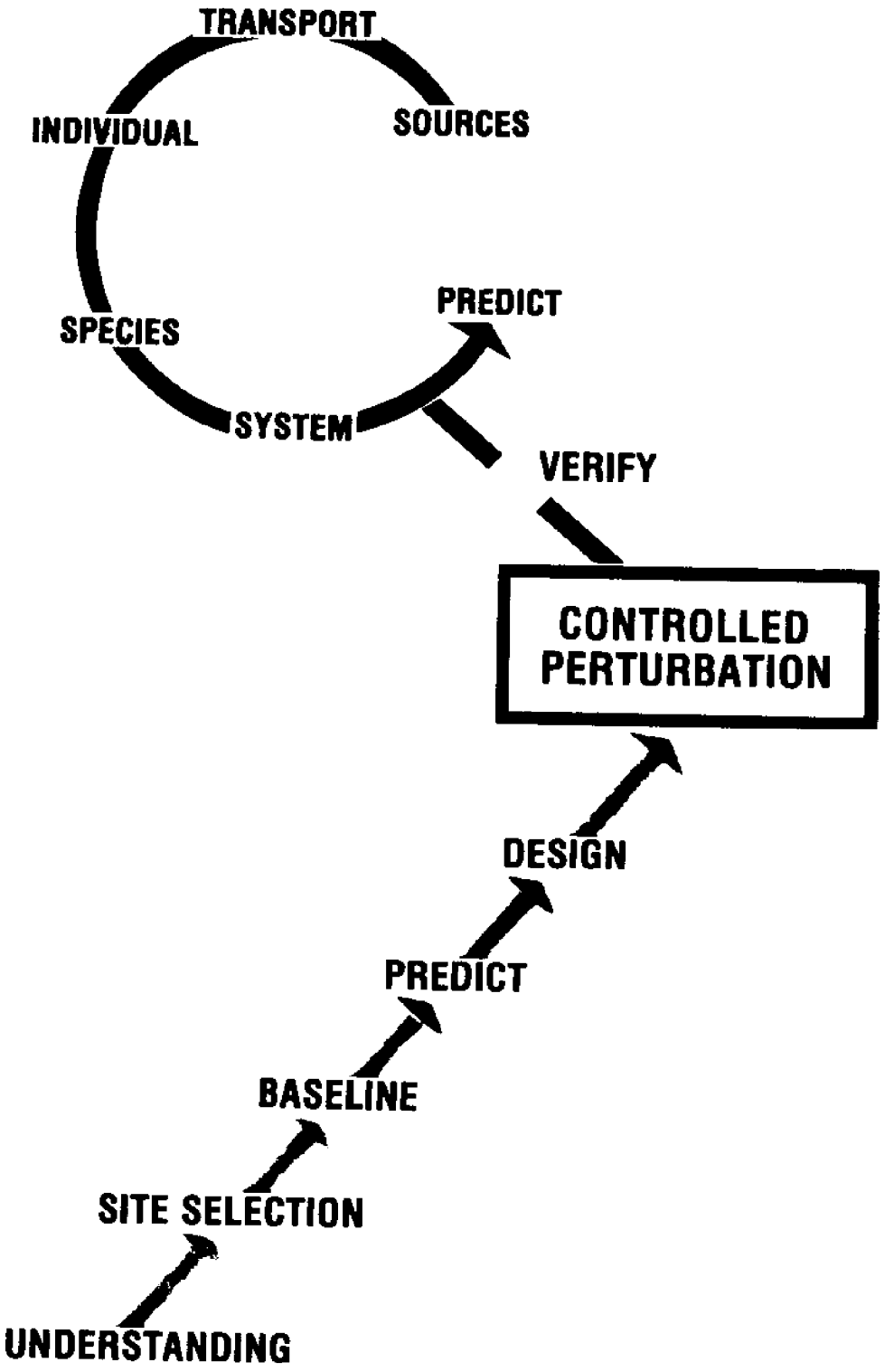
TRANSPORT
INDIVIDUAL
SOURCES
SPECIES
SYSTEM
PREDICT
VERIFY
CONTROLLED PERTURBATION
DESIGN
PREDICT
BASELINE
SITE SELECTION
UNDERSTANDING

Figure 12.

condition after the perturbation is removed. Then you make a final design and conduct the test to verify whether your understanding of the system and your model is correct and adequate. Now I assure you that if you don't do these kinds of controlled perturbations, then you will always have controversy as to whether your predictions are valid.

Okay, so there's the wheel and the arc (Figure 13). So much for the research this week. Just write it up and you're all done. I call this the "National Science Foundation Syndrome." The scientist does his work and he publishes it in referred publications. It comes out maybe a couple of years later, and is very fine work. It has a lot of big words in it, not too many pictures, it's very carefully phrased, and its conclusions are very tentative. They tend to be recommendations for future research. If you want to find it, Secretary of Interior Andrus, all you have to do is go to the University of Alaska or Georgetown University Library and look up your Journal of Applied Ecology or the Journal of Oceanography.

As a matter of fact the OCSEAP program is producing a great volume of reports. Secretary Andrus has plenty to read. One thing that OCSEAP feels very strongly about is translation of these reports. I call it translation because we're really trying to get it into language that decision-makers can understand and use in their limited time.

There are several steps or decision points in the BLM offshore leasing process (Figure 14). Before even an impact statement is written, BLM calls upon other agencies and interested parties to identify uses of other resources (such as fishing, mining, etc.) that may conflict with oil and gas development in that proposed lease area. On the basis of the response received, certain tracts or blocks within the lease area are selected for writing a Draft Environment Impact Statement. The DEIS uses the information from the OCSEAP and any other sources to assess the impact of the proposed development. Interior takes the available transport models, assumes a release of oil at selected tracts, calculates the track of that oil and notes what biology it intercepts. These results go into the DEIS. The DEIS is reviewed publicly, and perhaps some of the tracts proposed for sale are deleted as a result. Any new information coming from OCSEAP goes into this tract deselection process and into the Final Environmental Impact Statement. Then the staff of Interior puts together a "Program Decision Option Document" or PDOD. This presents to the Secretary several choices as to which combinations of tracts are to be put up for sale. The text discusses the oil potential and the environmental aspects of each of the options.

At each decision new environmental information is considered. If earlier information should prove to be faulty, the Secretary is informed even if he has already made his final selection. A situation like this arose in sale 39 in the Northeast Gulf of Alaska (NEGOA). OCSEAP discovered a gyre west of Kayak Island which could produce a

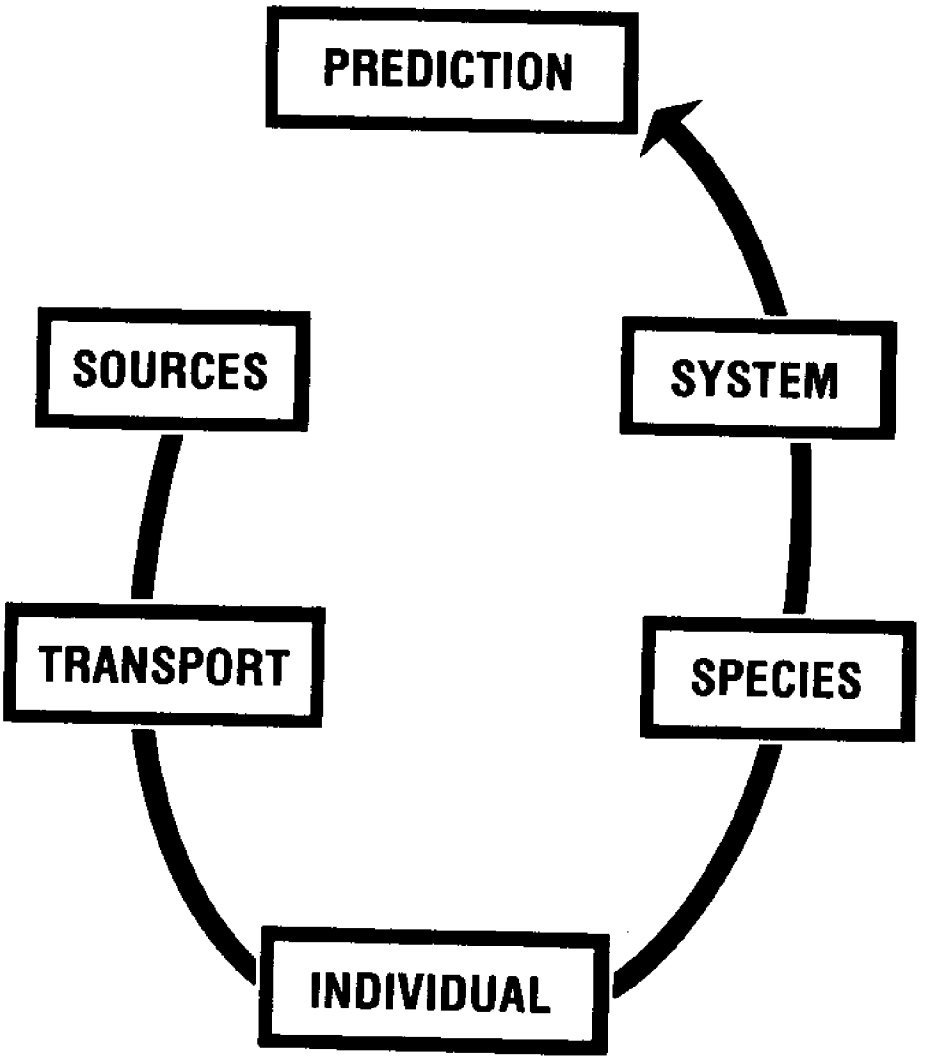

Figure 13.

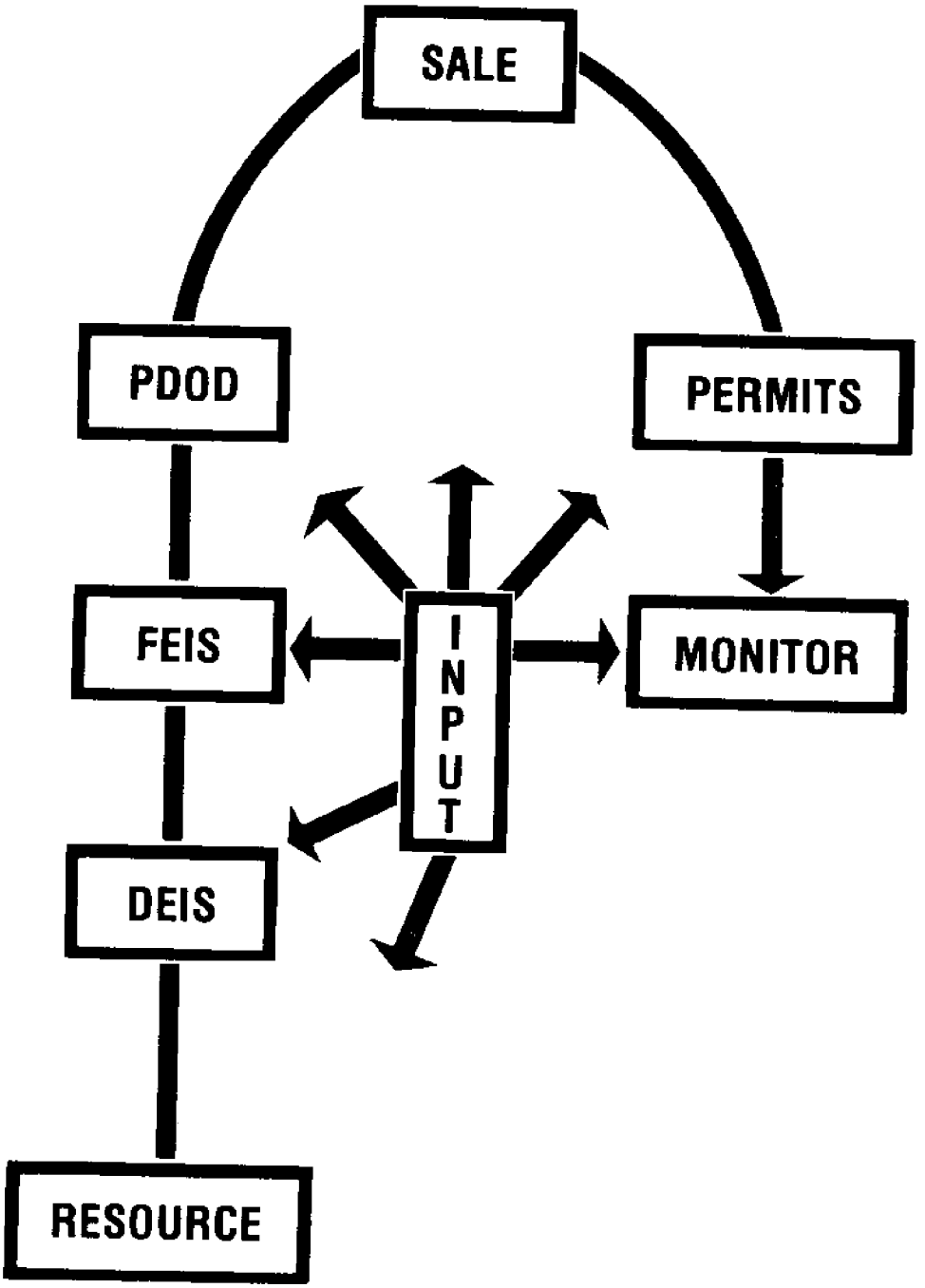

Figure 1C.

long residence time for oil in contact with the biology there, and potential for transport to the Copper River Delta critical habitat. We discovered this after the PDOD was written and the sale was announced. But the sale was modified at the last minute to delete the tracts where the gyre was. Following a sale, BLM asks for OCSEAP data for the particular sites where oil companies seek drilling permits. And, when the discovered field goes into production, OCSEAP input is used in the design of a monitoring program.

In responding to a recent request for all data for certain tracts in the NEGOA, we found that the data bank contained enough physical oceanography information for 7,000 pages of computer printout. It is an enormous task to condense this information and put it into a format that's usable (Figure 15). The format usually consists of maps, charts and tables, and can often be handled by computers. The OCSEAP has accepted the responsibility of summarizing the overwhelming volume of material coming from the program. You don't have to read 14 volumes of annual reports, because we produce a report about two inches thick which summarizes and organizes the knowledge by lease areas. This report comes out several months after the Principal Investigators' reports are printed. We have pretty good turnaround on those by the way. In about six weeks to two months after we get these reports from the Principal Investigators, we have them on the way to the printer, and the Government Printing Office has them out in a matter of about four weeks. We print them in an unedited form because we recognize the disadvantages of editing. By doing it this way we get a fast turnaround, and get it back to the Principal Investigators so that they can see what the other parties involved are doing. We get them to the BLM quickly and to anyone else who can use that information for a decision. We distribute upon request. This amounts to several hundred copies.

You know, you hear a lot about interdisciplinary studies and interdisciplinary reports. Many of these are reported on inside one cover. There is an introduction, sections on physical oceanography, meteorology, and chemistry, and perhaps even a section on recommendations for research. The recommendations for research are probably suggestions that, "We need to do a particular study on whales, clams or sediment" for example. These reports are stapled all together, covered and entitled "interdisciplinary work." That's damn well not enough. What we in OCSEAP strive for is to have a report that says "this is the way NEGOA works, this is the superposition of currents and biological systems, these are the critical processes and the key species, these are the critical habitats, these are the questions that should be answered, and these are the hazards that you risk with your decisions." That would be a sophisticated understanding that's not easy to come by. It's a full-time job for several people to learn all they can about a specific lease area. We don't have that kind of time. Therefore, we rely on the Principal Investigators and the knowledge they have in their heads (they don't put it all in those annual reports you know). We hold lease area synthesis meetings and we throw some of our own staff in with the experts to act as catalysts. Together they achieve

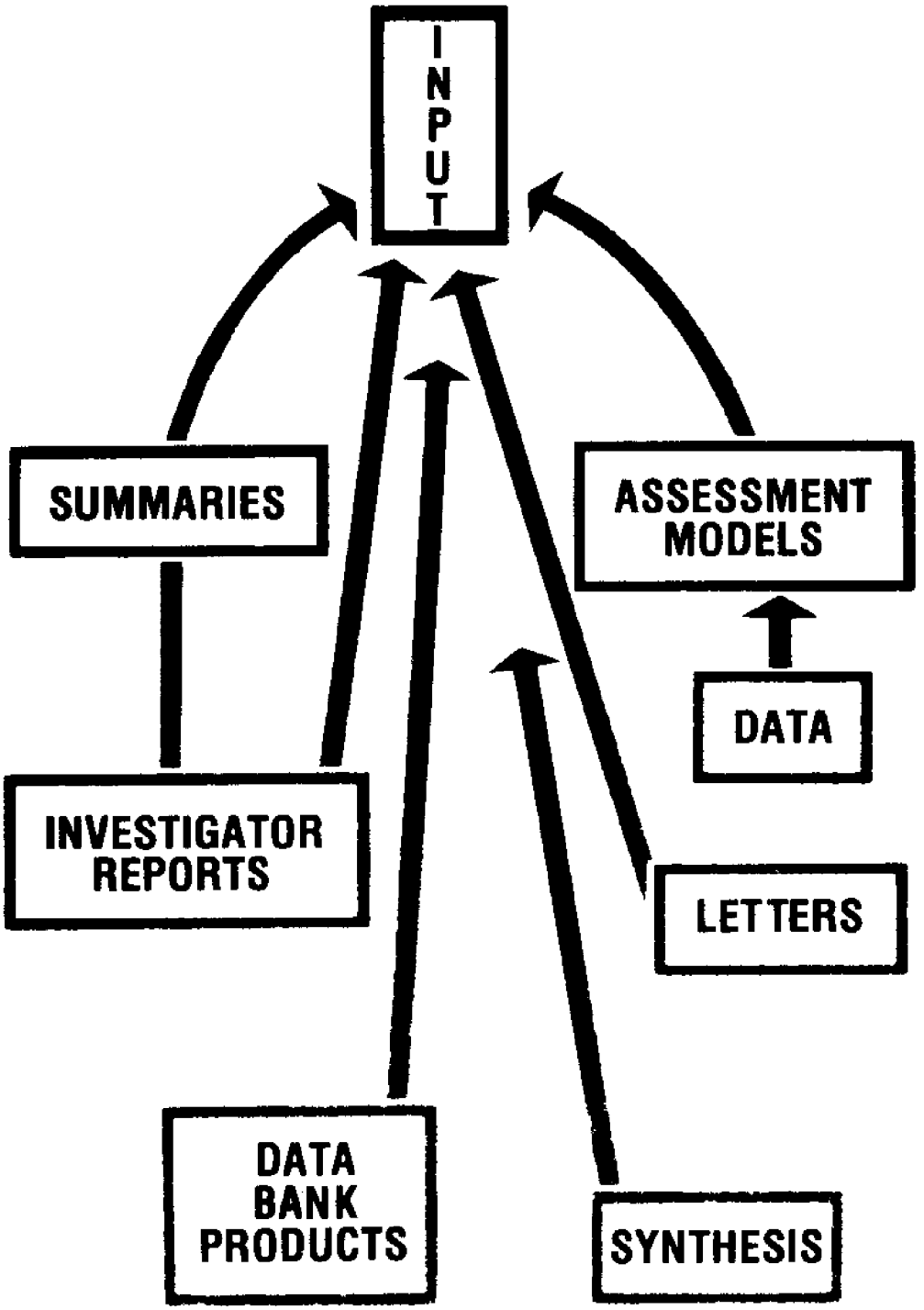
INPUT
SUMMARIES
ASSESSMENT MODELS
DATA
INVESTIGATOR REPORTS
LETTERS
DATA BANK PRODUCTS
SYNTHESIS

Figure 15.

an understanding of what we call "The Big Picture," which comes out as part of the report. We held such synthesis meetings on the Lower Cook, NEGOA, Kodiak, and Beaufort Sea--Chukchi Sea areas. Successive synthesis meetings next year will include the other five lease areas and will be able to build upon the past synthesis reports. Synthesis reports are some of the most valuable products that are going to come out of the program. These reports will rely a great deal on maps for presentation, and have in them a number of graphs, tables, and figures. Hopefully, they'll be in the kind of language that decision-makers can grasp, understand, and highlight.

These synthesis reports are a component of our "end products and deliverables" effort. We are striving to provide finite tools and summaries of immediate use to the non-scientist. These products include maps, models, statistical distributions, engineering data, summaries and collations from the data bank, and recommendations in special letters and special reports. All must be delivered in time to be useful. This concentration on utility has not degraded the science, but rather has added a sense of excitement at all levels of the program. We think we are succeeding at something that has never before been tried on such a scale.

OIL SPILLS: WEATHERING, POSSIBLE EFFECTS AND THEIR ALLEVIATION

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INTRODUCTION

This paper reviews the weathering and documented temporary effects of oil spills, and summarizes the advantages of chemically dispersing oil slicks. No attempt is made to give complete literature citations, but rather to select recent studies that highlight the various processes involved. For some processes, there are abundant studies; for others, there are few. Some areas require additional investigations to substantiate preliminary information.

Additional details and more complete discussion of oil spills and their effects are given in the National Academy of Sciences Report "Petroleum in the Marine Environment" (1975), and by McAuliffe, et al., (1975), and McAuliffe (1977a, b).

FATE OF SPILLED OILS

Table 1 summarizes the processes involved when oil is spilled on a water surface.

TABLE 1. Fate of Spilled Oil

I. Rapid

- A. Spreading and Movement
- B. Evaporation and Solution
- C. Emulsification, Dispersion, Sedimentation
- D. Direct Sea-Air Exchange

II. Slow

- A. Microbial Modification
- B. Organism Uptake and Depuration
- C. Chemical Modification

Dispersal and alteration will be influenced by location, wind, waves, currents, water depth, air and water temperatures, salinity, types of organisms, nutrients, and type of oil.

Spreading and Movement

Most oils added to calm water spread as a thin continuous layer, because of gravity and surface tension. In open water, spreading is aided by wind, wave motion, and currents. The interactions of wind and waves elongate and distort surface slicks (Jeffrey 1973, Murray 1975). Oil drift velocity is about 3 to 3.5 percent of the wind velocity (Nelson-Smith 1973, Smith 1968). On cold water, highly viscous oils such as Bunker C will not spread as rapidly as less viscous oils. Highly paraffinic crude oils with a high pour point, such as Minas from Indonesia, form semi-solid chunks when spilled on water. These chunks disperse much as solid particles would.

Spreading accelerates weathering by increasing the surface area of the oil exposed to air and seawater.

Evaporation of volatile hydrocarbons from oil slicks

Hydrocarbons evaporate according to their vapor pressures, which are closely related to molecular size. Rates of evaporation are directly dependent upon temperature, wind velocity, and oil slick agitation by waves. Table 2 summarizes the findings of several investigators on the loss of volatile hydrocarbons from oils on the sea surface.

TABLE 2. Loss of Volatile Hydrocarbons from Oils on the Sea Surface

	Investigators				
	Harrison et al. (1975)	Kinney et al. (1964)	McAuliffe (1977a)	Sivadier and Mikolaj (1973)	Smith and MacIntyre (1973)
Type of Oil	Crude	Crude	Crude	Crude	No. 2 Fuel
No. of Spills	5	1	4	2	1
Vol. Spilled, bbl	6.6	Small	10.5	0.02	4.8
Water, °C	24	25	11-14	19-20	5
Air, °C	21-25	--	12-17	28-30	5
Wind, knots	0-18	9-12	8-24	8-12	1-18
Waves	Calm to Whitecaps	--	1-5 ft		Calm to Whitecaps
Time for Hydrocarbon Loss:					
C_9 and lower	40-90 min	8 hrs (10% left)	4-8 hrs	90 min	
C_{10} and lower					7 hrs
C_{12} and lower	3-8 hrs				

In several investigations the rate of loss of volatile hydrocarbons was shown to vary as the wind and sea state changed. Smith and MacIntyre (1971) observed increased evaporation when the wind rose from relatively calm to 15-18 knots and seas built up to whitecaps. Harrison, et al., (1975) also noted increases in the loss of n-C_9 to n-C_{13} hydrocarbons from a south Louisiana crude oil with a sudden onset of whitecapping.

Figure 1 (typical of the investigations reported in Table 2) shows the loss of low-molecular-weight hydrocarbons over different periods of time from surface samples collected from an experimental spill of La Rosa crude oil (McAuliffe 1977a).

During the test spill, the water temperature was 14°C, the air temperature was 17°C, and wave heights were one to two feet. Winds subsequently varied from 10 to 18 knots, with occasional whitecaps.

The above studies show the rather rapid loss of low-molecular-weight hydrocarbons from slicks. Because these low-molecular-weight hydrocarbons (particularly the aromatics) are thought to be the principal cause of immediate toxicity to aquatic organisms, the biological impact potential of a spill is quickly reduced.

Low-Molecular-Weight Hydrocarbons in Waters Under Oil Slicks

Four experimental spills (10.5 bbl each) were made on the open ocean off the U.S. east coast, two with a 39.0° API gravity Murban crude oil (Abu Dhabi) and two with a 23.9° API gravity Venezuelean La Rosa crude oil (Johanson et al.). A total of 68 water samples were collected at different times at five and ten feet under the oil slicks. Each water sample was analyzed for C_2 to C_{10} low-molecular-weight hydrocarbons using a method sensitive to less than 1 µg/l (McAuliffe 1971).

Truly dissolved hydrocarbons were not found in these near-surface water samples 15 minutes or later after the oil discharges (McAuliffe 1977a). Apparently hydrocarbons that dissolved from the slicks quickly evaporated to the atmosphere. This conclusion (discussed below) is based upon the relative concentrations of hydrocarbons observed in the dispersed oil under the oil slicks.

Of the 68 water samples collected, C_2 to C_{10} hydrocarbons were found in only five. These were the first samples collected 15 to 20 minutes after each spill (the time required for the research vessel to sample after discharging the oil). Low-molecular-weight hydrocarbons were not found in water samples collected 30 minutes or later after the spills. Table 3 shows concentrations of individual low-molecular-weight hydrocarbons in the water samples collected. The highest observed total concentration was 60 µg/l (ppb) in the five foot water sample collected after the first Murban spill (39° API gravity crude). Total hydrocarbon concentrations in the other four samples ranged from 2 to 16 ppb. The difference is probably due to higher winds at the time of the first Murban spill.

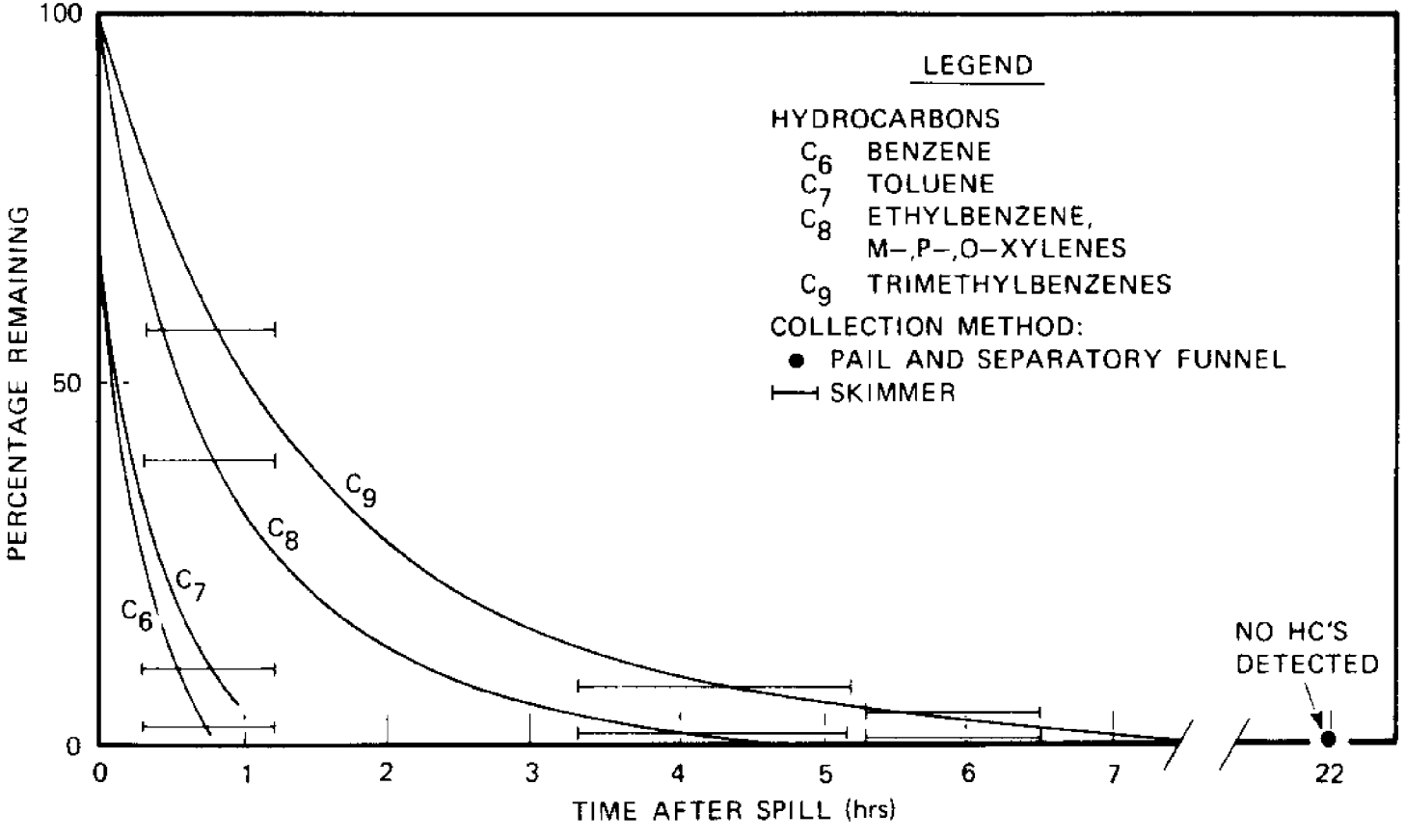

FIGURE 1. Percent of aromatic hydrocarbons remaining in surface oil slick--La Rosa crude oil (Venezuela)

TABLE 3. Hydrocarbons Dissolved in Water Samples under Oil Slicks

Oil Spill	Murban 1	La Rosa 2	Murban 2	Murban 2	Murban 2
Time After Spill, Min	20	19	15	15	18
Depth, Ft	5	5	5	10	5
Hydrocarbon	Concentrations in µg/l (ppb)				
Ethane	(a)				
Propane					
Isobutane	0.01	0.02			
n-Butane	0.02	0.04			
Isopentane	0.01	0.05			
n-Pentane	0.04	0.04			
Hexanes	0.07				
n-Hexane	0.24				
Methylcyclopentane	0.20	0.10	0.05	0.04	
Benzene	1.58	0.50	0.51	0.25	0.12
Cyclohexane	(b)	(b)	0.68		
n-Heptane	2.30	0.54			
Methylcyclohexane	7.60	0.80	0.30		
Toluene	6.20	0.61	1.22	0.61	0.41
Ethylbenzene	5.30	0.55	1.66	0.34	0.50
m-, p-Xylene	11.40	1.43	3.57	0.71	1.07
o-Xylene	12.20	0.79	3.95	0.39	0.79
Trimethylbenzenes	12.90	0.23	3.87		
Total Saturates	10.50	1.59	1.03	0.04	
Total Aromatics	49.60	4.11	14.80	2.40	2.89
Total Hydrocarbons	60.00	5.70	16.00	2.40	2.90

(a) No value, not detected.
(b) Present, but not resolved by GC integrator from benzene.

The relative concentrations of the individual low-molecular-weight hydrocarbons in Table 3 indicate that these were residual in dispersed oil droplets in the water column, and were not in true solution at the time of collection. As for evaporation, hydrocarbons (each class, i.e., alkane, cycloalkane, and aromatic) would dissolve into water inversely to their molecular weights with evaporation prevented. The smaller the molecule, the higher the amount found in solution for a given concentration in the oil phase. Table 3 shows little or none of the lowest molecular-weight hydrocarbons (C_2 to C_6) in water samples, and thus the conclusion that truly dissolved hydrocarbons were not present under the oil slicks. The measured hydrocarbons shown in Table 3 have relative concentrations expected for weathered oil and resemble the evaporative loss of volatile hydrocarbons from surface slicks (Figure 1).

A similar distribution of these hydrocarbons was observed in a chemically dispersed emulsion plume of 34° API gravity crude oil in a Gulf of Mexico spill (McAuliffe et al. 1975).

Emulsification, Dispersion, and Sedimentation

Many crude oil slicks (particularly those with high API gravities) break into droplets and disperse rather quickly. During the Chevron Gulf of Mexico spill of 34° API gravity crude oil, the life of the slick was about one day (McAuliffe, et al. 1975, Murray 1975). Kinney et al. (1969) found that the half-life of Cook Inlet crude on 5°C Cook Inlet water was one day, with complete disappearance in four to five days.

Oil no longer observable as a surface slick apparently disperses mainly into near-surface water as droplets or attached to particulates. Brown et al. (1973), Brown and Huffman (1976), and Brown and Searl (1976) measured nonvolatile hydrocarbons along tanker routes in the Atlantic, Pacific, and Indian Oceans and the Caribbean Sea. Concentrations at 10 and 30 feet were about 40 percent those observed in surface samples. This indicates that the hydrocarbons are particles floating in near-surface waters. They are continually mixed downward by wave action, but return to the surface because they are less dense than sea water. If the measured hydrocarbons were in solution, a relatively uniform concentration with depth would be observed as has been shown for methane by Swinnerton et al. (1969), and Swinnerton and Lamontagne (1974).

Some crude oils have a tendency to form water-in-oil emulsions, frequently referred to as "chocolate mousse". These emulsions ultimately can become tar balls that strand on beaches. However, crude oil spills probably contribute a minor amount of tar balls, as compared with washings of tanker compartments, Bunker C discharges, and bilge pumping from all vessels (NAS 1975).

Some spilled oil ultimately sediments, apparently through association with suspended inorganic mineral matter. In one case of a relatively large spill in 40 feet of water, about one percent of the oil was identified in bottom sediments within five miles of the spill site (McAuliffe et al. 1975).

Biodegradation of Oil

All natural waters tested contained hydrocarbon-utilizing bacteria, yeasts, and fungi (Atlas 1973, Button 1974, Cundell and Traxler 1973, Dean-Raymond and Bartha 1975, Kinney et al. 1969, Robertson et al. 1973, Traxler and Cundell 1975-1976, Walker et al. 1973). This is especially true for waters exposed to recurring or continuous petroleum contamination, such as seeps or discharges from municipal and industrial sources.

Very large contributions of petroleum hydrocarbons to oceans have occurred throughout geological times from seeps (Wilson et al. 1974), and erosion of oil sands and source rocks. However, there is no evidence of hydrocarbon buildup in the oceans (McAuliffe 1976). Oxidation by microorganisms and photooxidation are probably the major ways hydrocarbons are removed from the environment.

Major portions of oil biodegrade even in extremely cold marine environments (Atlas 1973-1974, Button 1974, Cundell and Traxler 1973, Kinney et al. 1969, Robertson et al. 1973, Traxler and Cundell 1975-1976). Table 4 shows data on the percent loss of crude oils at different temperatures.

TABLE 4. Biodegradation Rates of Crude Oils at Various Temperatures

Conditions	Investigators									
	Atlas (1973)				Kinney et al. (1969)	Zobell (1973)		Robertson et al. (1973)	Walker and Colwell (1977)	
Crude Oil	Prudhoe Bay				Cook Inlet	Prudhoe Bay		Cook Inlet	South Louisiana	
	Lab		Field		Lab	Lab		Lab	Field	
Temp. °C	5	25	5-12		10	-1.1	8	10	30	
Nutrients Added	no	no	no	yes	no	yes	yes	no	no	
Percent Lost After Given Days	21	39	60	80	Complete	61	82	90	97	
	3	3	35	35	30-60	70	70	30	21	

Additional cold-water losses were observed by Atlas (1974) in experiments conducted with Prudhoe Bay crude oil on small ponds near Barrow, Alaska. He found the following three-week losses: 70 percent when treated with organisms, nitrogen, and phosphorus; 40 percent when treated with nitrogen and phosphorus; and 25 percent when untreated. Button (1974) documented the conversion of $n\text{-}C_{12}$ to CO_2 in waters at Port Valdez (3°C); Point Barrow, through shore ice (2°C); and under an Arctic ice station (-1.7°C).

Oil that sinks to the bottom also biodegrades. Crude oil that sedimented in 40 feet of water during a Gulf of Mexico spill underwent relatively rapid biodegradation and was gone after 11 months (McAuliffe et al. 1975). Walker et al. (1976) found hydrocarbon-degrading bacteria in coastal and deep marine sediment samples collected off the Atlantic coast. Bacteria in the deep ocean sediment (2200 to 4400m) accomplished significantly greater degradation in the laboratory under ambient conditions than did bacteria from coastal sediment samples. However, if oil penetrates into sediments where oxygen is limited, anaerobic degradation of petroleum by microorganisms appears to be slow (Blumer and Sass 1972). Nevertheless Shelton and Hunter (1975) demonstrated the loss of oil from river-bottom sediments when anaerobic conditions occurred in the overlying water.

Hydrocarbon Uptake and Depuration by Organisms

Larger organisms may ingest dispersed particulate oil or dissolved hydrocarbons (if they are present in aqueous solution). Normally exposure to dissolved hydrocarbons is minimal. A number of laboratory tests exposing various species of organisms to both dispersed and dissolved hydrocarbons have demonstrated relatively rapid uptake. Almost universally these studies have shown rapid depuration of ingested oil or metabolized products when exposure ceases (Corner et al. 1973, DiSalvo and Guard 1975, Fossato and Canzonier 1976, Lee 1975, NAS 1975, Neff and Anderson 1975, Rice et al. 1976).

Organisms such as clams and oysters eliminate ingested hydrocarbons more slowly than do fish and other organisms with metabolic processes (livers). Zooplankton appear to eliminate most ingested particulate oil in feces (NAS 1975). Conover (1971) noted that zooklankton ingested Bunder C fuel oil droplets during an actual spill. Thus, larger organisms may contribute to the breakup, dispersion, and destruction of petroleum hydrocarbons, complementing oxidation by microorganisms.

Photochemical modification

Photochemical processes alter oils and partly account for the oxidation of hydrocarbons. Klein and Pilpel (1974) demonstrated photooxidation of crude oils irradiated with a mercury arc. In laboratory studies Hanson (1975) found the principal oxidation products to be aliphatic and aromatic acids, with lesser production of alcohols and phenols.

Evidence from field studies suggests that photooxidation may be important. If biodegradation were the only mechanism destroying hydrocarbons in near-surface waters, the proportions of aromatic and cycloalkane hydrocarbons would increase relative to the normal and branched alkanes as nonvolatile oils weathered, compared to the relative concentrations of these classes of compounds in crude oils and refined products discharged from transportation sources (biodegradation rates decrease in the order: normal alkanes, branched alkanes, aromatics, and cycloalkanes (Perry and Cerniglia 1973). Brown and co-workers, as reported above, measured the proportions of alkanes, cycloalkanes and aromatic hydrocarbons in nonvolatile dispersed oil along tanker routes. They found proportionally more cycloalkanes, but fewer aromatics. This suggests that aromatic hydrocarbons (known to be photosensitive) are probably being destroyed by sunlight. Ledet and Laseter (1974) found that hydrocarbons at the air-sea interface in the Gulf of Mexico consisted of mostly alkanes and cycloalkanes.

KNOWN ADVERSE EFFECTS OF SPILLED OIL

Table 5 lists the documented temporary adverse effects from spilled oil.

The most obvious one is to contacted seabirds, should they be present in the spill area. Oil may also adversely affect sea otters, although this has not been documented. Large slicks temporarily restrict fishing. Although a slick may have no adverse effect on the underlying fish and shellfish, the catch and trawl can become contaminated by pulling the trawl up through a slick.

TABLE 5. Temporary Adverse Effects of Spilled Oil

I. Oil on the water surface

   A. Birds, sea otter?
   B. Restricted fishing due to gear fouling

II. Stranded oil on shorelines

   A. Reduced aesthetics
   B. Kill of some species of plants and animals on sandy beaches, rocky intertidal and marshes
   C. Incorporation into sand or marsh sediments

The other very obvious effect occurs when oil concentrates on shorelines, making recreational beaches temporarily unusable. Studies of oil spills have also shown some adverse effects to

some species of plants and animals in the intertidal zones and limited damage subtidally. Oil that penetrates into sand or marsh sediments can persist for several years.

Many of the listed adverse effects can be alleviated or minimized by chemical dispersion.

DISPERSING OIL SPILLS WITH CHEMICALS

The behavior and weathering of oil slicks can be markedly altered by chemical dispersants (surfactants), to form oil-in-water emulsions. This accelerates weathering of toxic constituents and otherwise alters the properties of oil, reducing or eliminating most of the known adverse effects.

Many of the new dispersant formulations are very much less toxic than those used at the time of the Torrey Canyon spill. Thus their use should not add appreciably to adverse effects of spilled oil and the overall effect should be very beneficial.

Oil-in-Water Emulsions

Stable oil-in-water emulsions are formed if sufficient emulsifier is present to form a film at the oil-water interface. Emulsifying agents (surfactants) have long hydrocarbon chains soluble in oil, and polar groups (such as carboxylate, sulfonate, ether, and alcohol) that are soluble in water (Becker 1975).

Oil-in-water emulsion droplets can be formed by applying from two to ten percent dispersant relative to the amount of oil. The droplets generally exceed 0.1 μm diameter, and often have median diameters ranging from 10 to 40 μ. The distribution of droplet sizes for a given emulsion cover a relatively large size range (Becker 1965, McAuliffe 1973).

Movement and Dilution of Emulsified Oil

An important advantage of emulsification of oil slicks is rapid dilution and downward mixing in near-surface waters. This removes the oil from most of the wind's influence, so it does not travel as far as a surface slick. During the Chevron Gulf of Mexico spill (McAuliffe et al. 1975), chemical dispersants were sprayed on the platform and surrounding water. The dispersed oil was observed as a plume only one to one and a half miles from the spill site, whereas untreated surface slicks extended six to nine miles on most days and 45 to 55 miles on two occasions.

Dispersed oil in the emulsion plume was found in surface water samples, but not at 20 to 40 foot depths. Dispersed oil droplets mix downward in the near-surface waters by wave motion, but are buoyant enough to return toward the surface. Thus emulsifing oil does not cause it to sink. In fact, as discussed below, emulsified oil droplets have less tendency to adhere to suspended mineral particles and should thereby reduce the amount of oil that may ultimately sink.

Limiting the travel of oil from the spill site by dispersing it reduces the need for oil spill trajectory models or refinement of existing models. Oil that does not travel far is less likely to strand on beaches. Areas temporarily restricted to commercial or sport fishing by surface oil slicks would be much reduced.

Preventing slicks from stranding is very important. Stranded oil has adversely affected some species of intertidal organisms (Chan 1973 and 1975, Cimberg et al. 1973, NAS 1975, Smith 1968, Strachan 1972, Straughan 1971 and 1972, Wormald 1976), coated rocky substrates and penetrated into sandy beaches and marshland (Baker 1970, 1971 and 1973, Berns and Teal 1971, Morris and Butler 1973). Oil that penetrates into sediments biodegrades slowly because of low oxygen concentrations, and oil on sandy beaches may subsequently be eroded and redeposited in near-shore sediments. Stranded oil also decreases the esthetic value of beaches.

Some oils may form water-in-oil emulsions known as "chocolate mousse", which slows weathering (Harrison et al. 1975, Regnier and Scott 1975), and may generate "tar balls", some of which could strand. These water-in-oil emulsions have viscosities as high as and often higher than those of the original crude oils. Chemical dispersants may help prevent the formation of viscous water-in-oil emulsions, prevent formation of tar balls, and accelerate weathering.

Acceleration of Weathering and Biodegradation

The formation of small oil droplets results in a large ratio of surface area to oil volume, and accelerates evaportion, solution, and biodegradation (McAuliffe 1977a). These small droplets lose the volatile hydrocarbons more rapidly than from slicks, thereby reducing the toxicity of oil that organisms come into contact with or ingest.

Concentrations of dispersed oil in the water are not high. During the Chevron Gulf of Mexico spill when 1500 bbl of oil per day were being discharged, dispersed oil in the emulsion plume at the platform ranged from 2 to 60 mg/l (ppm). These concentrations decreased to 1 ppm at one mile down current. Thus, organisms were exposed to decreasing concentrations of dispersed oil and for only a short time.

Bacteria operate at the oil-water interface, so the increased surface accelerates biodegradation (Gatellier et al. 1973) by making the oil more readily available to bacteria. The movement of emulsion droplets through water also makes oxygen and nutrients more readily available to microorganisms.

Furthermore, exposing a large surface area per unit volume of oil may increase photooxidation in near-surface waters (Brown et al. 1973, Brown and Huffman 1976, Brown and Searl 1976, Klein and Pilpel 1974).

Dispersion Lessens Oil Adhesion

Normally oils adhere to almost all solid surfaces. However, droplets in an oil-in-water emulsion do not stick to each other nor to solid surfaces. Thus dispersants reduce adhesion of emulsified oil droplets to suspended solid mineral particles, and thereby decrease the amount of oil that sinks (Canevari 1971). This mechanism can be particularly effective when a dispersed oil slick encounters turbid water such as that generated by rivers. Without emulsification the oil could sink and be concentrated in sediments at the zones of mixing (Kolpack et al. 1971).

If chemically dispersed oil from a nearshore spill stranded in the intertidal zone, it should have less tendency than untreated oil to adhere to sand, rocks, and marine plants and animals. The lowered adhesion should minimize or eliminate the smothering of intertidal marine life that has occurred with nondispersed, partly weathered crude oil (Straughn 1971) or viscous Bunker C (Chan 1973). Most of the emulsified oil would be expected to wash out with the receding and subsequent tides.

Reduced adhesion should also lessen the adverse effects of oil on seabirds. Chemically dispersed oil does not wet feathers like nondispersed oil. Further, the smaller areal extent of an emulsion plume, compared with the much larger slick of unemulsified oil, should lessen the opportunity for birds to be contacted by oil.

SUMMARY

Oil spilled on water undergoes alteration by physical, chemical, and biological processes. Rapid physical processes include spreading, movement with winds and water currents, evaporation of volatile components, solution, water-in-oil emulsification, dispersion as small droplets into water, spray injection into the air, and sedimentation.

As the oil spreads, less rapid biological and photochemical processes start. Biolgical processes include degradation by microorganisms and uptake by larger organisms. The latter is followed by either discharge or metabolism of the ingested oil. Photooxidation destroys hydrocarbons, especially aromatics.

Low-molecular-weight hydrocarbons rapidly evaporate, and the very small amounts of these that dissolve quickly evaporate from near-surface waters.

Surface oil slicks can adversely affect birds, possibly sea otters, and can foul fishing gear. If oil strands, it is concentrated and can kill some shoreline species of plants and animals.

Chemical dispersants can be used to change an oil slick into a dilute oil-in-water emulsion. Dispersed oil does not travel as far as in a slick, and shorelines are less threatened. Weathering processes of dispersed oil are accelerated, oil toxicity is more quickly reduced, and most of the known adverse effects from oil spills are lessened or eliminated.

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MARINE RESEARCH BY ADF&G IN KACHEMAK BAY

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Kachemak Bay, on a per-unit of area basis, may well be one of the most highly productive marine environments in the world. This contention is based upon historical harvest data and results of marine studies by the Department of Fish and Game and other resource agencies. Five species of salmon, as well as king crab, tanner crab, dungeness crab, shrimp (five species), herring, and halibut are all harvested commercially from Kachemak Bay. (Table 1).

The average annual catch from shellfish products alone is nearly 10 million pounds and most of this is from an area in the outer bay of about 100 square miles. To put the importance of Kachemak Bay into proper perspective it comprises less than five percent of the marine waters of the Cook Inlet management area yet produces, on an annual basis, 60 percent of the areas total shellfish products. (Figure 1). In addition, Kachemak Bay supports major sport and subsistence fisheries and, although exact figures from these fisheries are not available, there is no question that substantial harvests of halibut, crab, shrimp, salmon and other sports fish are made annually. Concern for this valuable fisheries resource was raised by the state's oil and gas leasing of outer Kachemak Bay in 1973. (Figure 2). The lease tracts were in the outer bay and those with the greatest petroleum potential were also in the same area where the major part of the commercial shellfish harvest takes place, as well as being adjacent to several major salmon streams (Figures 3-7).

As a response to this concern over the state's oil and gas leasing, the legislature funded a comprehensive baseline study of the marine environment in Kachemak Bay. A total of ten separate studies were undertaken during 1975 and 1976 by the Department of Fish and Game. Certain studies were performed directly by the Coastal Habitat Protection section while others were performed by contract to other agencies under general supervision of Department Habitat biologists. (Table 2).

A listing of these studies and a brief summary of salient findings as they relate to potential impact from oil and gas development follows:

TABLE 1. Kachemak Bay Commercial Fisheries Harvest, 1969-1976[1]

Numbers of Salmon

Year	Kings	Reds	Cohos	Pinks	Chums	Total
1969	59	12,578	485	70,753	2,600	86,475
1970	91	12,245	3,705	208,174	8,174	232,389
1971	41	18,403	3,151	50,066	2,857	74,518
1972	69	31,345	1,283	9,126	4,936	46,759
1973	139	24,072	1,241	97,574	3,588	126,614
1974	182	27,029	3,054	48,875	2,725	81,865
1975	142	27,393	3,039	893,709	5,428	929,711

Shellfish (Pounds)

Year	King Crab	Tanner Crab	Shrimp	Dungeness Crab
1969	1,302,544	1,436,680	1,849,710	49,894
1970	1,501,288	1,152,609	5,817,633	209,819
1971	1,251,142	1,186,488	5,451,340	97,161
1972	1,900,006	2,942,082	5,548,507	38,930
1973	2,114,841	3,763,060	4,876,804	310,048
1974	1,505,493	1,129,099	5,748,919	721,243
1975	1,460,984	1,129,777	4,752,139	362,815
1976	1,800,000	1,500,000	6,150,000	135,000

Year	Shellfish Total
1969	4,638,838
1970	8,681,349
1971	7,986,131
1972	10,429,585
1973	11,064,753
1974	9,164,753
1975	7,705,715
1976	9,585,000

Year	Herring
1969	1.1 Million Pounds
1970	5.4 Million Pounds
1971	25,000 Pounds
1972	2,000 Pounds
1973	407,500 Pounds
1974	219,359 Pounds
1975	48,833 Pounds
1976	-0-

[1] 1976 data preliminary

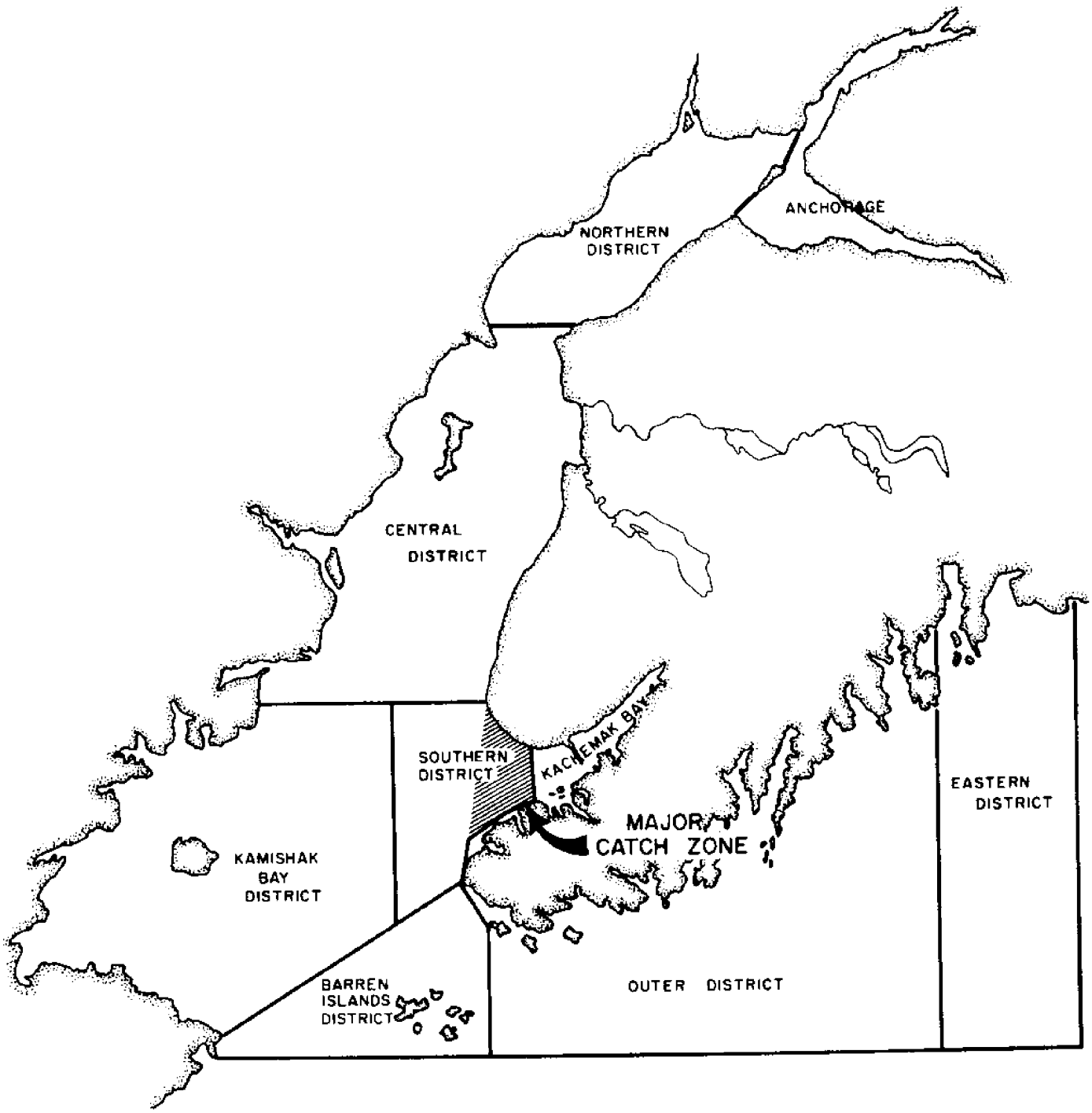

Figure 1. Kachemak Bay - Comprises less than 5% of management area yet produces 60% of shellfish catch.

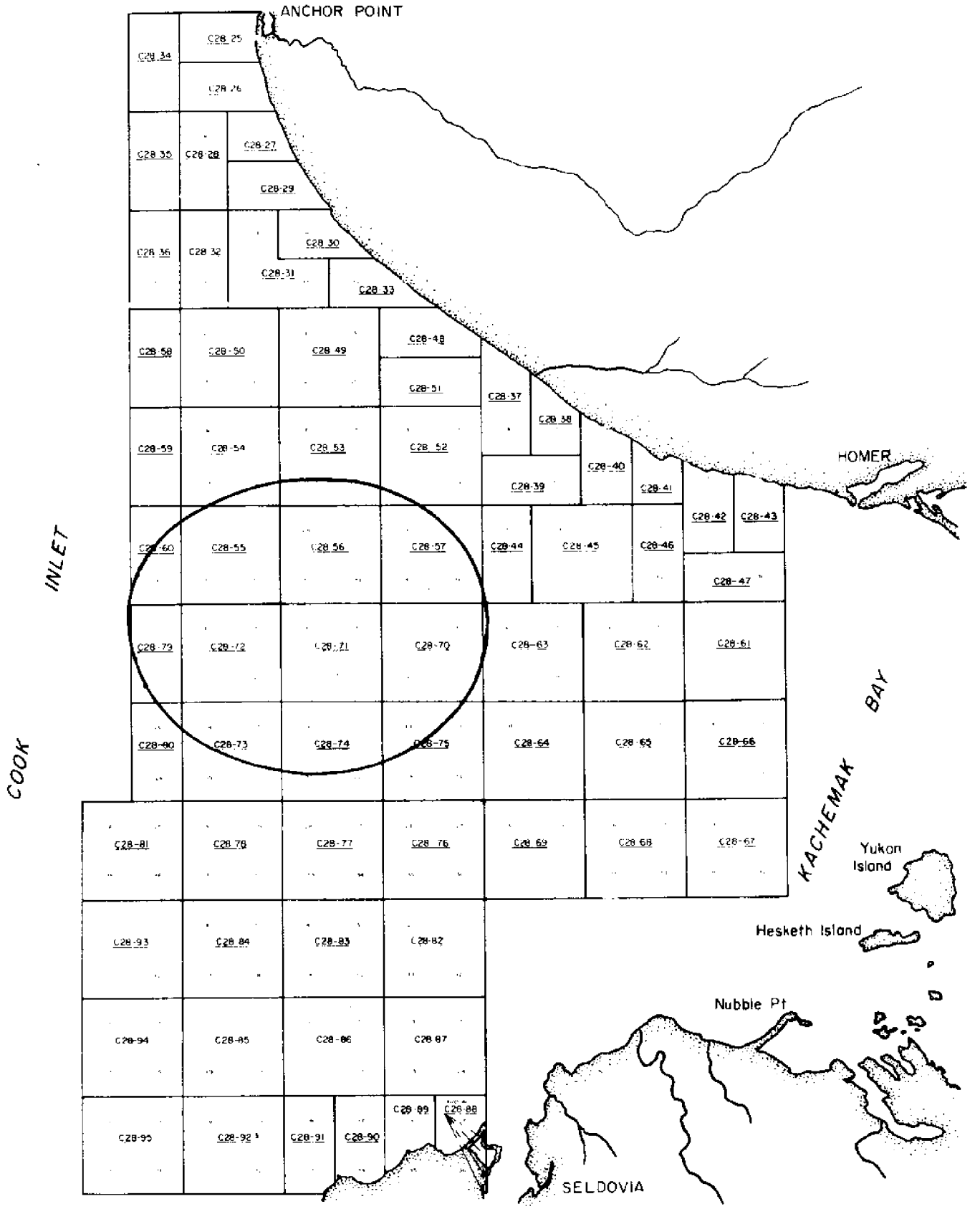

Figure 2. 28th Oil and Gas Lease Sale Area, Kachemak Bay
○ - Greatest petroleum potential

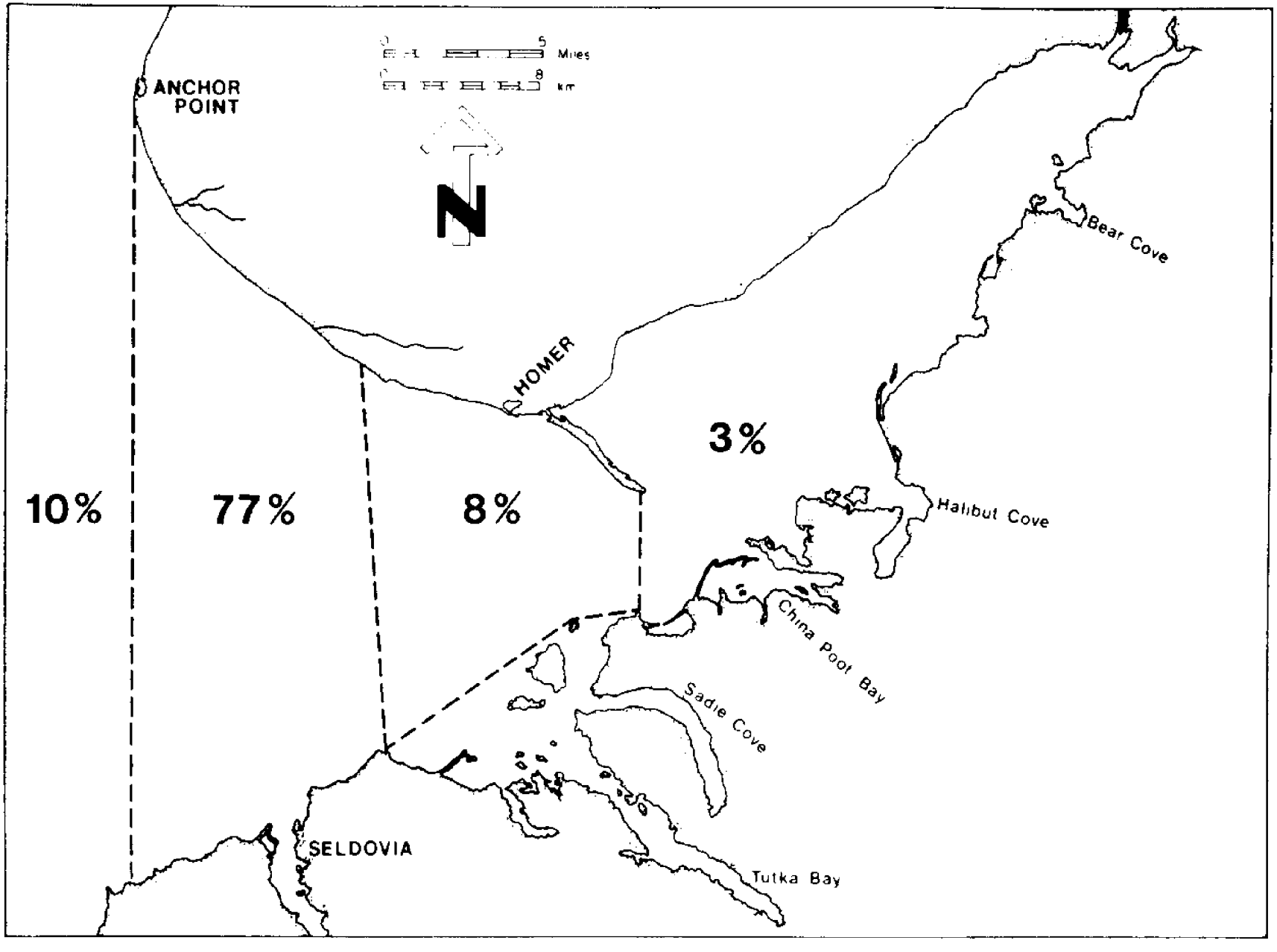

Figure 3. Distribution of Commercial King Crab Catch in Kachemak Bay, 1968-1975.

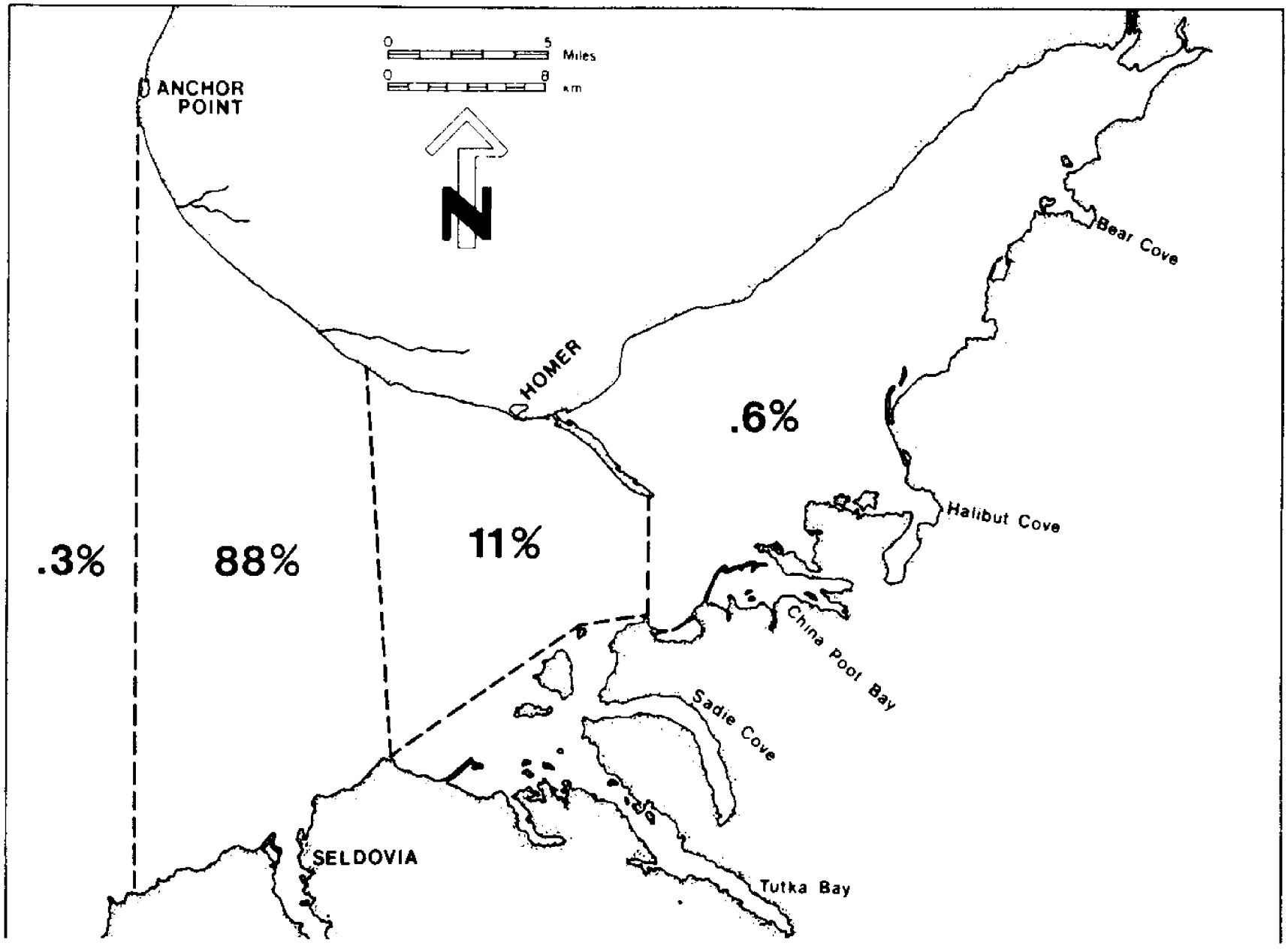

Figure 4. Distribution of Commercial Tanner Crab Catch in Kachemak Bay, 1968-1975.

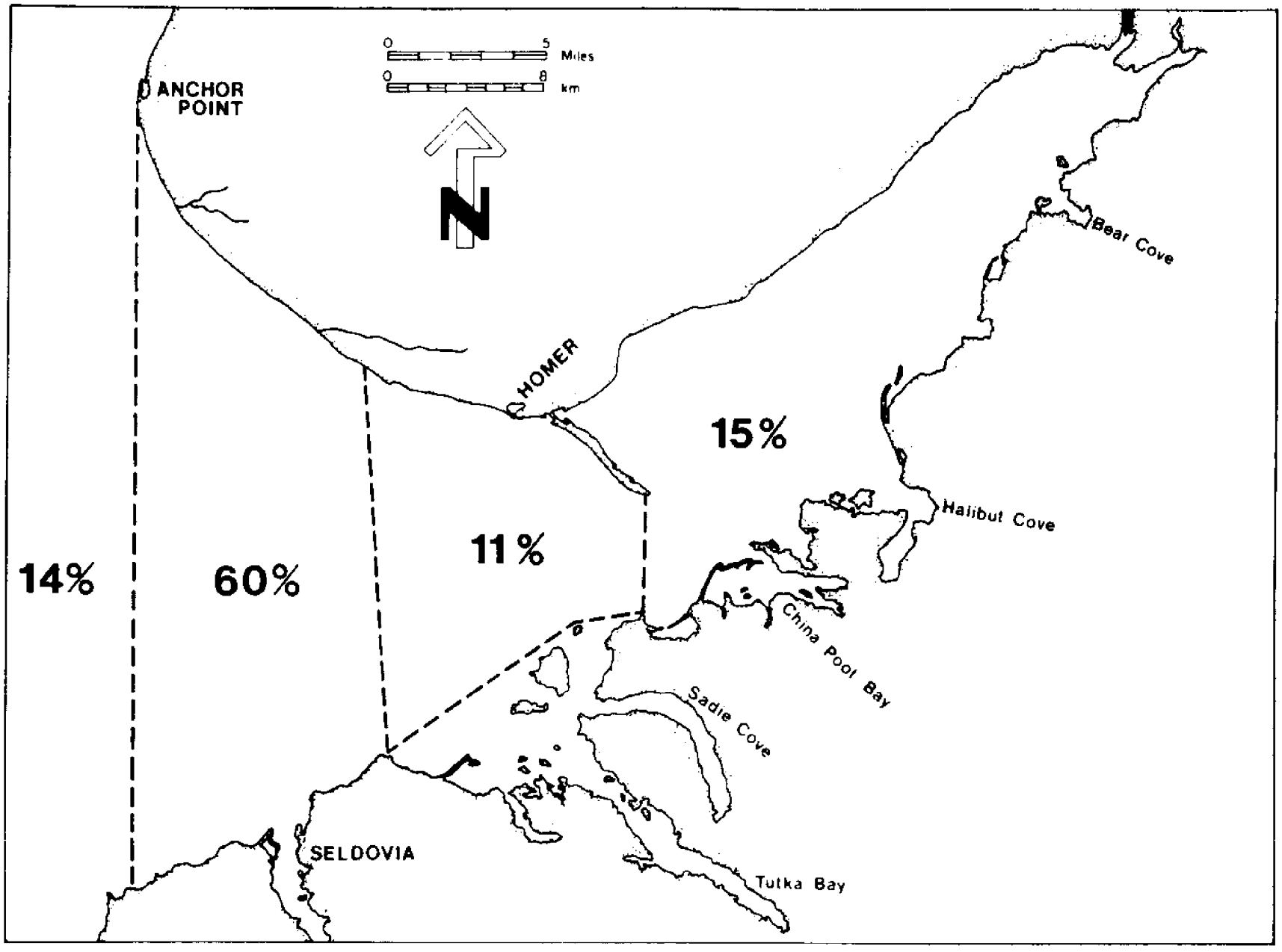

Figure 5. Distribution of Commercial Dungeness Crab Catch in Kachemak Bay, 1968-1975.

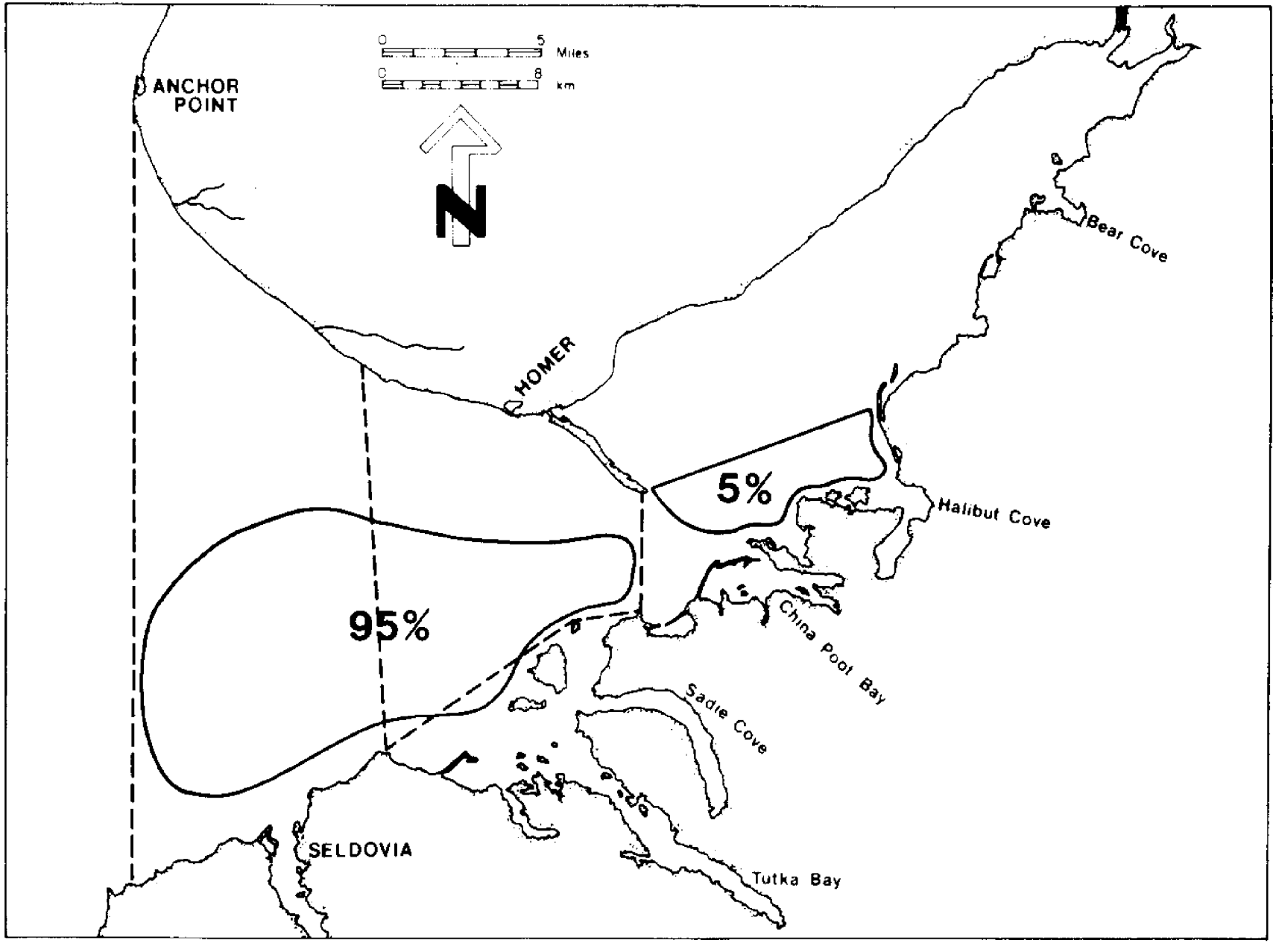

Figure 6. Distribution of Commercial Shrimp Catch in Kachemak Bay, 1968-1975.

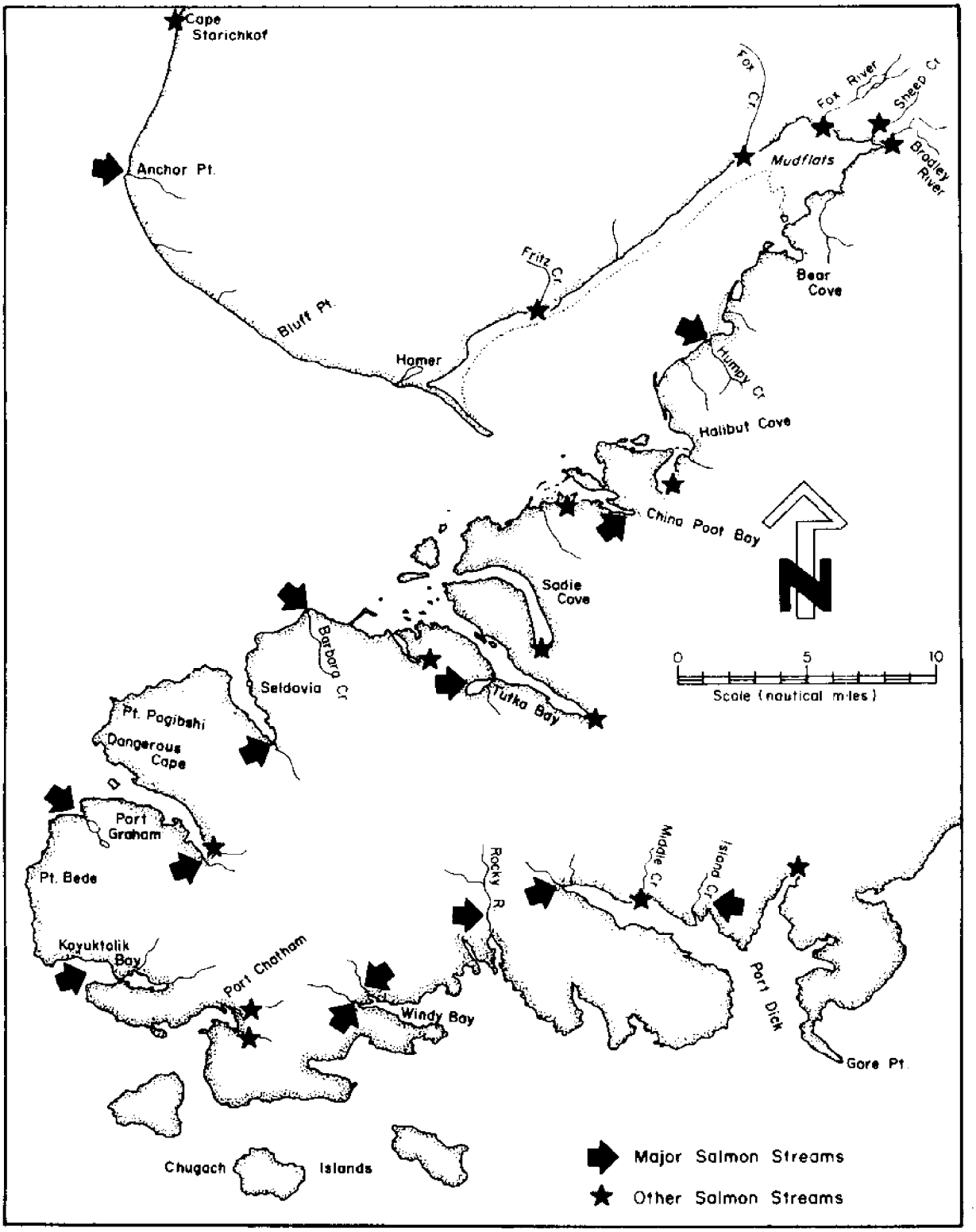

Figure 7. Anadramous Streams of Kachemak Bay and Outer District.

TABLE 2. Kachemak Bay Studies, 1975-76.

	Name of Study	Principal Investigator	Affiliation
1.	Coastal Morphology and Sedimentation	Miles Hayes	U.S. Carolina
2.	Water Circulation	David Burbank	ADF&G
3.	Larval Shellfish Distribution	Evan Haynes	NMFS
4.	Post Larval King Crab Distribution	Sundberg & Clausen	ADF&G
5.	Food Habits Commercial Species	John Crow	Rutgers U.
6.	Benthic Reconnaissance	Bill Driskell	ADF&G
7.	Marine Bird Distribution	David Erikson	ADF&G
8.	Marine Plant Communities	Rick Rosenthal	Dames & Moore
9.	Beach Drift Composition	Artina Cunning	ADF&G
10.	Baseline Hydrocarbons	David Shaw	U. of Alaska

KACHEMAK BAY COASTAL HABITAT STUDIES

Physical Studies

1. Coastal Morphology and Sedimentation: Lower Cook Inlet is a high-risk area for the occurrence of oil spills with respect to potential residence time. A total of 44.5 percent of the shoreline was classified as having high-risk value with a potential of oil remaining in place for several years. Studies of geomorphic indicators show that the general trend of coarse-grained sediment transport by wave-induced longshore currents is primarily into the large embayments (Kachemak and Kamishak Bays) and into the smaller embayments. These areas would be the most greatly affected by an oil spill and would have the highest oil residence time.

2. Shrimp Food Habits: Examination of the stomach contents of three commercially important types of shrimp in Kachemak Bay revealed that amorphous organic matter (detritus) and algae were principal food sources. Shrimp stomachs also contained substantial amounts of invertebrate parts and grit. Since phytoplankton species collected at stations where shrimp were caught did not correspond with the species seen in stomach samples, it was assumed that shrimp were ingesting matter at or very close to the bottom.

3. Marine Birds: Surveys conducted through four seasons of the year in the Lower Cook Inlet region demonstrated the key importance of Kachemak Bay. Kachemak was shown to be a major feeding, nesting, rearing, and resting area for several bird species at various seasons of the year. During the critical winter months the ice-free waters of Kachemak Bay harbored over 90 percent of the marine birds found in Lower Cook Inlet. A total of 48 breeding bird colonies and over 100 marine bird species were documented throughout Lower Cook Inlet during the study.

4. Marine Plant Communities: The marine plant community in Kachemak Bay inhabits a rigorous environment exemplified by variability and change. The investigation examined two major zones in the marine environment: the rocky intertidal and the shallow subtidal. Plant and animal species inhabiting these zones at several sites around Kachemak Bay were identified and, where possible, biotic associations were analyzed.

Marine plant communities in general are highly diverse and among the most productive biological systems on earth. The kelp community along the south side of Kachemak Bay epitomizes this concept. Countless numbers of organisms on both a transitory and year-round basis take advantage of the habitat provided by these plant communities. Over 100 plant species and 250 animal species were identified during this study. Permanent baseline study sites were established at various locations around the bay.

5. Beach Drift Composition: Daily collections of materials deposited by high tides on three sites of the Northwest Gulf of Alaska were conducted during three seasons of 1976. Collections occurred

on two sites within Lower Cook Inlet adjacent to proposed OCS least areas and at one control site outside the mouth of the inlet at Gore Point. All items collected were identified and enumerated to provide indicies to biological mortality occurring in adjacent areas and current pollution levels. Items transported into Lower Cook Inlet from the gulf were deposited on the west side of the inlet and not on the east side. This finding indicates that surface waters are deflected westerly across the inlet rather than northerly along the east side, then back down the west side. This has been indicated in previous literature.

6. Baseline Hydrocarbons: Samples of sediment and three species of biota were each collected at four intertidal locations within Cook Inlet: Douglas River, Kasitsna Bay, Dogfish Bay, and Mud Bay. Hydrocarbons were extracted from each sample and quantitatively analyzed by gas chromatography. The hydrocarbons found appeared to be predominantly biogenic in origin. Indications of minor amounts of petroleum hydrocarbons were found only at Mud Bay, near the town of Homer.

7. Larval Shellfish Distribution: Outer Kachemak Bay was shown to be a major area for both release and settling of several species of commercially important shellfish larvae. Initial release of king crab and pink and humpy shrimp occurred primarily in the central and southern portions of the outer bay. King crab larvae were primarily distributed from the central part of the bay toward Anchor Point, while humpy shrimp larvae were distributed westward toward the mid-portion of the lower inlet. Areas of settling for king crab larvae included the entire mouth of Kachemak Bay but especially along the northern shore off Bluff Point. (Figures 8-11).

8. Post Larval King Crab: Sampling conducted throughout Kachemak Bay utilizing various techniques (i.e., shipex, bottom skimmer, suction dredge) demonstrated the critical importance of shallow (<15 fa.) inshore areas to the survival of post larval king crab. The largest concentration of post larval crab was in the Anchor Point to Bluff Point region along the north side of the bay. Post larval crab were found on hard substrates and were associated with certain types of epifaunal growth. In particular, an association with the bryozoan, *Flustrella gigantea*, was noted. (Table 3, Figure 12).

9. Benthic Reconnaissance: Based on substrate samples and underwater television observations, subtidal substrates of outer Kachemak Bay at depths greater than 10 fathoms were divided into four major geological facies; shell debris, sand, muddy sand, and silt. The assemblages of infaunal organisms associated with each facies were distinctly dissimilar in terms of species diversity and characteristic species. Clams, snails, and polychaete worms were the most common and diverse major taxa in most assemblages.

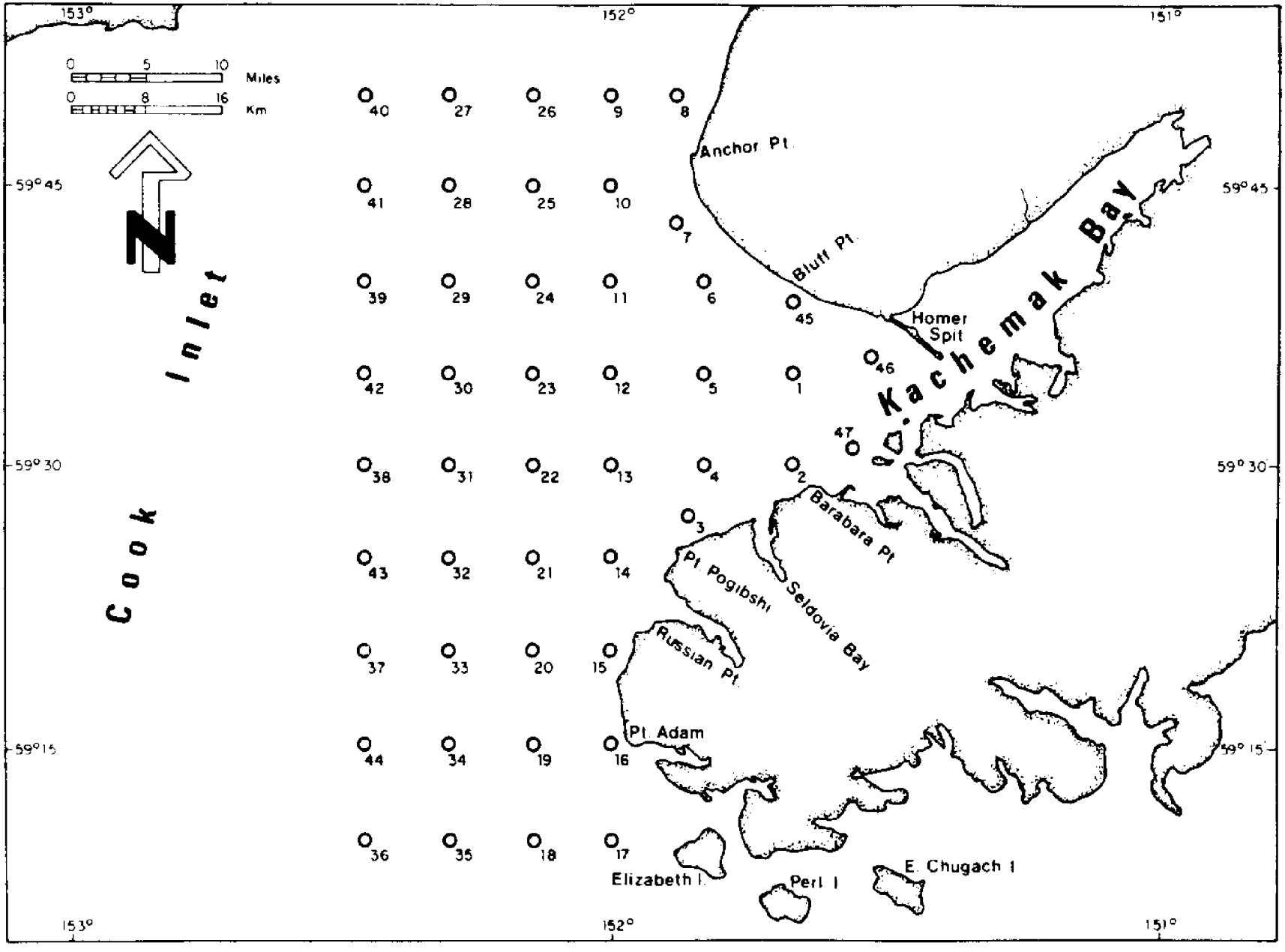

Figure 8. Location of sampling stations to determine distribution of king crab and pandalid shrimp larvae in Kachemak Bay-Lower Cook Inlet, 1976.

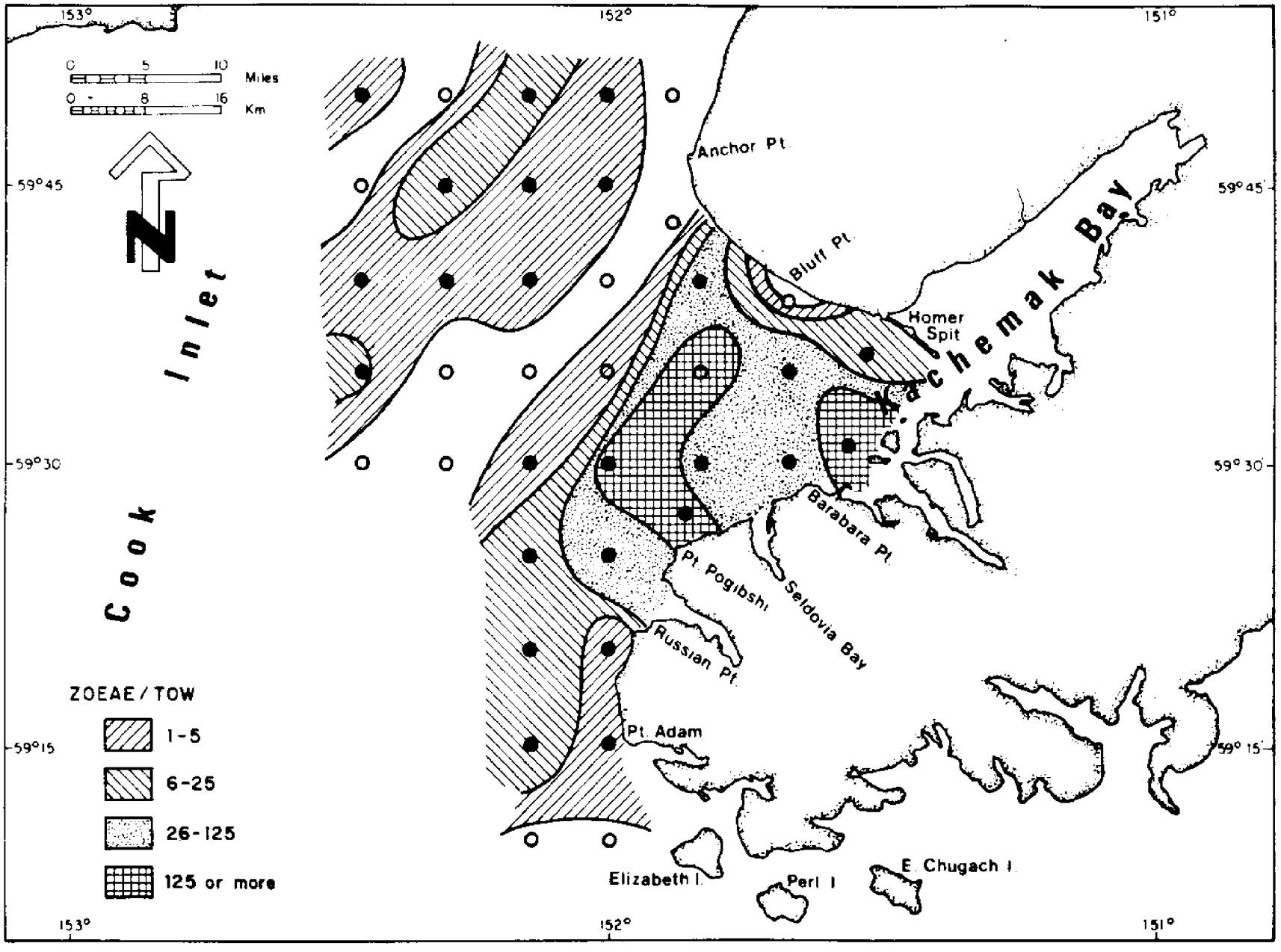

Figure 9. May, 1976 King Crab

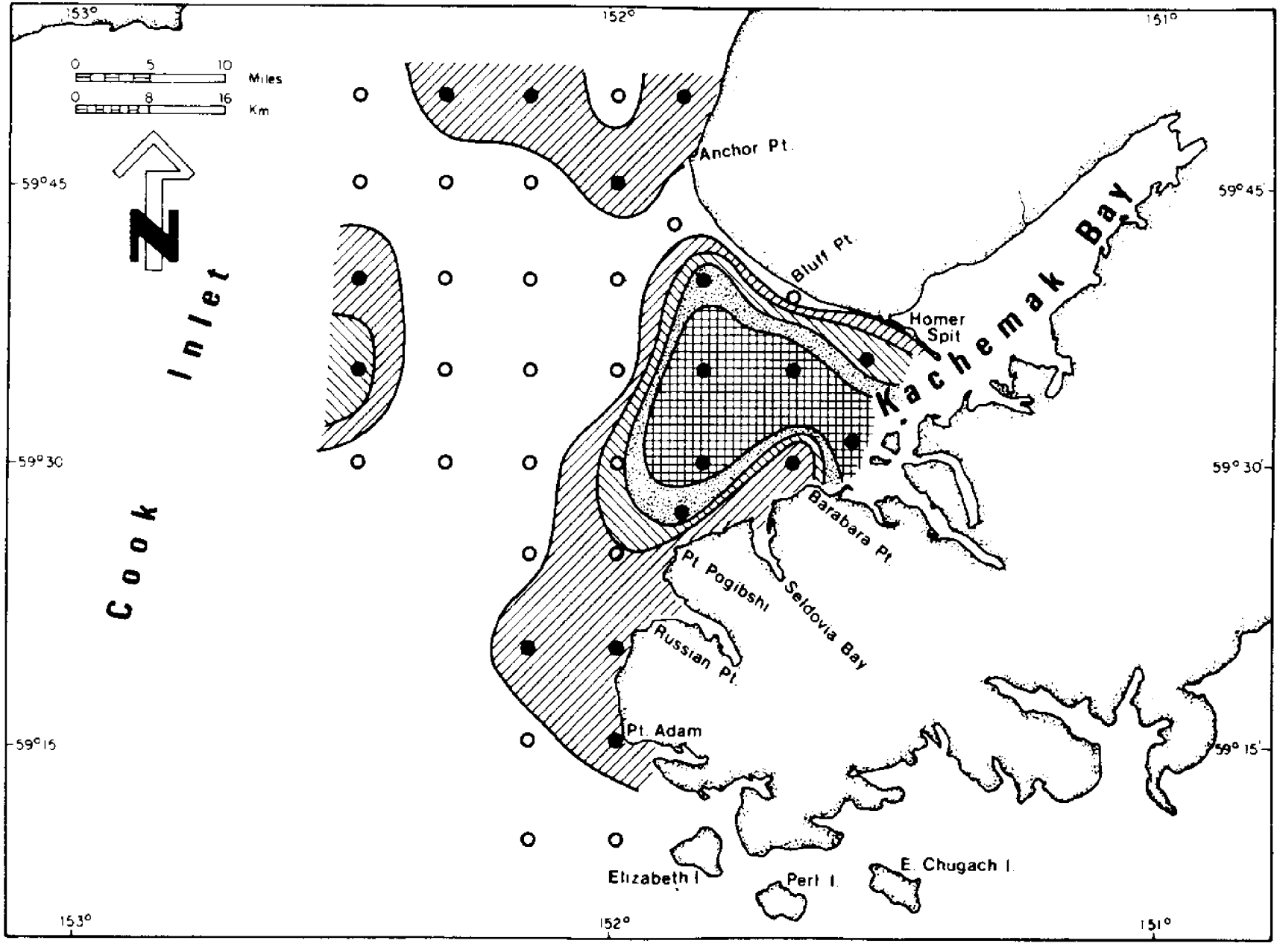

Figure 10. May, 1976 Humpy Shrimp

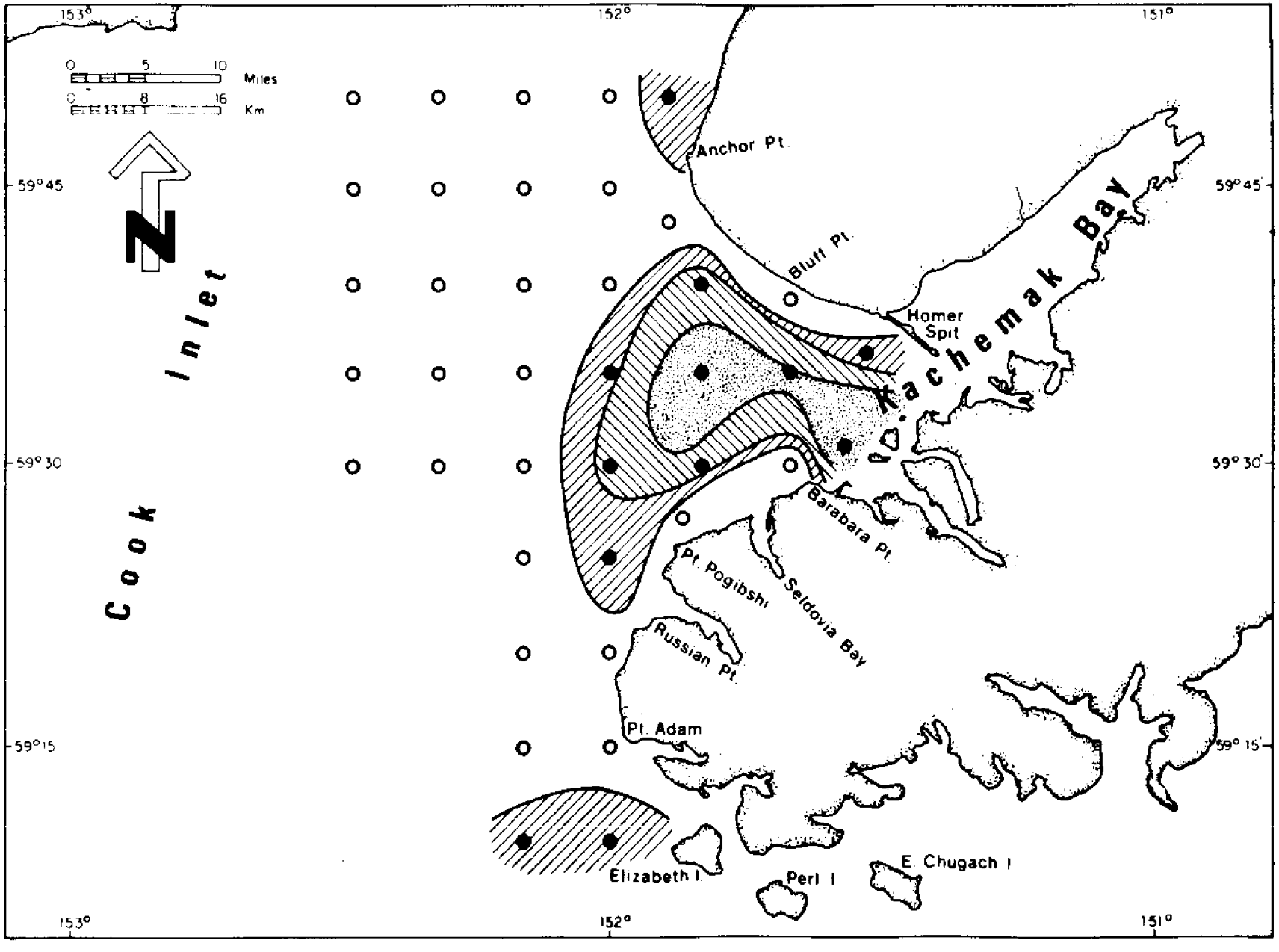

Figure 11. May, 1976 Pink Shrimp

Table 3. Post-Larval King Crab Collected from Bottom Skimmer Tows by Region, 1976.

	"X" =	Central Bay	Anchor Point-Bluff Point	Bluff Point-Homer Spit	Homer Spit-Bear Cove	Bear Cove-Tutka Bay	Tutka Bay-Pt. Pogibshi	Pt. Pogibshi-Elizabeth Is.
Number of Tows Having "X" Number of Crabs	0-1	18	12	9	7	22	16	29
	2-5	0	9	3	1	4	0	0
	6-10	0	2	0	0	2	0	0
	>10	0	3	0	0	0	0	0
Number of Tows		18	26	12	8	28	16	29
Percent of Total Tows		13%	19%	9%	7%	20%	12%	20%
Total Crabs		0	100	8	2	32	2	0
Percent of Total Crabs Collected		0%	69%	6%	1.5%	22%	1.5%	0%

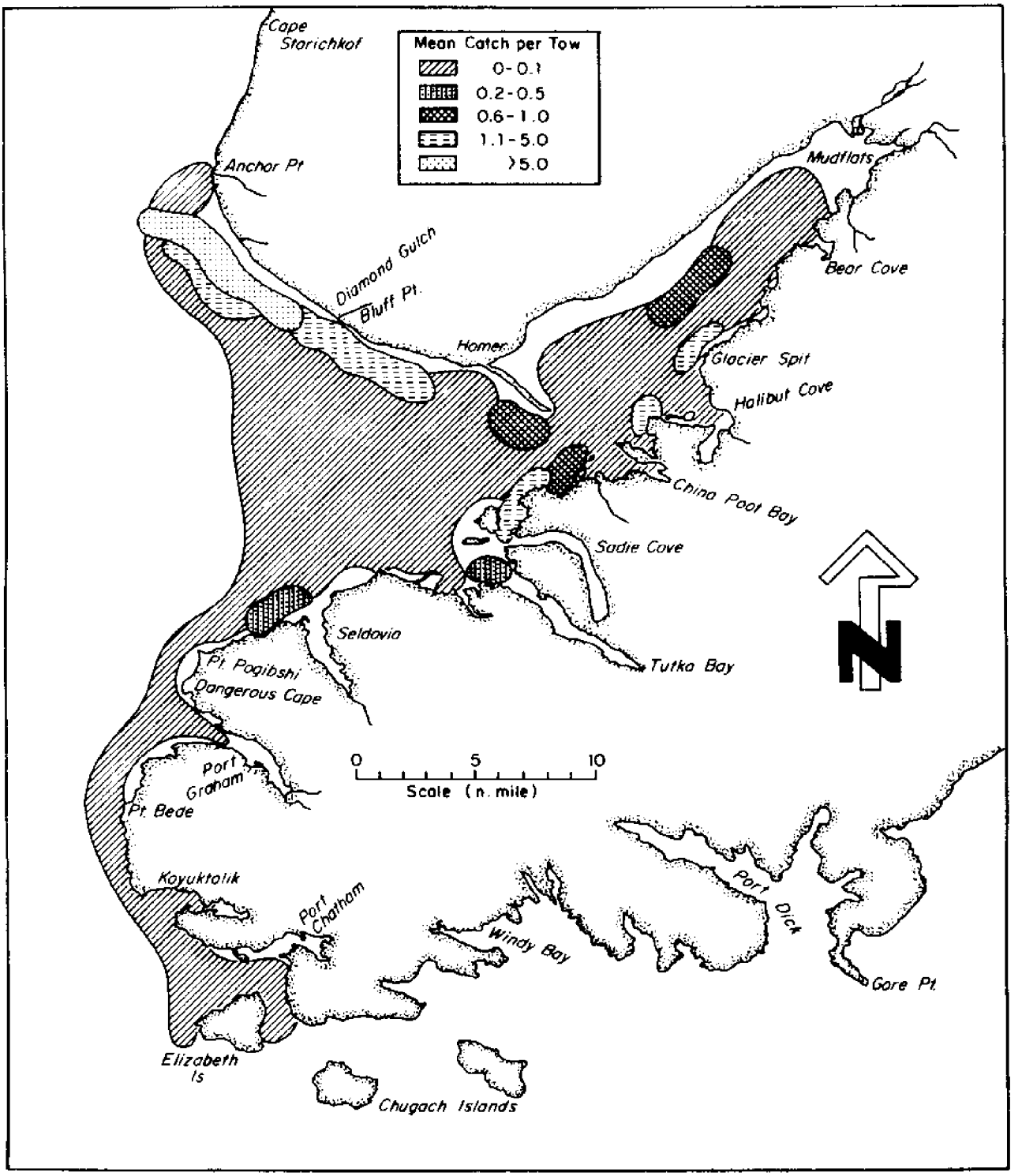

Figure 12. Map of study area showing mean catch per tow from bottom skimmer samples.

Outer Kachemak Bay was found to be an area of considerable diversity and abundance of marine benthic life. Over 200 animal taxa were identified from samples collected in this area. The northern shell debris assemblage off Bluff Point was by far the richest area sampled. Over 80 percent of the total number of species observed were found there. The average number of species per station ranged from 29.2 for the northern shell assemblages to 13.5 for the silt assemblage. The northern shell debris area was characterized by rich clam and bryozoan faunas. (Table 4, Figure 13).

10. Water Circulation: Net transport of incoming clear oceanic waters was shown to occur primarily along the east side of Cook Inlet with net outflow of turbid waters along the west side. A westerly deflection of incoming water occurs in the lower inlet mainly south of Cape Starichkof. A gyre system exists in the outer Kachemak Bay area which may be of key importance to the development and survival of commercially important shellfish larvae. Because the gyres tend to entrain and concentrate tremendous numbers of larvae they are also potential hazard areas. If oil or other pollutants entered the gyre system during the spring or early summer months when larval concentrations are high the result could be the reduction of substantial numbers of larvae as they come in contact with the pollutant. (Figures 14-16).

TABLE 4. Distribution of Major Taxa in Outer Kachemak Bay

	NORTHERN SHELL	SOUTHERN SHELL	SAND	MUDDY-SAND	SILT
STATIONS EXAMINED	17	4	8	9	11
Depth Range (M)	12-34	29-65	25-64	28-65	34-141
TAXA					
Total Mollusca	79	21	22	43	21
Total Polychaetes	22	10	11	16	22
Total Bryozoans	34	4	1	1	1
Total Misc. Taxa	28	18	11	16	15
Total - All Taxa	163	47	45	76	59
Mean Taxa/Station	29.2	20.0	13.9	22.6	13.5

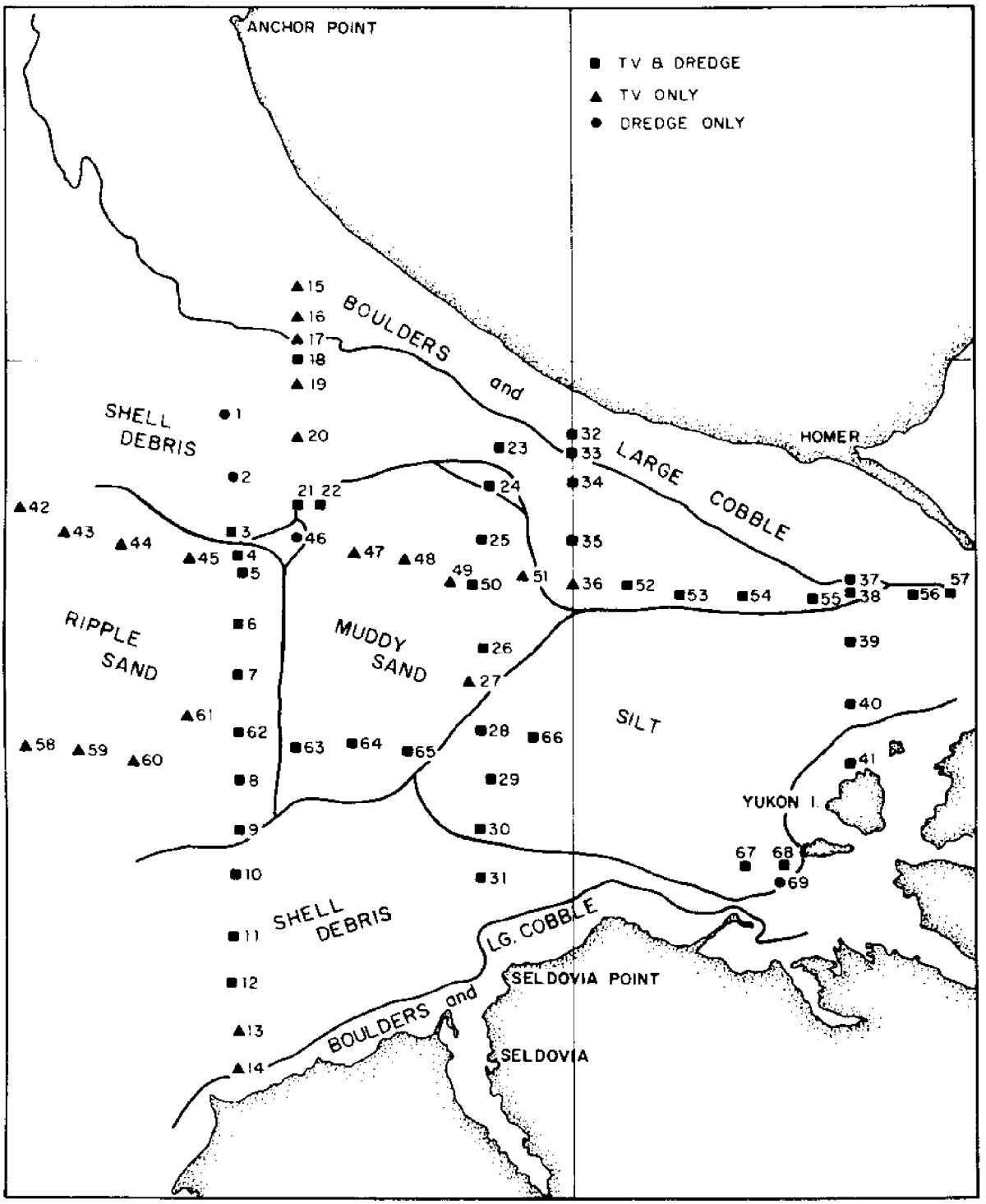

Figure 13. Location of sampling stations and sediment groups, Kachemak Bay.

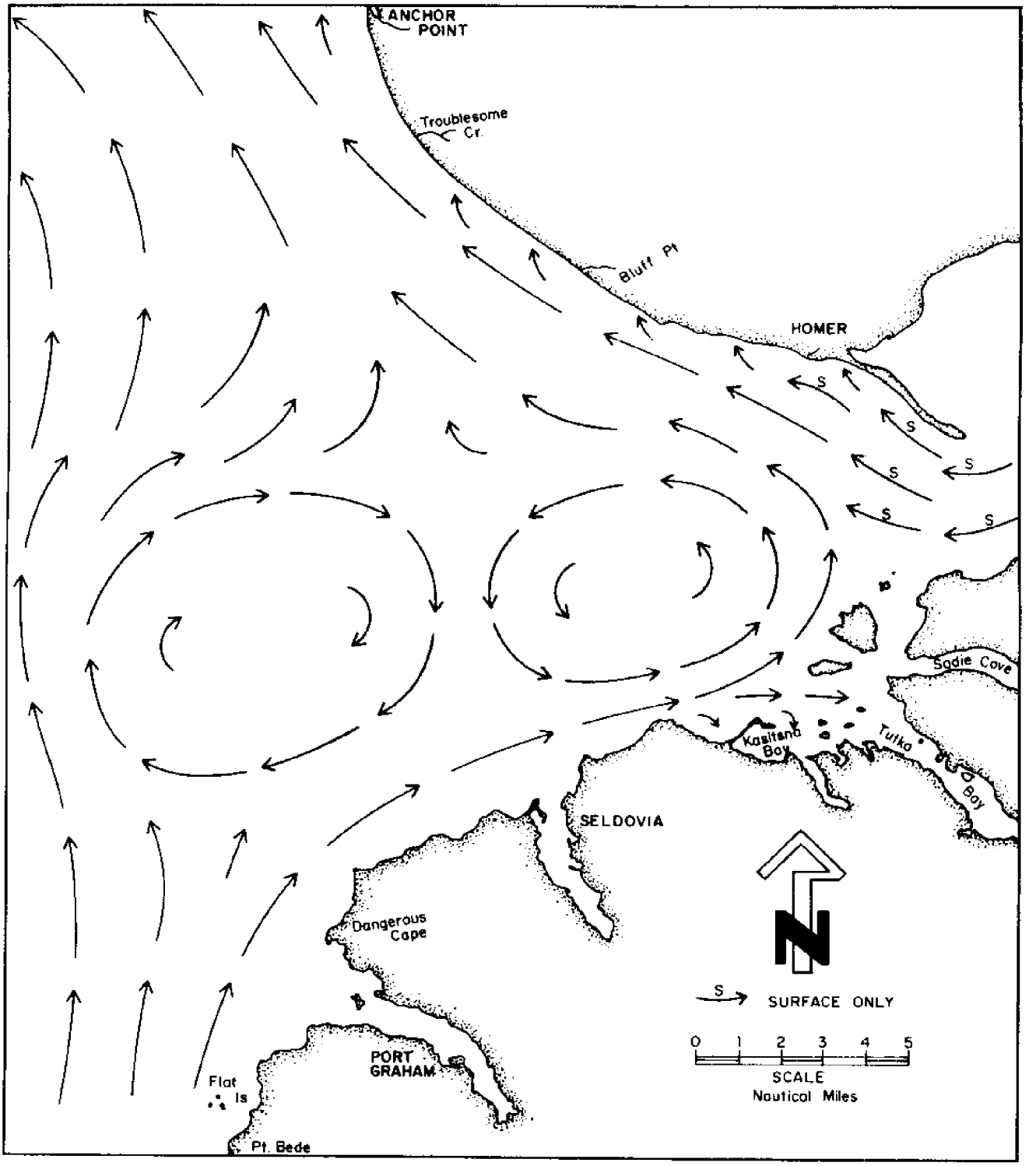

Figure 14. Kachemak Bay circulation. (ADF&G, Burbank; 1976)

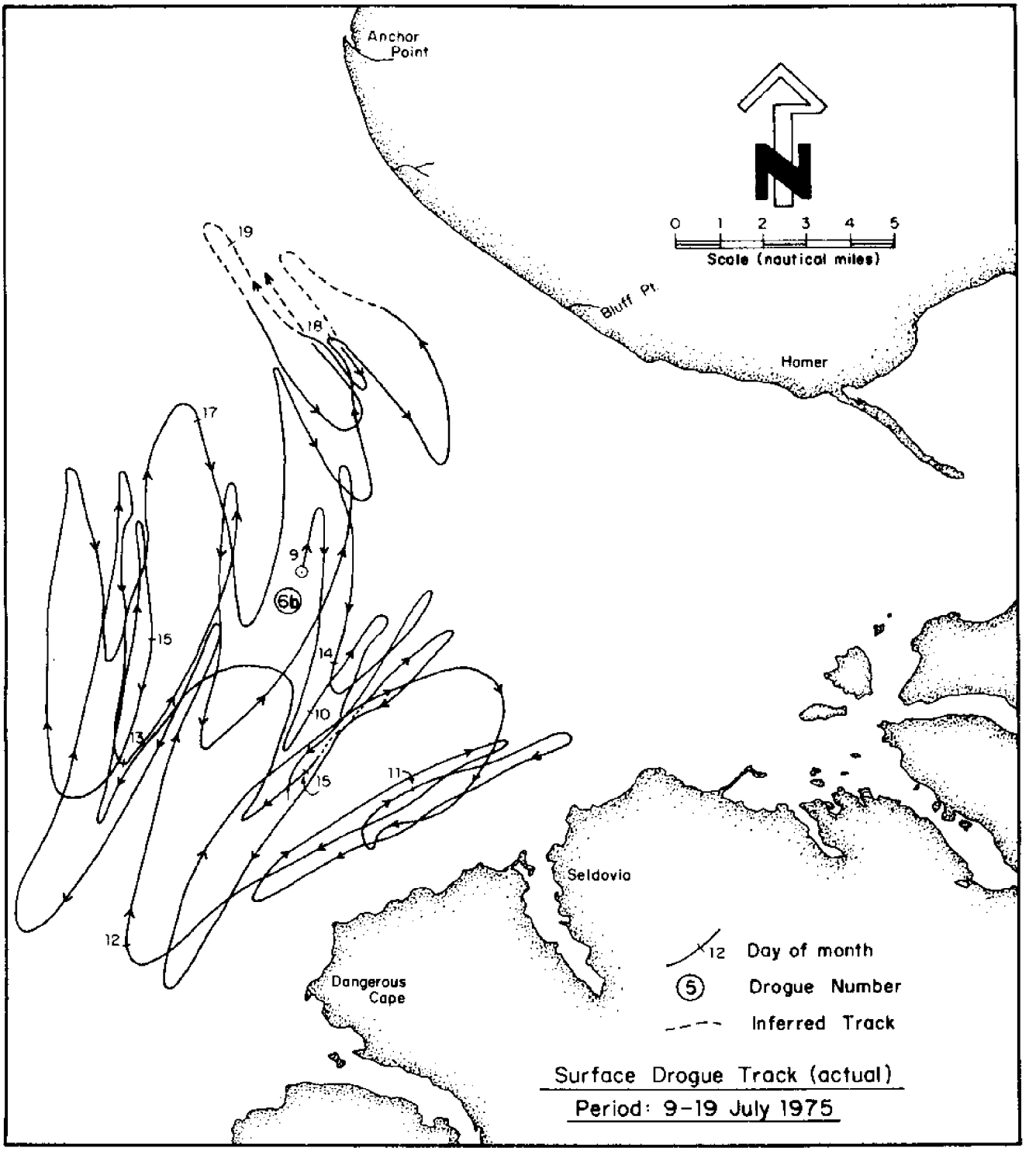

Figure 15. A surface drogue tract in outer Kachemak Bay illustrating the tidal excursion. Movement north or east occurs on the flood tide and reverses on the ebb tide. The movement due to the flood and ebb of the tide is superimposed on the much slower net clockwise movement in the eddy in which the drogue is moving. The drogue is observed leaving the eddy on 17 July.

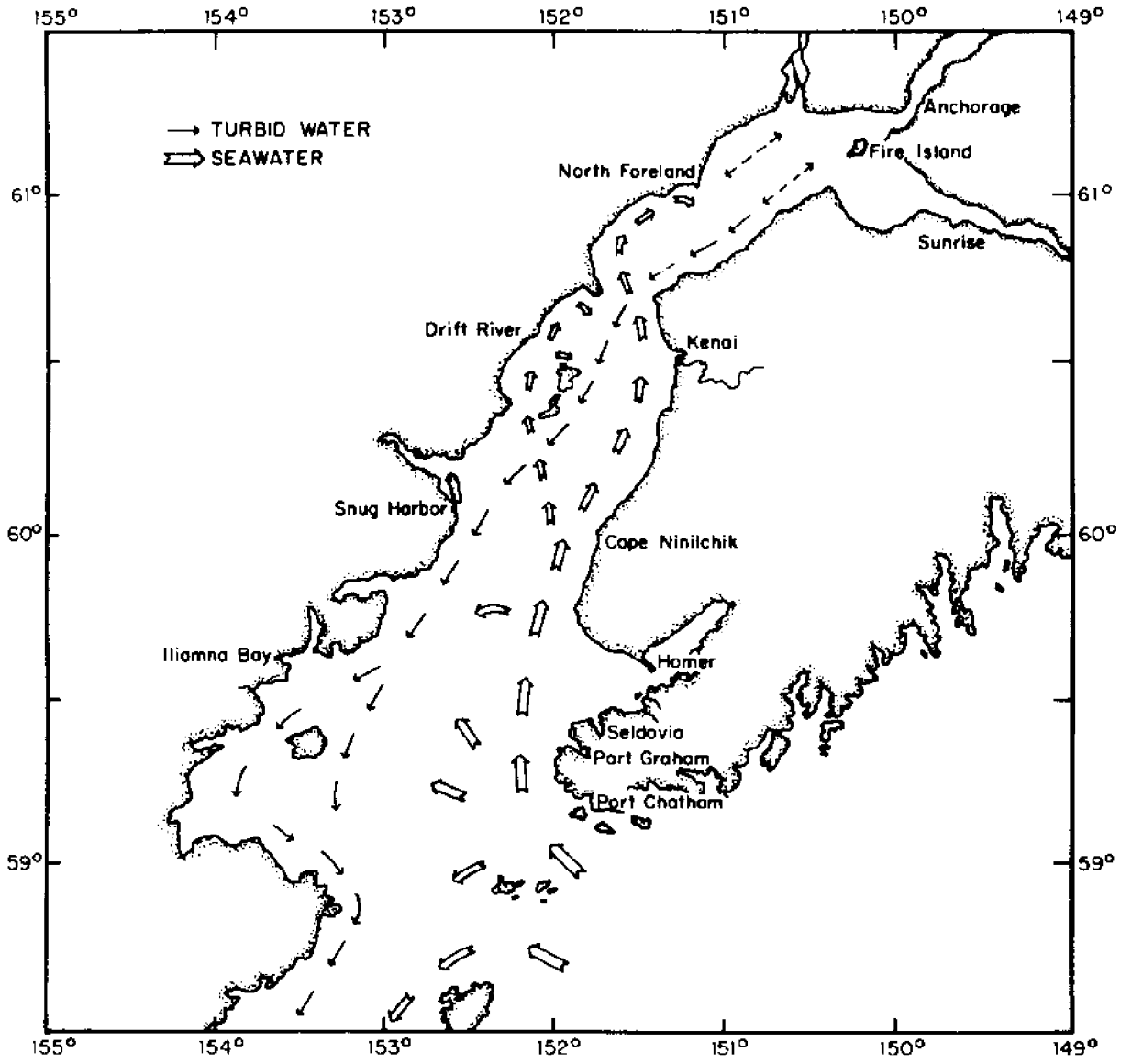

Figure 16. Net circulation within Cook Inlet, Alaska.

SOME EFFECTS OF OIL ON ALASKAN MARINE ANIMALS

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Environmental management is difficult and complex. It requires a great deal of technical information from scientists, engineers, economists, and others. From this information conclusions about the likely benefits and risks associated with any course of action can be drawn. But technical information alone is not a sufficient basis for management. A key piece of information must be supplied by the people whose environment is to be managed. Those people must let environmental managers know how they want their environment managed, how much risk, such as potential impacts to fisheries stocks, they will take in order to obtain a benefit such as that to be gained from developing new supplies of petroleum.

As a scientist I am pleased to have the opportunity to communicate technical information about the impact of petroleum on marine animals to concerned people who want to have a voice in the management of their environment. I can tell you what I think the risks are but you must decide how much risk you are willing to accept. That decision is much too important to leave to scientists, engineers, economists or bureaucrats.

The exposure of marine animals to petroleum can cause a variety of effects. The most severe, obvious and well studied effect is death. While the death of an individual fish is not generally considered a serious matter, the death of a large number of fish can diminish fisheries stocks. A considerable body of scientific data indicates that the concentrations of petroleum in seawater required to produce widespread mortality of marine animals are higher than those normally encountered, except in the immediate aftermath of sizeable oil spills.

From the environmental manager's point of view, avoiding massive mortalities of marine animals from acute petroleum toxicity is fairly straightforward. Since the petroleum concentrations causing such mortalities are known for a variety of animals and petroleum types, operational procedures to reduce the likelihood of exceeding those concentrations can be required. The only problem is deciding how much expense is to be incurred to reduce the risk. This appears to be the present point of contention about tanker traffic in Prince William Sound. A great deal has already been done to prevent accidents but still more could be done. How much is enough? How much risk is acceptable?

There undoubtedly are adverse effects of petroleum on marine animals which are less obvious than wide-spread mortality. Concentrations of petroleum less than those which cause death have been shown to alter body structure and function. Some of these alterations are stressful, making the affected animals less able to find food, avoid predators or to reproduce. Sub-lethal effects such as these can diminish fisheries' stocks just as surely as can direct acute mortality. However, the scientific task of determining the petroleum concentrations which cause various sub-lethal effects is considerably more difficult and has progressed much more slowly than has the work of determining acute toxicity concentrations. It appears from laboratory experiments that at least for some animals, sub-lethal exposures lead to marked changes in behavior, physiology or morphology. Unfortunately the effect of these changes on an animal's ability to survive, grow, and reproduce in the wild is poorly understood.

In several scientific laboratories, including my own, work is underway studying sub-lethal effects of petroleum on a particular species of clam. Because this work illustrates the sort of information currently available about sub-lethal effects and because it is directly applicable to southcentral Alaska, I will review these studies in some detail.

The animal which we have chosen for study, *Macoma balthica*, is a small (about fingernail sized) clam which occurs in intertidal mud flats of southcentral and southeastern Alaska. This species is also found to the south along the Pacific coast as far as California and on both sides of the North Atlantic. Although this species is of no commercial importance, it is an important food item for migratory shore birds. *Macoma balthica* is both a filter and deposit feeder. It can obtain nourishment both by filtering food particles out of seawater or by picking them up from the surface of the mud in which it lives. The animal is small, abundant and hardy, three characteristics which make it practical to use in carrying out laboratory experiments.

Our first experiment with *Macoma balthica* was carried out not in a laboratory but on the intertidal mudflat known as Island Flats at Port Valdez, Alaska, where we simulated the stranding of a slick of Prudhoe Bay crude oil for five successive days as might follow an oil spill. Hydrocarbons were monitored for sixty days following the oilings in both *M. balthica* and the sediments in which the animals live. Petroleum concentrations declined in both the animals and sediment until at the end of the experiment the added oil was no longer observable. When oil was added at the rate of 5.0 $\mu\ell/cm^2$ (43 gallons/mile^2), significantly greater mortalities occurred than in controls (Table 1).

There are two important results of this experiment. First, the rapid loss (two months) of petroleum from sediment is in marked contrast to observations following some actual spills. For instance, petroleum which entered marsh sediments after the West Falmouth oil spill in Buzzards Bay, Massachusetts, in 1969 was evident for several years.

TABLE 1. Mortalities of *Macoma balthica* subject to 5.0 $\mu\ell/cm^2$ oil for five days at Port Valdez, Alaska.

Days of Exposure	Percentage Mortality Oiled/unoiled	Significant difference (95% confidence interval
0	/0	
3	0 /0	no
5	0.9/0	no
7	6.4/2.2	yes
15	1.6/0	yes
29	11.4/02	yes
44	8.7/0	yes
60	1.1/0.6	no

In my opinion, the major reason for this marked difference is that at Port Valdez the petroleum remained very near the surface because of the low permeability of the sediments and the absence of wave action. Oil at the surface would be rinsed away by the tides and subject to evaporation. At West Falmouth, on the other hand, permeable sediments and a storm caused oil to penetrate many inches from which it was released very slowly.

The second important result of the experiment at Port Valdez was finding a level of experimental oiling which resulted in a low but significant percentage of mortality in *M. balthica*. We have reasoned that animals which survive such an exposure are suitable to be examined for sub-lethal effects. Under conditions where about 10 percent of the animals died, it would be very surprising if the other 90 percent were completely unaffected.

Our experimental result stimulated our further interest in the responses of *Macoma balthica* to petroleum. We saw a potential oil pollution indicator in the animal's mortality in the presence of environmentally realistic amounts of oil. We also considered *M. balthica* a suitable organism in which to study the physiological and biochemical bases of petroleum toxicity to marine invertebrates.

Several laboratory experiments with *Macoma balthica* have been carried out in which animals are exposed to oil in very much the same way as in the experiment at Valdez described above. In one of these experiments the relationship of dry tissue weight to shell length was determined for oiled and unoiled groups of animals 30 days after exposure to oil. This relationship is an indirect measure of the general health and fitness of marine organisms. Animals under stress would be expected to use their stored bodily reserves and thus contain less tissue (dry weight) for a given shell size. However, as shown in Table 2, surviving oiled and unoiled animals showed no significant difference in mean dry tissue weight for any of the shell length intervals although significantly greater mortalities occurred in oiled than unoiled *M. balthica*. This experiment suggests that oil-induced mortality is the result of one or a few specific modes of poisoning rather than of a general stress induced weakening of the animal.

In another experiment we investigated the cumulative effect of repeated oiling events by subjecting oiled and unoiled animals which had survived one 30-day oiling experiment to a second oil treatment. This sequence lead to four groups of animals: those that had been exposed to oil in both treatments (++); those that had first been exposed, then kept unoiled (+-); those that had first been unoiled, then exposed (-+); and those which were kept unoiled in both phases of the experiment (--). The number of mortalities of each of these groups is shown in Table 3. Although the greatest number of mortalities of each of these groups was observed in the twice-oiled (++) group, the number observed, nine, is within the range of mortalities observed in other single oiling experiments which we have carried out. Thus it appears that the first oiling did not induce a major lethal sensitivity to further oiling. However, we do not

TABLE 2. The mean dry tissue weights of *Macoma balthica* as a function of shell length. Standard deviation and the number of individuals in each size interval are also shown.

Shell length (mm)	Mean dry weight (mg) oiled	unoiled
4.0- 4.9	1.1±0.7 (n=38)	n=0
5.0- 5.9	2.5±0.0 (n=32)	2.2±4.7 (n= 5)
6.0- 6.9	3.1±0.1 (n=14)	3.4±1.9 (n=19)
7.0- 7.9	4.9±0.1 (n=12)	5.1±1.2 (n=19)
8.0- 8.9	6.4±1.9 (n=20)	6.6±1.5 (n=52)
9.0- 9.9	8.4±2.1 (n=40)	8.2±1.8 (n-41)
10.0- 10.9	12.0±3.1 (n-93)	11.5±3.1 (n=34)
11.0- 11.9	14.2±3.9 (n=39)	15.8±4.0 (n=33)
12.0- 12.9	17.2±3.5 (n=35)	19.4±5.1 (n=27)
13.0- 13.9	21.4±5.6 (n=15)	21.2±2.3 (n= 5)
14.0- 14.9	27.0±3.6 (n= 7)	25.2±2.6 (n= 5)

TABLE 3. Mortalities of *Macoma balthica* following two exposures to crude oil; see text for explanation of the group designations.

Group	Number of Animals	
	Alive	Dead
(++)	246	9
(+-)	288	1
(-+)	276	0
(--)	254	0

yet know whether there are more subtle cumulative effects or whether one or more oilings permanently impairs any biological function (e.g., reproduction).

It was first noted at the National Marine Fisheries Service Laboratory at Auke Bay, Alaska, that in laboratory experiments oiled *Macoma balthica* tend to come to the surface. Subsequently we have studied this behavior as a function of the depth of sediment available to oiled animals. We found that oiled animals which inhabited 3.5 cm deep sediment showed no tendency to come to the surface, that 0.3 percent of animals come to the surface from 2.0 cm of sediment, and that 8.0 percent of the animals come to the surface from 1.0 cm of sediment. No unoiled animals came to the surface from any depth of sediment. This behavior may be put to use as a petroleum indicator if animals are kept in special trays with only a thin layer of sediment available. However, caution would be required since laboratory stresses other than oil (high water temperature, coarse sediment) will also cause *M. balthica* to come to the surface.

In all of the experiments described above, *Macoma balthica* were exposed to oil in ways that simulated the stranding of an oil slick. The fact that the animals took up oil in these experiments strongly suggests that they can ingest petroleum in the course of deposit feeding. We have carried out other experiments to test *M. balthica's* ability to accumulate oil droplets directly from seawater and found that the animal can also take up petroleum in this way. Experiments are currently underway examining the influence of seawater temperature on *M. balthica's* sensitivity to crude oil. We also are studying the effect of petroleum on the animal's growth rate, respiration, and a variety of biochemical parameters.

Several useful bits of information about sub-lethal effects of oil on *Macoma balthica* emerge from the studies just described. Unfortunately, what does not emerge is a general enough understanding for use in environmental management. Scientifically, we are only beginning to put together a very complex puzzle. Anything approaching a complete solution is undoubtedly years away. How does one manage sub-lethal environmental effects of petroleum without a good scientific understanding of what those effects are? One extreme position is to forbid any operation until it is proved safe. The other extreme is to allow any operation until it is proved harmful. Clearly there are compromise positions between these two extremes which will generally be more acceptable. In any particular situation, striking such a compromise is a long and difficult process. Without a good basis of fact, scientific opinion must be relied upon. At this point the role of the scientist as the provider of information and the role of the policymaker as the balancer of risks and benefits become confused and overlapping. The confusion is often compounded by the quasi-legal adversary form that these debates often take with each side marshalling arguments favorable to its case.

I am afraid that I can't suggest an easy way out of this situation or a quick way for a non-scientist to avoid the scientific questions in order to focus on the management-policy questions. However, it seems clear that the opinions and wishes of non-scientists should be of great importance to all environmental management decision. I can only encourage that everyone persist in asking questions, listening to the answers and making his views known.

ACKNOWLEDGEMENTS

I wish to thank L. M. Cheek, L. E. Clement, H. M. Feder, A. J. Paul, E. R. Smith and M. S. Stekoll for their work with me in studying *Macoma balthica*. Financial support for that work has been provided by the Environmental Protection Agency. This is contribution number 323 of the Institute of Marine Science, University of Alaska. However, the author is solely responsible for all opinions expressed.

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THE EFFECTS OF PETROLEUM ON AQUATIC ORGANISMS: A MULTIDISCIPLINARY APPROACH

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The responses of marine organisms to environmental contaminants are reflected in a number of changes which can be detected at molecular, cellular, organismal, and population levels. The purpose of the studies reported here is to determine the effects of petroleum on subarctic and arctic marine animals; aspects of the chemistry, morphology, physiology, pathology, and behavior are used to evaluate alterations from exposure of the animals to petroleum. A summary of the work of a number of scientists at the Northwest and Alaska Fisheries Center, National Marine Fisheries Service, 2725 Montlake Boulevard East, Seattle, Washington 98112, is included (Malins et al. 1977) as well as a more detailed summary of current research in the field of morphology, which is my area of research. Additional details on the work from the Montlake Laboratory may be obtained from several recent publications: Clark and Brown 1977, Clark and Finley 1977, Clark and MacLeod 1977, Craddock 1977, Hawkes 1977, Hodgins and Hawkes 1976, Hodgins, McCain, and Hawkes 1977, Hodgins et al. 1977, Johnson 1977, Karrick 1977, MacLeod et al. 1976, Malins 1977a, Malins 1977b, Malins et al. 1977, McCain, Wellings, and Miller 1976, Patten 1977, Roubal, Collier, and Malins 1976 and 1977, Roubal et al. 1977, Sanborn 1977, Sanborn and Malins 1977, Varanasi and Malins 1977.

These studies include both definition and evaluation of: (1) effects of water-soluble fractions of crude oil and a model hydrocarbon mixture on salmon homing behavior; (2) effects of long-term ingestion of crude oil-coated food on reproduction of rainbow trout; (3) alterations in cellular structure of fish after petroleum exposure; (4) changes in feeding behavior of shrimp during exposure to water-soluble petroleum fractions; (5) uptake and depuration of toxic trace metals by salmon and flatfish; (6) effects of selected hydrocarbons on olfactory acuity of coho salmon; (7) uptake and depuration of petroleum hydrocarbons by salmon, flatfish, and shrimp; (8) enzymes (AHH) that metabolize (detoxify, activate) aromatic hydrocarbons in a variety of aquatic species; (9) pathological effects of exposure of flatfish to crude oil-comtaminated sediment; (10) effects of exposure to oil in diet or in water on disease resistance of salmon.

Several of the above studies have been completed and others are in progress. In the first completed investigation, it was concluded that postlarval spot shrimp were highly susceptible to low concentrations of naphthalene in seawater; ten ppb of naphthalene was acutely toxic. Metabolites of naphthalene were retained by

the larval shrimp at relatively unchanged concentrations while concentrations of the parent hydrocarbon were lowered. This is of considerable concern because there is clear evidence linking metabolities of aromatic hydrocarbons in various animal species to genetic damage and other aberrations.

In the second completed study in which petroleum effects were shown, it was demonstrated that at concentrations of 20 ppb of the seawater-soluble fraction (SWSF) of Prudhoe Bay crude oil, there was a distinct reduction in behavioral activity of adult spot shrimp in response to food stimuli. Symptoms of narcosis appeared at 300 ppb. Conclusions were that adult as well as post-larval spot shrimp were at risk from petroleum contamination. (For further information contact Mr. H. Sanborn, NMFS, Seattle, Washington).

In another completed experiment, maturing rainbow trout were fed high doses (one part oil added to 1,000 parts food) of Prudhoe Bay crude oil components for six to seven months prior to spawning and their ability to produce healthy offspring was evaluated. In contrast to the effects of post-larval and adult shrimp in the above work, it was concluded from this study that there was no significant effect on trout offspring viability. However, untested behavioral and physiological aspects of salmonid reproduction may be affected by petroleum exposure in the natural environment. (For further information contact Dr. H. Hodgins, NMFS, Seattle, Washington).

Coho salmon and starry flounder exposed to <1.0 ppm of a salt-water-soluble fraction of Prudhoe Bay crude oil accumulated significant concentrations of aromatic hydrocarbons representing a broad spectrum of individual compounds. Starry flounder accumulated substantially greater concentrations of hydrocarbons than coho salmon. The evidence indicates that fish have a significant capability for metabolizing aromatic hydrocarbons to potentially toxic products, as indicated by enzyme (AHH) studies and chemical identification of total and individual metabolites in tissues. The finding that these fish accumulate hydrocarbons and metabolic products in a variety of body tissues suggests that potentially deleterious effects on the organisms arise and raises questions about their suitability for human consumption. (Contact Dr. E. Gruger, NMFS, Seattle, Washington).

Morphological changes were found in gills, livers, and eye lenses of salmonid fishes after petroleum exposures. Most of the changes were interpreted to be deleterious and are discussed in detail in the second half of this paper.

Studies were also completed in which either (1) petroleum hydrocarbons were introduced in home-stream water to which adult salmon were returning or (2) salmon were captured in their home-stream, exposed to petroleum (up to 26 hours), tagged, transported offshore, and released. Conclusions in both instances were that there was no significant effect on salmon homing migration or ability. Abnormally dry, hot weather conditions during the study may have

affected the results, however, by altering salmon homing patterns generally. (Contact Mr. D. Weber, NMFS, Seattle, Washington).

Experiments on effects of petroleum exposure on disease resistance of salmon and flatfish were also performed or initiated. English sole were placed on sediment contaiminated with Prudhoe Bay crude oil. No flatfish mortalities occurred during the first month of an anticipated several month study and no marked pathological changes were detected. Similarly, studies on effects of petroleum on resistance of salmon to bacterial diseases showed no difference between petroleum-exposed and non-petroleum-exposed fish. Conclusions were that short-term exposures of flatfish or salmon to petroleum in these assays had no marked effect on disease or disease resistance. These were very preliminary studies, however, and only after longer exposures and different exposure regimes have been completed can meaningful conclusions of this nature be made. (For further information contact Dr. H. Hodgins, NMFS, Seattle, Washington).

MORPHOLOGY

In the few papers which address the subject of morphological effects on fish from contaminants, differences in experimental designs, including methods and levels of exposure and types of contaminants, make comparison of data difficult. However, noticeable effects from toxic materials have been observed in organs and tissues of fish. Sloughing of epitheliam cells and excess mucous production were noted in the gills of marine fish taken in the Gulf of Mexico following a spill (Blanton and Robinson 1973). Exposure to No. 2 fuel oil and phenol can cause liver changes which range from gross color differences (Cardwell 1973, Waluga 1966) to subcellular alterations such as proliferation of the endoplasmic reticulum (Sabo and Stegemen 1977).

In addition to an extensive literature review on effects of petroleum (Malins 1977, Hodgins, McCain, and Hawkes 1977), a review on effects of petroleum hydrocarbons on the structure of fish tissue is in press (Hawkes 1977). Very little of the morphological research deals with arctic and subarctic species.

Methods and Results

TISSUE PREPARATION

For light microscopy (LM), transmission electron microscopy (TEM), and scanning electron microscopy (SEM), tissue samples were excised from freshly sacrificed fish and fixed in 0.75 percent glutaraldehyde, 3 percent formalin, 0.5 percent acrolein in 0.1 M sodium cacodylate buffer with 0.25 percent $CaCl_2.H_20$, 0.02 M S-collidine, and 5.5 percent sucrose (Hawkes 1974). The tissues designated for examination by LM or TEM were post-fixed in osmium tetraoxide in the same buffer, dehydrated in an ethanol series, and embedded in plastic (Spurr 1969). Sections were cut at 0.5 μ, stained with toluidine blue

or a trichrome (MacKay and Mead 1970) for LM. For TEM, sections were cut with a diamond knife and stained with lead citrate, uranyl acetate, again with lead citrate, and examined with a Philips 301[1] microscope. For SEM, the samples were dehydrated after the initial fixation, critically point-dried, coated with gold-palladium, and examined with an AMR-1000 microscope.

GILLS

Coho salmon and starry flounder were exposed to 83 ppb of the SWSF of Prudhoe Bay crude oil for five days in a flow-through saltwater system (Roubal et al. 1977). The gills of exposed fish developed lesions which reflected the loss of the surface cells or the first two or three layers of cells. Immature mucous glands below the surface were exposed when the surface sloughed and their contents, in some instances, were exuded.

The area of sloughing varied from gill filament to gill filament: 10 to 30 cells were lost in the smaller lesions and, in a few cases, the surface of the entire filament lost its outermost layer of cells. In both experimental and control coho salmon a gill ecto-parasite was observed, a monogenetic trematode (Gyrodactylus sp.). Caution must be exercised assigning direct action of petroleum on tissue sloughing, especially if parasites are present. Heavy infestation of Gyrodactylus sp., for example, can cause lesions and, if severe enough, a diseased state (Mellon 1928). In the present study, the fish which were not treated with petroleum had Gyrodactylus but did not have lesions. The infection, therefore, was low enough to not adversely affect the host.

SKIN

English sole were exposed to the SWSF of Prudhoe Bay crude oil: ten ml crude oil in one liter of seawater was stirred for 20 hours, allowed to stand for 3 hours, and the bottom, clear fraction was removed. The SWSF was then diluted with seawater to make a 13 percent concentration of SWSF solution. Experimental and control fish were held in aerated glass tanks and maintained between 10°C and 13°C.

In skin samples of English sole taken five days after the diluted SWSF had been added, many of the mucous glands were completely empty. In a repeat experiment, skin samples were taken from three different body locations during a two-hour to five-day time study. Results were inconclusive because of great variability in both the number of glands and in the number that had discharged their contents. More extensive studies are projected to understand the normal rate of mucous exudation and to define alterations of that process with increasing concentrations of the SWSF of petroleum.

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[1] Trade names referred to in this publication do not imply endorsement of commercial products by the National Marine Fisheries Service, NOAA.

LIVER

Depletion of energy-storage products and infiltration of hepatic blood vessels by connective tissue were found in the livers of rainbow trout that received large amounts of Prudhoe Bay crude oil in their diets for two weeks: each fish received an estimated 11 mg of crude oil per day and the average weight of the trout was about 90 g. Two fish were sampled from each of four replicates from the experimental and control groups. After two weeks of feeding, with no mortality, there were dramatic differences in levels of glycogen deposits in the liver: The hepatocytes of control fish were full of glycogen, whereas those of the experimental fish had virtually none. These changes were evident in 0.5 μ sections stained with toluidine blue. The polychrome method (MacKay and Mead 1970), which stains mucopolysaccharide moieties bright red when the cytoplasm is blue, was used on 1.0 μ sections to differentiate glycogen deposits in the cells. The sections for TEM analysis showed the same disparity. Proliferation of the endoplasmic reticulum was evident and cochlear ribosomes, a common feature of cells rapidly synthesizing proteins (i.e., in embryos), were apparent.

In a longer feeding experiment with the same parameters, all the fish gained weight and no mortalities were observed for 75 days, at which time tissue samples were taken. At the termination of the experiment, the control fish had gained an average of 95.5 percent in body weight and the oil-fed fish gained 70.5 percent, thereby suggesting depression of growth rate in petroleum-exposed fish. The glycogen in the liver of test fish showed the same striking differences as in the above experiment. The small amounts of glycogen present were evident by electron microscopy; however, the glycogen stores were so minute that only a rare cell showed differential staining with the polychrome method for light microscopy. In addition, lipid reserves were reduced in the oil-fed fish, compared to control fish.

In another experiment, rainbow trout were fed 17 mg Prudhoe Bay crude oil/kg body weight/day for eight months. The maturation and spawning of these fish were studied (Hodgins et al. 1977) and several tissues were sampled for microscopy at the time of spawning. An abnormal amount of collagen around the liver sinusoids was noted using both conventional electron microscopy and light microscopy with a connective tissue stain (MacKay and Mead 1970). Work is in progress to better define the extent of fibrosis and possible adverse effects. Such a response, however, is generally indicative of cell injury and may prove to be a useful gauge of liver damage.

EYE LENS

The same trout that developed liver fibrosis after exposure to crude oil in the diet also had enlarged eye lenses (Table 1) which were abnormally soft. Relatively mild pressure premanently

compressed the lenses of exposed fish into an amorphous mass, whereas the control lenses returned to their normal geometry after application of equal pressure.

The lens is composed of ribbon-like filaments which interdigitate and form a sphere. The filaments have simple projections on their broad surfaces which plug into pits on the adjacent fiber; in addition, there is a complex interlocking series of protuberances on their thin side. After treatment with petroleum the fiber structure changed: the broad surface was wrinkled and the interdigitating projections were not smooth and regular as in untreated fish. The fibers looked shriveled, as if the fixative was hyperosmotic, suggesting that the increase in size might be due to hydration of the lens rather than to increase dmass resulting from cell proliferation or cell secretory activity. To test the hydration hypothesis, lenses were removed from normal rainbow trout, measured, and placed in a dilution series of "Dulbecco's" saline and distilled water. Hydration occurred at slightly different rates but in approximately five hours there was an 80 percent increase in volume which stabilized until the termination of the experiment at 45 hours.

TABLE 1. Volume of eye lenses from trout fed Prudhoe Bay crude oil for eight months.

Group	Mean (mm^3)	S.D.	N
Control	110.90	19.2	4
Oil-treated	226.10	81.2	6

Discussion

Distinct morphological changes were observed in either the surface cells of fish exposed to SWSF of crude oil or in cells of organs from fish exposed to crude oil in their diet. The possible impact of these changes on the fish as well as a comparison of my observations with studies of others on other species are discussed below.

SKIN

There is morphological evidence for excessive discharge of mucous glands when fish are exposed to the SWSF of petroleum. However, the variability in both the total number of glands per unit area and in the ratio of empty to full glands is great enough that additional evidence should be obtained before final conclusions are reached concerning the severity of this effect of exposure to petroleum. Changes in skin epithelium and mucous glands have been observed by others in fish exposed to phenol. Not only were there more mucous glands but they were distended in phenol-treated bream (Waluga 1966). Also, in several species of fish sampled from the phenol-contaminated Rhine and Elbe Rivers, the epidermis was swollen and inflamed (Reichenbach-Klinke 1965).

LIVER

There are multiple structural changes in the liver cells of trout after dietary exposure to Prudhoe Bay crude oil which paralled some of the changes reported in other species exposed to a wide variety of toxic materials. Proliferation of the endoplasmic reticulum was frequently observed in the present studies and has been reported in the liver cells of Fundulus heteroclitus exposed to petroleum from an oil spill (Sabo et al 1975, Sabo and Stegeman 1977).

A common finding in these studies was the depletion of lipid and glycogen in liver cells of petroleum-exposed fish. This depletion may signify a generalized stress response during which carbohydrate and lipid metabolism and their storage is altered. Our observations are consonant with reports of biochemical changes in glucose and acetate metabolism (Sabo and Stegeman 1977) in Fundulus heteroclitus collected from a petroleum-contaminated estuary.

A common response to severe cellular damage is replacement of the necrotic regions with connective tissue. Fibrotic replacement was evident in the trout exposed to dietary petroleum. Such a response reflects cell injury and may prove to be a useful gauge of liver damage. Studies are in progress to determine the extent of fibrosis in the liver and other tissues resulting from petroleum exposure.

EYE LENS

One of the most striking and potentially deleterious effects of petroleum exposure observed in our studies was the increase in the size of the lens of trout. These changes could produce severe myopia in affected fish and may be an indicator of cataract formation, perhaps resulting in vision-related behavioral difficulties such as difficulty in avoiding predators or finding prey.

The increase in size of the lens could be the result of increased numbers of lens fibers or expansion of existing fibers. Counts and measurements of fibers as well as in vitro experiments on lens hydration with a series of saline solutions indicated that much of the volume increase was the result of hydration. In some instances in humans, such as during pregnancy and in certain diabetics and prior to cataract formation, lenses are known to temporarily hydrate and increase in size. A series of experiments are underway to better define factors contributing to lens enlargement in trout in order to clarify the role of petroleum in these changes.

ACKNOWLEDGEMENTS

This research was supported in part under Contract R7120819 with U.S. Department of the Interior and in part under Interagency Agreement EPA-IAG-E693 between NOAA and the Environmental Protection Agency.

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ASSESSING OIL IMPACTS WITH LABORATORY DATA APPLICATIONS, LIMITATIONS, AND NEEDS

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PREFACE STATEMENT

Thank you. This afternoon I will outline some of the problems associated with the utilization of laboratory data to assess the impact of oil in the environment and some of the considerations which we should make in trying to apply the toxicity and sublethal effects data described by the previous two speakers and others on the program. In applying these results to the environment to determine what the actual effects of oil exposure will be, there are both biological as well as chemical considerations which we must make. Dr. Engelmann, in his presentation this morning, discussed some of the biological aspects indicating that we must determine the effects of oil on the individual organism, then relate these to the population, and ultimately relate the effects to the ecosystem. In my presentation I will deal more with the chemical aspects than the biological, although I fully realize the great importance of the biological relationships. I will limit my discussion to a consideration of the behavior of oil in water and some chemical factors influencing the application of laboratory effects data toward assessing oil impacts.

INTRODUCTION

A considerable amount of information relating to the concentrations of petroleum hydrocarbons causing lethal and sublethal effects on marine animals has been published during the past five years. Reviews on the toxicity (Rice, et al., 1976c-in press) and sublethal effects of oil (Malins 1977-in press) are soon to be published. Much of the data collected on specific effects of hydrocarbons have resulted from laboratory studies, including acute and chronic toxicity bioassays, as well as sublethal effects such as uptake and depuration, metabolism and distribution, respiration, heart rates, feeding rates, growth, molting in crustaceans, tissue health and cellular ultrastructure, chemosensory mechanisms and behavior, reproduction, and enzyme activity rates.

Exposures to oil have involved a variety of methods from whole oil to oil dispersions to water-soluble preparations as well as the ingestion of oil-contaminated foods. In recent years, as analytical methods have evolved, reasonable data on the actual concentrations of oil in exposure solutions have been obtained. In many of the earlier studies this aspect was missing.

The lower limits of oil concentrations causing effects during short-term exposure are now becoming apparent. Concentrations of oil toxic to sensitive marine organisms are in the low ppm range (<10 ppm) (Rice, et al., 1976a, 1976b) while sublethal and behavior effects are initiated by concentrations less than 1 ppm (Brodersen, et al., 1977) and even in the ppb range (Kittredge, et al., 1974). If effects are observed in laboratory experiments then we may surmise that similar effects may quite likely occur in nature, providing that certain requirements are met; i.e., (1) exposure concentrations are similar in the laboratory and in the environment, (2) similar periods of exposure occur, and (3) compounds are the same in both cases.

The two requirements that similar concentrations and periods of exposure are obtained in the real environment are dependent upon physical dispersal of oil and behavior of organisms. Because of the dynamic nature of the marine environment, which may be quite different than conditions in the laboratory, these requirements may not be easily met. Length of exposure in the environment depends upon a number of factors; (1) size of spill, (2) rate of addition of oil versus its dispersal, (3) physical factors influencing mixing of oil and water, i.e., wind, currents, salinity, temperature and light, (4) confinement of spill by topographical features, (5) type of oil, (6) rate of degradation, (7) behavior of organisms--to name a few. If organisms cannot or do not avoid the oil, and the oil and the organisms remain in a particular water mass,the organisms may be exposed to oil for a considerable period of time, even though the mass of water moves from the actual spill site or site of oil introduction. On the other hand, if organisms are able to maintain position in a current, and the oil polluted water mass moves with the current, actual exposures to dissolved and dispersed oil may be of much shorter duration.

The third requirement, that organisms are exposed to the same types of compounds, is dependent upon: (1) the chemical behavior of hydrocarbon compounds, (2) the factors effecting bio- and chemical degradation, and (3) the relative intensity of these factors in laboratory and field situations. Data on actual concentrations of petroleum hydrocarbons in the environment are sparse but are now being reported for some areas. Generally these concentrations are quite low, aside from highly polluted areas, but they are within the range of exposures where we have noted effects in the laboratory. Some data are now being obtained (with analytical techniques identical to those used in laboratory studies) on the concentrations of oil in various environments resulting from chronic oil pollution (Searl, et al., 1977; Brown and Huffman, 1976; Oppenheimer, et al., 1977; Lee 1977). Concentrations of hydrocarbons range from as low as 4 µg/l. (ppb) in open Atlantic waters to as high as 2,300 µg/l. (ppb) in New York Harbor.

Concentrations and distribution of hydrocarbons in the water column following spills are not generally available. The temporal and

dynamic aspects are particularly lacking for spills under various environmental conditions. An effort is now being made to obtain such data with spill response teams. However, the concentrations and distribution of oil associated with spills changes so rapidly that valid data on maximum concentrations attained can probably only be obtained through the study of controlled spills.

An essential part of evaluating the impact of oil in the environment is to determine concentrations of hydrocarbons and metabolites taken up by organisms under various exposure regimes and compare these concentrations with hydrocarbon concentrations in the water, in particulate matter, and in the sediments. Several laboratory studies have determined rates of uptake and depuration (Anderson, et al., 1974; Rice, et al., 1976a; Dixit and Anderson, 1977), but few efforts have been made to ascertain uptake and depuration rates following exposure to oil in the environment. Such comparisons are needed.

Requisite to applying laboratory effects data to assessing oil impacts in the environment is the assumption that hydrocarbons in the environment are basically in the same phase (dissolved versus adsorbed) as in the laboratory studies. This may not be necessarily so. Germane to relating results of laboratory oil effects studies to the actual impact of oil in the environment is an understanding of the behavior of oil in water under laboratory experiments and in the environment with special consideration given to the temporal and spatial dynamics and major pathways of oil movement in the marine system. Along with this goes an understanding of the concentrations and phase distribution of oil in the water column and sediments resulting from various amounts and types of oil introduction under a variety of environmental conditions.

Several factors which may influence the behavior of oil in the environment cannot be satisfactorily duplicated in the laboratory, especially with static systems. Oil in the environment may be able to associate with a virtually unlimited supply of certain metals or natural organic compounds. Are these associations synergistic or antagonistic relative to toxicity or initiation of sublethal effects? We do not know. Light and other physical factors (O_2, CO_2, N_2, NH_3^+, etc.) are difficult to duplicate and maintain in the laboratory. Naturally occurring enzymes in seawater may not remain active under laboratory conditions. Certain bacteria may be either eliminated or enhanced by experimental conditions in the laboratory compared to populations in the natural environment. These bacteria may determine the presence and persistence of various oil-derived compounds. It is obvious that careful analysis and documentation of the compounds resulting from the introduction of petroleum to natural marine systems is needed before we can unequivocably apply laboratory data to field situations.

BEHAVIOR OF OIL IN WATER

As a basis for discussing oil in the natural environment I will review some factors which affect the behavior of oil in water, with respect to: (1) factors that affect the quantity of oil transported into water, (2) factors affecting the composition of oil in water, and (3) factors affecting the persistence of oil in water. These comments are taken from a recent review (Rice, Short, and Karinen 1976C) to be published in the Proceedings of A Joint NOAA-EPA Oil Symposium held in Seattle (November, 1976).

Factors that Affect the Quantity of Oil Transported into Water.

Oils can become associated with an aqueous phase in a variety of different ways, such as emulsion, dispersion, or accommodation (Peake and Hodgson, 1966); or some of the constituent compounds of an oil may dissolve, forming a true solution. The solubility of oil compounds in water varies considerably with the class of compound and is an important factor that determines the toxicity of oil-water solutions. Some hetero compounds such as pyridine are completely miscible with water. Benzene is the most soluble aromatic hydrocarbon at about 1,800 ppm in water. The solubility of other aromatic hydrocarbons decreases with an increasing degree of alkyl substitution and number of aromatic rings. Aliphatic hydrocarbons are among the least soluble hydrocarbons, with solubility decreasing sharply with increasing carbon number (McAuliffe, 1966, 1969).

The amount of the soluble fraction of oil that enters the water phase is mainly determined by mixing energy, mixing duration, and the viscosity of the oil. Turbulence (or mixing energy) was found to have a pronounced effect on the amount of both particulate and subparticulate oil going into the water phase (Gordon, et al., 1973). In similar studies at our laboratory we have been unable to detect concentrations of 10 ppm in water 1 cm beneath a slick that is gently layered on the water surface (Taylor and Karinen, 1976 NOAA-EPA Symposium-in press). Gentle mixing of oil in seawater for 20 hours will generate water-soluble fractions with oil concentrations in seawater from about 1 to 10 ppm (Anderson, et al., 1974; Rice, et al., 1976a). Violent mixing can produce oil concentrations in seawater in the hundreds of parts per million, with much of the oil present as dispersed droplets.

The amount of time that oil and water are mixed is as important as mixing energy in determining the quantity of oil that enters the water phase. Using gentle mixing, the amount of oil that enters the water phase steadily increases for over 30 hours (Gordon, et al., 1973; Anderson, et al., 1974; Percy and Mullins, 1975; Rice, et al., 1976a). The viscosity of the oil also affects the amount of oil that enters the water phase, because more mixing energy is required to mix thick, viscous crude oil. We have observed that the relatively viscous Prudhoe Bay crude oil yields WSF's that are about half the concentration of those from Cook Inlet crude oil when mixed under identical conditions (Rice, et al., 1976a).

There are several other less well-studied factors that affect the amount of oil entering the water phase. There is evidence that polar hydrocarbon derivatives are generated from oil by photo-oxidation (Lysyj and Russell, 1974). These polar hydrocarbons tend to dissolve into solution from an oil slick and, in time, raise the total concentration of oil-derived hydrocarbons. In addition, pH (Kauss, et al., 1973) and salinity (Rice, et al., 1975) affect the amount of oil entering the water phase.

Changes in temperature influence the transport of oil into water because changes in temperature change the viscosity of the oil. The viscosity of oil increases as temperature decreases, thus at low temperatures more mixing energy or time is required to transport oil into the aqueous phase. As temperature decreases, the solubility of the non-volatile components increases. Finally, emulsions and suspensions are more stable at lower temperatures. These conflicting effects make it difficult to predict the overall effect of temperature on the amount of oil transported into the aqueous phase.

Factors Affecting the Composition of Oil in Water.

The composition of oil transported into the aqueous phase is also strongly dependent on compound solubilities, mixing energy, mixing duration, and oil viscosity. The composition of oil in water may or may not be similar to the composition of the parent oil, depending on how the oil is associated with the water. When oil is mixed violently with water, many dispersed droplets having a composition similar to that of the parent oil are formed. When oil is mixed slowly, the bulk of the hydrocarbons transported into water is composed of the more soluble hydrocarbons, unlike the composition of the parent oil. For example, Bean, et al., (1974) found water-soluble fractions to have compositions quite unlike the parent oil. They found increases in IR absorption at 3,000- to 3,100 cm^{-1} for WSF's, indicating significant increases in the relative concentration of aromatic hydrocarbons in the WSF.

An "aromatic enrichment factor" (AEF) has been used by Anderson, et al., (1974) to evaluate the degree to which the composition of an oil-water solution differs from the parent oil. The AEF is the ration of the concentration of aromatic compounds to n-paraffins in the oil-water mixture, divided by the ration of the concentration of aromatic compounds to the n-paraffins in the parent oil. A dispersion from a turbulent mix will result in an AEF of 1-3 indicating that the composition of oil in water is about the same as the parent oil. In contrast, the AEF will be higher in oil-water solutions prepared with less turbulence. Aromatic enrichment factors of 10-125 and similar magnitude have been reported for WSF's prepared with slow, gentle mixing of Kuwait, Prudhoe Bay, and Cook Inlet crude oils (Anderson, et al., 1974; Short, et al., 1976, Rice, et al., 1976a).

In addition to solubility, mixing energy, mixing duration, and oil viscosity, there are undoubtedly other factors that affect the

composition of oil in water. For example, the solubility of many compounds is influenced by pH (Kauss, et al., 1973), salinity, and temperature. Removal of selected hydrocarbons from solution by biodegradation, evaporation, photochemical oxidation, etc., will change the composition of oil in water.

The fact that the amount and composition of oil that is transported into distilled water or seawater is stongly dependent on the method used to prepare the oil-water mixture, emphasizes the need for analytically determining the amount of oil actually transported into the aqueous phase. There have been many studies of static bioassays that report only the volume of oil used to prepare the oil-water test mixture. The concentrations of oil that the test species were actually exposed to in these studies are almost completely unrelated to the amount of oil used to prepare the test solutions, so that these studies are of limited value.

Factors Affecting the Persistence of Oil in Water.

After the oil has been transported into the water, several factors cause hydrocarbons to be lost, resulting in changes in both concentration and composition of the oil solution or dispersion. Cheatham, et al., (in prep.) demonstrated that the losses of total aromatics from WSF's of crude oil were significant, and that the rate of loss was less at low temperatures. Evaporation causes significant losses of low molecular weight aromatics. The low molecular weight aromatics all have significant vapor pressures at laboratory temperatures, although vapor pressures decrease with decreasing temperature. The evaporation of these light aromatics in static bioassay systems is a well-known phenomenon.

Both paraffinic and aromatic hydrocarbons are susceptible to microbial oxidation, although several studies (Kator, et al., 1973) have indicated that paraffins are oxidized by microbes more easily than aromatic hydrocarbons. Further, dinuclear aromatic hydrocarbons are lost from solutions primarily by biodegradation, while mononuclear aromatics are lost primarily by evaporation. Both processes occur at faster rates at higher temperatures (Cheatham, et al., in prep.).

Chemical and photo-oxidation can also change the concentration and composition of oil in water. Aromatic hydrocarbons in particular are susceptible to photo-oxidation. Finally, significant quantities of oil can be separated from the water when dispersed droplets coalesce into larger droplets and form a layer of oil at the surface.

FATE OF OIL IN THE ENVIRONMENT

Many of the factors influencing the behavior of oil in laboratory tests will also apply to oil in the natural environment. However, as noted in the introduction, factors strongly influenced and controlled by environmental conditions may modify the fate of oil in the environment. Judging from recently published work and observations of the behavior of oil components and metabolites of

oil in the environment and in the laboratory, one can predict that substantial differences between behavior of oil in the laboratory and in the field will occur.

Certain components of soluble fractions of crude oil may not be as long-lived in the natural environment as expected. There is evidence from the published literature indicating that aromatic hydrocarbons, a toxic group of compounds in crude oil, are selectively removed by various processes when oil is introduced to marine waters. Some aromatic hydrocarbons are absorbed by particulate matter (Lee, 1977; DiSalvo and Guard, 1975) and indirect evidence suggests that others disappear from the water column somehow (Brown and Huffman, 1976). Brown and Huffman (1976) examined the occurrence of non-volatile hydrocarbons in the Atlantic Ocean and found that aromatic hydrocarbons were at lower concentrations than would be expected if the source of the hydrocarbons were crude oil or petroleum refinery products. Hydrocarbons appear to persist in water to varying degrees with the most persistent being the cyclo-paraffins, then the iso-paraffins and finally the aromatics. They conclude that neither evaporation nor dissolution, however, explains the selective disappearance of 14-carbon and heavier aromatics.

Other processes that may contribute to this behavior include degradation of aromatic compounds through chemical and biological reactions, or more likely, adsorption of aromatic hydrocarbons to particulate matter and settling of this particulate material to the ocean bottom. The high concentrations of polycyclic aromatics in sediments (Blumer, 1976; Blumer and Youngblood, 1975) support the hypothesis that adsorption to detritus is one method of removal of large molecular weight aromatic hydrocarbons from the water column. However, in the recent study by Lee (1977) there was little adsorption of naphthalene, a major toxicant in oil, to sediment particles, at least with the type of particles he was using. Brown and Huffman (1976), however, indicate that double ring aromatics (i.e., naphthalene) are also lower in concentration than expected in ocean waters. I hypothesize that another method for removal of naphthalene and oxidized products of naphthalene is operating.

Previous work which I was involved with and supervised at Oregon State University, (Karinen, et al., 1967; Lamberton and Claeys, 1970) suggests that naphthol, an oxidation product of naphthalene, is photo-oxidized further to form a hydroxy-naphthol compound which reacts in seawater to form higher molecular weight compounds. These compounds precipitate from solution. A major portion of the naphthol added to seawater at 16°C formed a precipitate having a molecular weight of about 454. This precipitate was thought to contain a stable free radical[1] and was toxic to some estuarine organisms. This observation is significant in that it may serve to explain the disappearance of two-ring aromatics from the water

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[1] Free radicals readily react with biological systems causing disruptions in cellular growth and reproduction.

column and also that it may be a way that aromatic hydrocarbons in relatively concentrated form could be incorporated into the food web by filter-feeding organisms.

ASSESSING ENVIRONMENTAL IMPACTS

Several of the aromatic hydrocarbons are quite toxic with an increase in relative toxicity from naphthalene to benz(a)pyrene. In addition, they have been shown to have sublethal effects on organisms. Types of physiological effects, however, are dependent upon the route of entry or exposure method- i.e., ingestion of a hydrocarbon may have a much different effect than exposure to the same compound dissolved in seawater.

It is important, when trying to apply laboratory data to the field, to keep in mind what we have exposed the animal to and what effect similar exposures of chronic and acute additions of oil will have on the field environment. We need to realize the limitations of the data and look at the entire picture using all valid information. If we suspect that organisms are being affected by exposures in the field several courses of action can be taken to verify it.

(1) We should analyze the water, sediments, and organisms for hydrocarbons.

(2) We should apply these exposure concentrations and knowledge of the method and chemical type of exposure to get an approximation of the toxic and sublethal effects as estimated from controlled exposures.

(3) We should examine the health of these animals by looking at tissue structure, cell morphology, and subcellular structure and activities as reported by Dr. Hawkes in this meeting.

(4) We should measure baseline activities of enzymes specifically involved in hydrocarbon metabolism.

(5) We should observe behavior, relative abundance over time, reproductive success, and population stability.

A better understanding of the physiological requirements of organisms and how their behavior relates to these needs will further increase our ability to assess the impact of man-caused perturbations in the environment.

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A REVIEW OF OIL TOXICITY STUDIES CONDUCTED AT THE AUKE BAY LABORATORY

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Our laboratory has been involved in oil toxicity research since about 1971, but not significantly until after the state held the Kachemak Bay Oil Lease Sale in December 1973. During the subsequent controversies, many realized the paucity of toxicity information that was available for Alaskan species, but the oil industry was the first to fund oil research at our lab at a significant level. One of the early popular hypotheses (or fears?) was that Alaskan species would be more sensitive than animals from warmer waters, since Alaskan species have not been exposed to pollutants. Generally, we have found the Alaskan species to be more sensitive to oil than animal sensitivities reported in the literature, but probably because of the temperature differences used in the exposures. Temperature changes may affect an animal's ability to metabolize and excrete toxic hydrocarbons. However, the toxic components persist in oil-water solutions longer at colder temperatures, because losses through volatility and biodegradation are less than at higher temperatures.

Our research efforts on oil effects have several facets, and are described in the references given below. Currently, our research efforts have evolved to investigate the effect of temperature on toxicity and physiology. For example, we have found that pink salmon fry are more sensitive to toluene at lower temperatures, but temperature changes do not affect naphthalene sensitivities significantly. Our laboratory studies, funded primarily through the OCSEAP funds, focus on temperature effects on lethality of oil components and sublethal effects on marine organisms. We examine a variety of animals exposed to many different toxicants, in a variety of ways.

Although each of our publications has specific conclusions, the two most significant general conclusions are:

1. We have generally found crustacean larvae to be the most sensitive life stage, especially when molting.

2. Alaskan species may be more vulnerable to oil than species from warmer waters, since colder temperatures cause toxic aromatics to persist longer. Temperature effects on oil toxicity and animal sensitivity are complex and warrant further study.

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A SUMMARY OF OIL SPILL STUDIES DONE AT WOODS HOLE OCEANOGRAPHIC INSTITUTION

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My colleagues and I began studying wetlands many years ago and consequently, by a series of accidents, became involved in investigations of oil spills. For a number of years workers at Woods Hole, notably Howard Sanders, have been studying the faunal distribution of Buzzards Bay, Massachusetts. For fifteen years much of my research has been on the fauna and ecology of salt marshes along the east coast. Max Blumer, who was an organic petroleum chemist of great skill, was on hand along with Sanders, myself and a number of others when the barge *Florida*, carrying #2 fuel oil, ran aground in September 1969 off Cleveland's Ledge in Buzzards Bay. We were only a few miles away from the spill and were able to devote considerable time to investigating just what happened when the oil came ashore. We were also interested in the effects of the oil on plants and animals of the region. The spill was small compared to many in the world's oceans, but was large at our local level.

I first became aware of the spill when a strong smell of oil permeated my home a half mile from where the oil came ashore. I believed my oil burner had broken down and I went to the cellar to investigate. A short time later a friend called to tell me of the grounding. We all realized we had a golden opportunity to study the effects of a massive environmental insult, one which we would never duplicate intentionally and hoped would not reoccur by accident.

The shellfish warden in the town of Falmouth takes his job extremely seriously. He was very offended that the barge was allowed to go aground and the oil allowed to come ashore. In the morning session McCauliffe showed a few pictures of the benefits of oil activities around on what he called the artificial reef of an oil rig. I will try to give you an idea of the way George Souza, our shellfish warden, saw the harm that can be associated with oil activities.

The oil barge went aground over two miles from the ship channel. The night of the spill was calm and very foggy, probably contributing to why the barge was so far off course. Most of the oil came ashore at Wild Harbor, several miles from the grounding. The marsh which we studied lies within Wild Harbor. Booms were put out rather quickly after the spill, by the following morning, but a storm came up at night and very effectively dispersed the oil, emulsified it with water and mixed it into the shallow bottom muds. The breaking waves in the area were light brown in color from emulsified oil.

The immediate result was a massive kill of animals on the particular shore where the oil was driven up. What looked like black pebbles on

the beach were really periwinkles. They were all dead. A few eels and the adults of small-sized fish, along with the young of large species, died but there didn't seem to be any adult, large fish killed.

A large variety of benthic animals were killed. The storm mixed the oil down into the water so that it came in contact with the sediment, then moved down with the sediment to considerable depths in that immediate area adjacent to where it came ashore. A great number of worms were killed.

Young lobsters died and washed up on the beach. Lobstermen who were fishing in that particular area soon stopped because their catches dropped to zero. Dead crabs washed up on the beach or rotted in shallow water.

The spill occurred in September, just at the time when the scallop season was to open. The boom was put across West Falmouth Harbor area, and as a result visible oil didn't get into the harbor and the scallop fishermen were allowed in. Then a state inspector came down and tested the shellfish which were caught. The taste of oil was obvious; one didn't have to make any complicated analyses. Our shellfish warden then had to go out and tell those people who were harvesting the scallops that they had to throw them back, which they took badly and gave him a hard time about.

Although there was no visible oil in West Falmouth Harbor, a large number of dead scallops were gathered very shortly after the storm. We wondered why such a large number of scallops had died when there seemed to be so little oil in the harbor. When first gathered from under water the scallops didn't appear to be in bad condition, but then Mr. Souza noticed that the scallops seemed to be somewhat sluggish. In fact, the scallops were anaesthetized by the oil and as a result gaped a little more than usual. They didn't respond as readily to being annoyed by the minnow, Fundulus. As a result the fish attacked and cleaned the scallops out of their shells.

An oil boom was also spread across the entrance to Wild Harbor River where the study marsh and extensive clam flats lie. When the storm blew up the boom failed to hold the oil. In fact, it was totally useless. The oil was churned down in the water and simply was carried by the turbulent wave action.

A great number of shellfish and other animals living up in this small marsh area were killed. One could see numerous syphons of soft-shelled clams sticking out of the mud resembling worms half out of their holes. The soft-shells were the principal type of shellfish in the area and were nearly all killed.

Interestingly enough, after the spill the area was not unattractive to young clams. There was a large set of them during the following year. They didn't burrow. One could take a shallow water sample from the top sediment and get almost all of them out. As a result they didn't survive. There was a lot of oil in the sediment and they refused to dig down into it.

The oiled grass died immediately in September, 1969. By the following summer, 1970, there was very little regrowth but one of the weedier marsh plants, Salicronia or glasswort, had germinated in areas with only 500 ppm of oil in the mud. In large parts of the marsh the oil level was 1-5 parts per thousand and nothing grew.

By the following spring, 1971, some erosion had taken place since the grass growing in the oiled areas was greener than that behind. I think this is a simple result of the fact that so many animals and plants were killed in the area that the nitrogen which generally limits grass growth in these marshes was released by decomposition and the grass that did survive was fertilized and greener.

By 1976 there had been almost complete recovery of grass growth although the area is still closed to shellfishing and some areas of high oil content still have no grass cover.

This brief history has shown what happened immediately after the oil spill and the recovery processes that took place subsequently. Let me just briefly touch on some of the things the various studies showed.

The kill of the benthic animals was very rapid. A sample taken on September 19, 1969, three days after the spill, revealed large numbers of animals on and in the bottom, 94 percent of which were dead. The bodies of these dead animals had disappeared by the 25th and evidence of that massive kill had vanished. These animals were mostly different species than those found in the first sample meaning there had been a migration of animals into the polluted area. These animals were subsequently killed by the oil. After this had happened a certain recovery occurred. In some cases, the numbers of animals were much higher in the following year than before. These were made up almost entirely of species called opportunists; animals which are the counterpart of weeds in the plant world. These come into disturbed environments and occupy an area that has been opened up by death or damage to the usual residents.

There were a few other events of interest. One was that almost two years after the spill another severe storm occurred. A redistribution of oiled sediment, a movement of oil around the bottom, caused some fresh kills of animals and was comparable to the original oil spill. Another interesting point is that Sanders and Grassle investigated another oil spill in the New Haven region during the same period. They found the same sort of kill of animals but not immediately after the spill. The accident occurred in January when the water was much colder. The number of animals was reduced by about half, compared to the numbers they found at comparable stations nearby. But in May when the bottom warmed up the same kind of massive kill as we've seen in Wild Harbor occurred.

Now I want to take up the work we've done on the marsh. We extracted oil from the mud each year from 1970 on. Fuel oil is composed of three components: paraffins, toxic aromatics, and relatively inert napthenes. The paraffins are waxes which are

relatively non-toxic, are used as a carbon source by bacteria, and decompose fairly rapidly. Fairly rapidly in the case of Wild Harbor meant that it was about three years before the paraffin had disappeared.

The oil had penetrated immediately after the spill up to one meter down in the sediments, and concentration on the surface was in the order of 1,000 ppm or more. That concentration at the surface didn't change much; it's very patchy and therefore difficult to make statistically valid statements about but our samples showed thousands of ppm at the surface throughout the next five years, although the oil didn't penetrate as far down into the sediment as it had at first. In 1975, which is the last time we sampled down into the sediment, we couldn't find any oil below the top 15 cm.

The total amount of oil had not decreased at the surface, though, and total concentration of aromatics either stayed the same or increased slightly until about 1973 when the paraffins disappeared. Since then it has decreased. In the latest samples taken last winter we found about half the concentration of aromatics on a total weight basis as that in the original oil.

We looked at the effect of the oil on two animals as being representative of those that live in our salt marshes: the fish Fundulus and the fiddler crab. The year after the spill, the first time we could get a sample of active fish, Fundulus contained what seemed to be highly degraded fuel oil. We found about 70 ppm in the fish feeding in areas where there were 1,000 ppm or so in the sediment.

The fish responded to the oil spill by significantly increasing their ability to metabolize oil. It is possible they may have responded in other ways as well. Three years after the spill the amount of oil we found in Wild Harbor Fundulus was very much reduced. It began to again resemble hydrocarbons that you see from a control, or non-polluted area. These hydrocarbons are characteristic of algae and of Spartina detritus which the fish swallow in their feeding activities.

So the story is that after some time the fish modified their metabolism, perhaps modified their uptake. They were able to survive in this area by excluding or getting rid of the petroleum hydrocarbons they absorbed.

The fiddler crabs on the other hand, showed quite a different kind of response. Chromatograms of oil extracted from Uca collected in Wild Harbor in 1970, 1972, and 1974 looked virtually identical. Uca has some ability to degrade oil; actually about the same ability to degrade oil as other crustacea. The fact that they developed and have this ability has been used by some as an argument to show that the crabs can respond like Fundulus and rid themselves of the oil. In fact, we believe the situation to be just the reverse. These crabs develop so little ability to degrade oil that

they would need more than their lifetimes to get rid of what they contain within their bodies. Of course, they're continually exposed to the oil so they're continually accumulating fresh amounts of it.

We also made studies of the populations of Uca. All were killed in the immediate area of the oil spill, and a reduced number lived farther away. The population distribution also was very different from that in unoiled areas with most of the crabs being adult males with no juveniles, no young, and few females in polluted areas.

The crabs that were the most territorial, the males, moved into the areas in which the other crabs had been killed and then fell victim themselves so that a continual migration of new animals into the oiled region occurred. In fact, the animals responded in a very predictable fashion. As they became poisoned their activity slowed down. They didn't retreat into their burrows when disturbed and would stand and look at you as you walked near. As the poison took more effect they became poorly coordinated as well. (This sequence of events was born out by experimental studies in the laboratory.) Male fiddler crabs have a large claw which they use for display purposes. One of their reactions when threatened is to raise their fiddle in a defensive manner. As they became poisoned they fell over on their faces from the weight of the raised claw. They lost the ability to make the other adjustments in their limbs in order to maintain balance. They eventually became immobilized and died.

The fiddler crab populations have recovered to a very considerable extent now, seven years after the oil spill. Looking at the data over those seven years there's a fairly good correlation between the amount of fiddler crab population which was essentially zero at 1,000 ppm of oil in the sediment to a more or less normal population level when the oil level was below 500 ppm. There were about 1,000 young crabs per square meter in areas that were lightly oiled with no more than 200 ppm in the substrate and about 500 in the areas that had as much as 1,000 ppm in the substrate. The probability is that the crabs do not avoid settling on the oiled areas but are killed immediately in the heavily oiled areas.

The crabs settled in the fall. The biggest effect came over the winter. From 90-95 percent of these small crabs that were sampled in the fall were alive the following spring in the control areas. In areas of 200 ppm of oil about 80 percent survived. In heavily oiled areas less than 20 percent survived.

In summary, we extensively studied this spill of particularly toxic oil that came ashore in one small area. The oil became mixed into the sediment and had a long-lasting effect with high concentrations remaining. It's perhaps the worst kind of situation possible, and so represents the extreme condition that one might expect from an oil spill. However, confined areas, where there are sufficient waves to mix oil down into the sediment, do exist in Alaska and therefore I think the results of our study are pertinent to the situation here.

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VULNERABILITY OF SHORELINE ENVIRONMENTS TO OIL SPILL IMPACTS

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INTRODUCTION

The presentation at Cordova contained a large number of colored slides and other graphics that cannot be included in this manuscript. Two oil spills, those of the tankers *Metula* and *Urquiola*, were described in some detail in the talk, and a classification of coastal environments with respect to vulnerability to oil spill impacts was discussed. A summary of these facets of the talk follows.

THE PROBLEM

Loss during transportation is the major contributing factor in oil pollution of the marine environment (Table 1). Oil losses are incurred by tanker accidents, off-loading to shore-based facilities, and from normal ship operations (Cox, 1974). Spills from tanker accidents are the most obvious source of contaminants and the center of public awareness. Table 2, compiled from a wide variety of sources, presents a partial list of major oil spills that have occurred since the *Torrey Canyon* disaster of 1967. Note that even with advances in navigational and technical equipment, there have been three major oil spills involving tankers and one major spill from a shore facility since 1974[1]. All of the spills listed have affected the nearshore coastal zone. Cost estimates for the control and treatment of oil from the Mizushima Refinery spill in Japan in 1974 were placed at $100 million (Nicol, 1975). This may be considered as typical for a conscientious clean-up and idemnification program in a populated and developed country. The important fishing industry and large wildlife population of Prince William Sound pose special problems.

With the beginning of tanker traffic in Prince William Sound in the fall of 1977, this area will immediately become the most endangered area in all of Alaska with respect to major oil spills. Case histories of past oil spills have indicated a singular lack of preparedness and familiarity with the marine processes which influence oil distribution and perserverence. Undoubtedly, this is partially due to the crisis situation surrounding an oil spill, but it also

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[1] This table does not include the rash of tanker accidents that have occurred recently.

TABLE 1. Sources of Petroleum Hydrocarbons found in the Marine Environment from World-Wide Imports. Estimates Derived from the National Academy of Sciences Workshop (From Cox, 1974).

	Millions of Tons per annum	
	Recent estimate (1973)	High estimates (1980's)
Marine Transportation	2.2	2.0
Offshore Oil Production	0.1	0.1
Coastal Oil Refineries	0.2	0.05
Municipal and Industrial Waste	0.9	0.6
Runoff	1.6	1.9
Natural seeps	0.6	0.6
Atmospheric Rainout	0.6	0.6
TOTAL	6.2	5.85

TABLE 2: MAJOR OIL SPILLS

OIL SPILL	DATE	OIL TYPE & AMOUNT (SHORT TONS)	AFFECTED COASTLINE	CONTROL/TREATMENT COST	CONTROL/TREATMENT METHODS
Torrey Canyon 7 miles N/E of Isles of Scilly, S/W England	March 1967	Type: Kuwait Crude 2% Bunker C 117,000 tons total 18,000 tons reached British coastline	180 km in Britain 320 km in France Sandy Beaches Rocky Shores Estuaries	$1 million	Detergents Chalk Heavy Machinery Manual Labor
Metula Strait of Magellan, Chile	August 1974	Type: Saudia Arabian Crude 3% Bunker C 53,000 tons total 40,000 tons on coastline	150 km Sand & Gravel Beaches Estuaries Marshes/Tidal Flats	No clean-up or control activities	
Mizushima Refinery Shorebased tank, Inland Sea Japan	December 1974	Type: Bunker C 46,686 tons 20-40,000 tons on coastline	Rocky Shores Sandy Beaches	Over $100 million	Dispersants Heavy Machinery Booms and Pumps Manual Labor
Urquiola La Coruna Spain	May 1976	Type: Persian Gulf Crude 2% Bunker C 110,000 tons total 25-30,000 ashore	215 km Sandy Beaches Rocky Shores Estuaries Marshes/Tidal Flats	?	Dispersants Booms and Pumps Heavy Machinery Manual Labor
Jakob Maersk Porto, Portugal	January 1975	Type: Iranian Crude 2% Bunker C 80,000 tons total 15-20,000 tons ashore	 Sandy Beaches Rocky Shores Shore Facilities	?	Dispersants Booms Heavy Machinery Manual Labor

TABLE 2: MAJOR OIL SPILLS
(continued)

OIL SPILL	DATE	OIL TYPE & AMOUNT (SHORT TONS)	AFFECTED COASTLINE	CONTROL/TREATMENT COST	CONTROL/TREATMENT METHODS
Santa Barbara Blowout Santa Barbara Channel, Calif.	January-May 1969	California Crude 12,320-124,190 tons total	Rocky Shores Sandy Beaches	?	Detergents Sand Blasters Hydro-blasters Heavy Machinery Manual Labor
Arrow Chedabucto Bay Nova Scotia	February 1970	Bunker C 18,220 tons total	150-190 miles Sandy Beaches Gravel Beaches Rocky Shores	?	Mechanical Removal Manual Labor
Tamano Portland, Me.	July 1972	No. 6 Fuel Oil 380 tons total 114-138 tons	46 miles affected Sandy Beaches Rocky Shores Marshes/Tidal Flats	?	Mechanical Removal Adsorbants Booms Manual Labor
F. L. Hayes Long Island Sound, Conn.	March 1972	No. 2 Fuel Oil 304 tons total Minor amounts ashore	Rocky Shores Sandy Beaches	?	Booms Adsorbants Manual Labor

pertains to the lack of clear information on how oil reacts with particular environments. It is hoped that environmental vulnerability maps will be constructed for Prince William Sound. These maps, plus some kind of current trajectory probability studies, would aid in selecting the areas that should be protected first in the event of a spill. This would allow the placement of booms and the institution of other protective measures for the most sensitive areas.

THE *METULA* SPILL

The VLCC *Metula* ran aground on August 9, 1974 while navigating through the eastern passage of the Strait of Magellan (Fig. 1). Over the next month, 53,000 tons of oil leaked from the ship, and 40,000 tons washed onto the nearby shores (Hann, 1974). Because of the remoteness of the area and questionable legal responsibility for the accident, no attempt was made to control or clean up any of the spreading oil. We were able to visit the spill site during August 1975 and found that oil coverage was still extensive in many of the coastal environments that were originally affected (Fig. 2), including beach face and low-tide terrace portions of gravel and sand beaches, tidal flats, marsh areas, and tidal channels (Hayes and Gundlach, 1975; Hayes, et. al., 1976). Because of the great similarity of the area to the coasts of New England and Alaska, a full study was sponsored by NSF-RANN the following January - March. A total of 66 zonal stations were set up and profiled to determine the overall distribution and perseverence of the oil, as well as the overall geomorphic units present in the affected area. Sixteen stations were selected as representative areas and studied in much greater detail. Trenches were analyzed to determine oil distribution beneath the present beach surface, and plan-view oil distribution maps were superimposed on our physiographic maps for each locality.

The distribution of oil within the affected environments assumed many forms. On the beaches, oil was usually preserved at the upper high-tide swash areas and on the low-tide terrace. In the middle beach face zone, the beach was either swept clean of oil by the waves, or the oil was buried by newly-deposited sediment. The sheltered tidal flats and salt marshes were the most severly-affected zones. Gravel areas were also highly affected, being especially susceptible to penetration by the oil. Many of the areas were only slightly modified two years after the spill.

THE *URQUIOLA* SPILL

At 8:00 a.m., 12 May 1976, the supertanker *Urquiola* ran aground at the entrance to La Coruna harbor in northwestern Spain. The ship exploded in the early afternoon. Part of its cargo of 110,000 tons of crude oil burned, but approximately 25-30,000 tons washed into the coastal environment. After nine days, the oil was dispersed over 60 km of shoreline. At the end of 30 days, a total of 215 km of coastline was affected.

A preliminary study of the *Urquiola* spill was carried out by Hayes and six associates immediately after the spill, from May 17 through June 10, 1976. Many different coastal environments were affected by

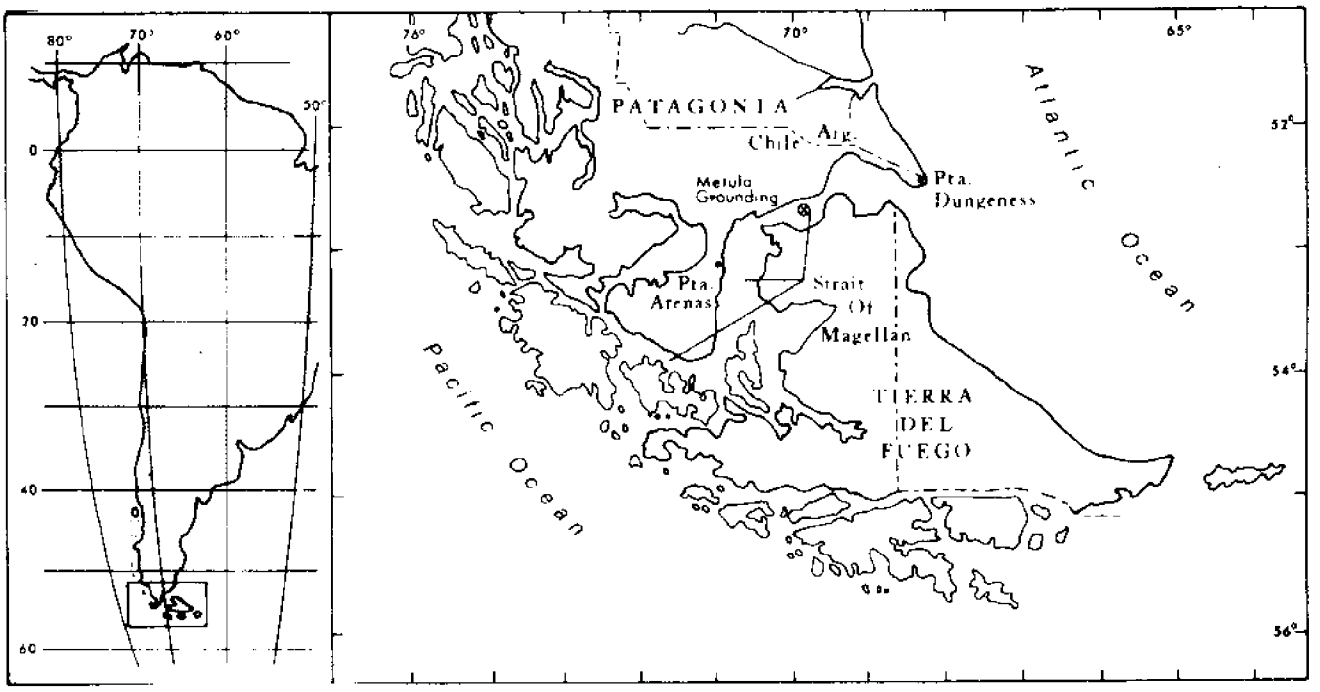

Figure 1. Location of the *Metula* grounding on 12 August 1974. 40,000 tons of Saudi Arabian crude were spread over 150 km of shoreline (Hann, 1974).

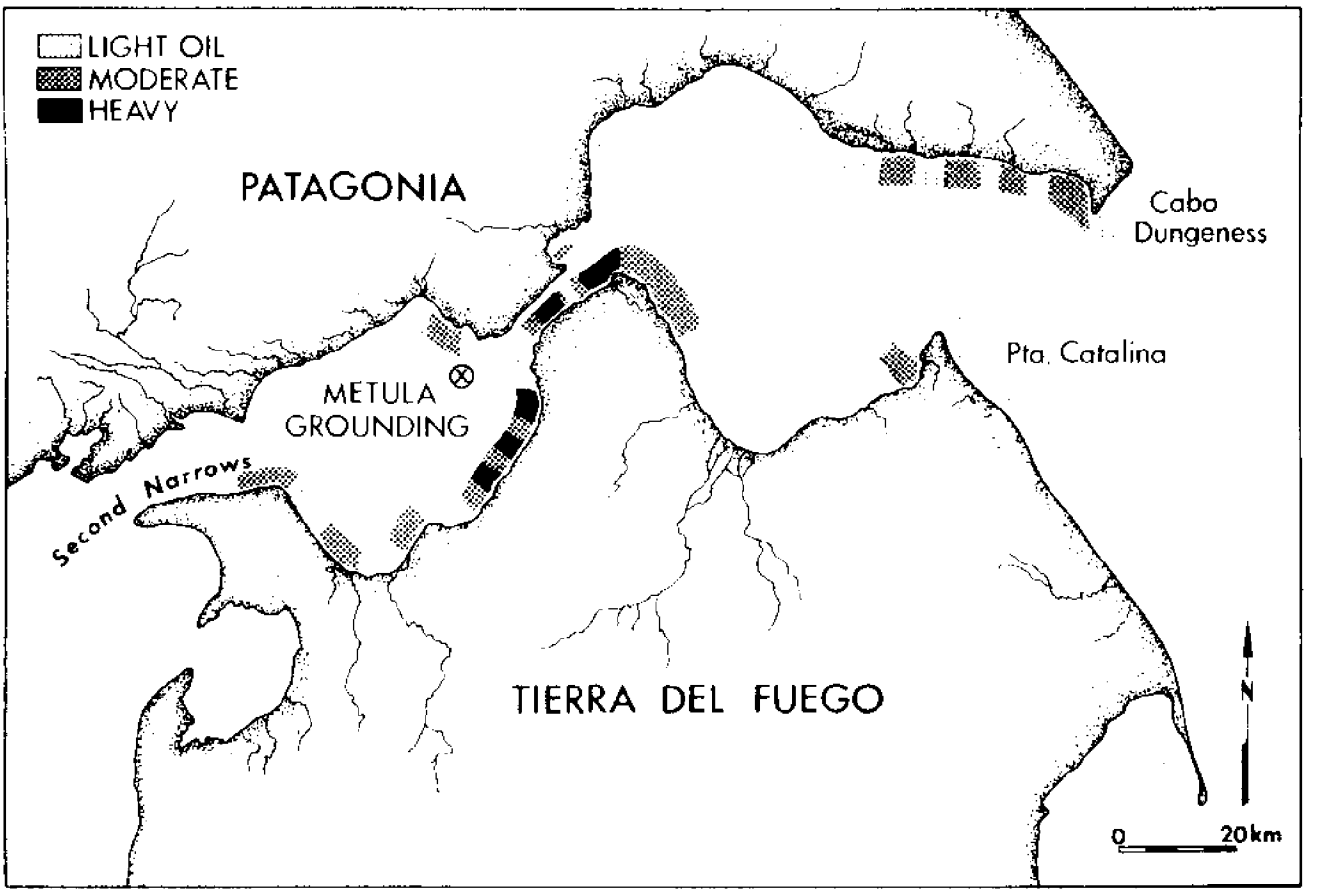

Figure 2. Distribution of oil spilled by the supertanker *Metula* in August and September, 1974. Sand and gravel beaches, tidal flats, low-tide terraces and marshes were heavily affected. Map based on study conducted by Hayes and associates in January - March 1976.

the oil, including open ocean beaches, rocky cliffs, protected beaches, tidal flats, and marshes. The *Urquiola* site also shows some similarities to Prince William Sound in that it is predominantly a ria (embayed) shoreline (the type locality, in fact). Climatic and tidal conditions are different, however. This study provides us with the opportunity to actually see a large mass of oil come on-shore and observe its behavior through time.

A PROPOSED ENVIRONMENTAL VULNERABILITY CLASSIFICATION

On the basis of the two case studies cited above, plus careful study of the literature, a scale of environmental vulnerability to oil spill impacts has been derived. This scale relates primarily to the longevity of oil in each environment. The subtleties of chemical weathering of the oil within each environment have not yet been studied in enough detail to be incorporated into the vulnerability scale. A preliminary study by Rashid (1974) concluded that chemical weathering processes are more active on high energy coasts than on low energy coasts, although the details of his environmental classification are rather obscure. Also although biodegradation rates are thought to be slower in cold temperatures, little documentation exists to verify that notion.

Coastal environments are listed and discussed below in order of increasing vulnerability to oil spills:

1. Straight rocky headlands:

   Most areas of this type are exposed to maximum wave energy. Waves reflect off the rocky scarps with great force, readily dispersing the oil. In fact, waves reflecting off the scarps at high tide tend to generate a surficial return flow that keeps the oil off the rocks (observed in Spain).

2. Eroding wave-cut platforms:

   These areas are also swept clean by wave erosion. All of the areas of this type at the *Metula* spill site had been cleaned of oil after one year. The rate of removal of the oil would be a function of the wave climate. In general, no clean-up procedures are needed for this type of coast.

3. Flat, fine-grained sandy beaches:

   Beaches of this type are generally flat and hard-packed. Oil that is emplaced on such beaches will not penetrate the fine sand. Instead, it usually forms a thin layer on the surface that can readily be scraped off by a motorized elevated scraper or some other type of road machinery. Furthermore, these types of beaches change slowly, so burial of oil by new deposition would take place at a slow rate. There are very few beaches of this type in Prince William Sound.

4. Steeper, medium-to coarse-grained sandy beaches:

   On these beaches, the depth of penetration would be greater than for the fine-grained beaches (though still only a few centimeters), and rates of burial of oil would be greatly increased. Based on earlier studies by our group in numerous localities, it is possible for oil to be buried as much as 50-100 cm within a period of a few days on beaches of this class. In this type of situation, removal of the oil becomes a serious problem, inasmuch as it would be necessary to destroy the beach in order to remove the oil. This was a common problem encountered during the clean up of the *Arrow* spill in Chedabucto Bay, Nova Scotia (Owens and Rashid, 1976). Another problem is that burial of the oil preserves it for release at a later date when the beach erodes as part of the natural beach cycle, thus assuring long-term pollution of the environment.

5. Impermeable muddy tidal flats (exposed to winds and currents):

   One of the major surprises of the study of the *Metula* site was the discovery that oil did not readily stick to the surfaces of mud flats. Also, penetration into the sediments was essentially non-existent. Therefore, if an oiled tidal flat is subject to winds and some currents, the oil will tend to be eventually removed, although not at the rapid rate encountered on exposed beaches.

6. Mixed sand and gravel beaches:

   On beaches of this type, the oil may penetrate several centimeters, and rates of burial are quite high (a few days in Spain). Most of the beaches on both the *Metula* site and Prince William Sound are of this type. The longevity of the oil at the *Metula* site, particularly on the low-tide terraces and berm top areas, attests to the high vulnerability of these beaches to long-term oil spill damage.

7. Gravel beaches:

   Pure gravel beaches have large penetration depths (up to 45 cm in Spain). Furthermore, rapid burial is also possible. A heavily-oiled gravel beach would be impossible to clean up without completely removing the gravel.

8. Sheltered rocky headlands:

   Our experience in Spain indicates that oil tends to stick to rough rocky surfaces. In the absence of abrasion by wave action, oil could remain on such areas

for years, with only chemical and biological processes left to degrade it. Many miles of the sheltered embayments of Prince William Sound are fringed by rocky coasts of this type.

9. Protected estuarine tidal flats:

   Once oil reaches a backwater, protected, estuarine tidal flat, chemical and biogenic processes must degrade the oil if it is to be removed.

10. Protected estuarine salt marshes:

    In sheltered estuaries, oil from a spill may have long-term deleterious effects. We observed oil from the *Metula* on the salt marshes of East Estuary, on the south shore of the Strait of Magellan, that had shown essentially no change in one and one-half years. We predict a life span of at least ten years for that oil.

ACKNOWLEDGEMENTS

This manuscript was prepared with the assistance of Erich Gundlach and Jacqueline Michel. Anne Blount, Ian Fischer, Chris Ruby, Robert Stein, and Larry G. Ward collaborated on the field work on the *Metula* and *Urquiola* spills. Financial assistance was provided through a contract with NSF-RANN, (No. ENV. 76-068-98-A02).

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TANKER SAFETY AND NAVIGATION STANDARDS

TANKER SAFETY AND NAVIGATION IN ALASKA

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I will be commenting today on the Coast Guard's role in tanker safety and navigation. First I would like to speak on developments on the national level, particularly the President's recent message on tankers and oil spills, which was amplified by Secretary Adams in his March 18th appearance before the Senate Committee on Commerce, Science and Transportation. Then I will give my assessment of the Vessel Traffic Service encompassing Valdez, Prince William Sound, and the approaches to Hinchinbrook.

With its primary objective being the protection of life, property, and the marine environment, and as the federal government's principal maritime law enforcement agency, the Coast Guard performs various missions in and around United States waters, and throughout the world. Many of these missions are familiar to you. Search and Rescue is, perhaps, the most visible mission, historically. Each year, the Coast Guard saves thousands of lives and millions of dollars worth of property. Another mission area probably well known to you is Fisheries Law Enforcement. The new 200-mile Fisheries Conservation and Management Act has added greatly to our responsibilities in this area, particularly here in Alaska. Tanker safety and navigation concerns the Coast Guard in a number of functional areas: the protection of vessels, their crews and cargos; the protection of the ports and waterways used by these vessels; the protection of the marine environment; and the facilitation of marine transportation. We have been performing the first two of these functions and, as such, have been in the tanker safety business since 1942. Our Office of Merchant Marine Safety has been primarily responsible for these matters. The protection of the marine environment became a Coast Guard mission in the late 1960's and for the first few years was carried out under the then existing Coast Guard organizational structure. But, in 1971, in a major reorganization, the Coast Guard formed the Office of Marine Environment and Systems which is headed by a Flag Officer and has the same status as does any other major Coast Guard mission area.

In all of the mission areas I have mentioned, the Coast Guard is the recognized expert, not only nationally, but internationally. Many countries seek our professional advice on establishing or expanding their own Coast Guard. We are the acknowledged professionals in maritime search and rescue, in aids to navigation, and in the field of marine safety. And our reputation as seamen is similarly excellent. As many of our missions often require our sailors to perform under the harshest of conditions, it is necessary for these men to be among the most experienced and competent in the world. We can also apply such competence to our regulatory functions.

I mentioned that the Coast Guard has been in the tanker safety business for about thirty-five years. Many of you may not be aware of the extent of that involvement. For a U.S. tanker, conformity to standards begins with the design and construction of the vessel. Plans must be approved and the vessel is frequently inspected during its construction by Coast Guard officers who are specifically assigned to various ship yards around the country. The inspection program continues throughout the vessel's life. The Coast Guard specifies equipment for vessels and periodically inspects it as well. The personnel that man U.S. vessels are examined and licensed by the Coast Guard and many facets of vessel operation are governed by Coast Guard regulations. I must emphasize, however, that regulatory actions are not always the product of unanimity, but frequently involve substantial conflict and difference of viewpoint, even among the experts.

About two weeks ago, President Carter issued a comprehensive message on oil pollution which provided direction for the resolution of several important and much-debated issues and included a number of initiatives concerning safety and environmental protection. I think it is important to concentrate first on some of the President's comments, rather than just to list the new initiatives, though I will note those as well.

The President mentioned that oil tankers pose a danger to human life as well as the environment. The international initiatives which the President is undertaking state that the major problem has been with foreign vessels, not with U.S. vessels. He also noted that far more pollution resulted from operational discharges than from tanker accidents. However, I consider our primary concern with regard to Valdez/Prince William Sound to be the prevention of a catastrophic oil spill.

The President identified three objectives which his actions are designed to meet. These are: (1) to reduce oil pollution from both operational discharges and tanker accidents; (2) to improve our ability to deal with oil spills which do occur; and (3) to assure that citizens damaged by oil spills are compensated for losses.

With regard to the new tanker standards, the President has chosen administrative processes for implementation rather than the legislative approach that was initially considered. The President has directed the Secretary of Transportation to prepare proposed regulations within sixty days which would apply to all oil tankers over 20,000 DWT, both U.S. and foreign, which enter U.S. ports. The regulations will include:

1. Double bottoms on all new tankers.

2. Segregated ballast on all tankers.

3. Inert gas systems on all tankers.

4. Backup radar systems with collision avoidance systems on all tankers.

5. Improved emergency steering standards for all tankers. Requirements for existing vessels will be phased in over a five-year period.

The President's message identified a number of international initiatives which he has undertaken. These include:

1. Endorsement of the 1973 Marine Pollution Convention and a call for rapid ratification.

2. International negotiations on standards for crew qualification.

3. A call for an international conference to consider upgrading international standards to a level considered satisfactory by the United States.

4. Directing the State Department and Coast Guard to begin diplomatic efforts to upgrade the present international system of inspection and certification.

The President has directed the Coast Guard to board every foreign tanker which enters U.S. ports to insure that the vessels meet all existing safety and environmental protection regulations. Comprehensive records will be maintained and tankers with a history of violations and accidents will be excluded from U.S. ports, if necessary.

The Coast Guard and the Environmental Protection Agency will be upgrading their spill response capability with a goal of responding within six hours to a spill of 100,000 tons.

The President also endorsed the enactment of the Comprehensive Oil Pollution Liability and Compensation Act of 1977, which will be discussed here tomorrow.

The President noted that human error is involved in 80 to 85 percent of all tanker accidents. This point was also made by Commissioner Mueller in his testimony on proposed regulations for Prince William Sound Vessel Traffic Service. From the outset, we have recognized that properly trained pilots are probably the single most important factor in building a safe tanker transportation system for Prince William Sound. To this end, we have implemented local qualification standards for Central and Western Alaska that represent a quantum step in upgrading Coast Guard pilotage requirements. Pilots now seeking an endorsement will be required to move up in steps through four different tonnage classes of vessels before they will be allowed to pilot the larger vessel involved in the Valdez tanker trade. In order to go through a new training program under the direction of a licensed pilot. Before an unlimited license can be earned, a pilot will

have to go through an additional rigorous training program that must include practical experience on vessels over 60,000 GT or approximately 100,000 DWT. and may include simulator training. The pilots who initially will be handling the Valdez tanker traffic are already highly qualified. They have been handling vessels up to 70,000 DWT. in Cook Inlet, docking at Nikiski without the use of tugs under arduous conditions of ice and current, and have all undergone simulator training for piloting large vessels. Furthermore, in the near future they will participate in tanker operations during the ARCO Fairbanks visit.

(Editor's Note: The following was presented by Lt. Comdr. Thompson)

I will be briefly describing the Vessel Traffic Service (VTS) which the Coast Guard is installing and will operate in Prince William Sound. The authority for the Coast Guard to establish and operate VTS's was set forth in the Ports and Waterways Safety Act of 1972.

The TAP Authorization Act passed in 1973 amended the PWSA to specifically require the Coast Guard to establish and operate a VTS in Prince William Sound.

The Coast Guard will have spent nearly $8 million on the Prince William Sound VTS when it goes into operation this summer. This is slightly more than is being spent on the New York VTS which will go into operation shortly after Valdez. It is considerably more than is being spent on a VTS for the lower Mississippi River and New Orleans - the nation's busiest port. While talking money, I might also mention that the Coast Guard's $13 million, Gulf of Alaska LORAN C chain will go into operation next month and will add a new dimension in navigational accuracy in the Gulf and Prince William Sound. One of the prime users will be the TAPS tankers which, by the way, will be required by Coast Guard VTS regulations to carry a LORAN C receiver. This slide depicts LORAN C coverage in the northern Pacific, including, of course, the northern Gulf of Alaska and Prince William Sound.

There are four basic system elements to the VTS. The first of these is the traffic separation scheme (TSS). The VTS TSS will officially commence at Hinchinbrook Entrance, Prince William Sound's major opening to the Gulf of Alaska. The TSS is laid out first in a NNW and then in a northerly direction through the Sound to Bligh Reef. Over this stretch the traffic lanes are 3/4 mile wide, the separation zone is a mile wide. Inbound traffic proceeds in the east lane; outbound in the west lane. Beginning at Bligh Reef, where it turns northeasterly, the TSS narrows as it enters Valdez Arm. At its termination point just south of Jack Bay, the lanes are 1000 yards wide and the Separation Zone is 800 yards wide.

A stretch of water approximately four miles long through Valdez Narrows will be restricted to one-way traffic for tank vessels.

I should emphasize that the TSS and one-way traffic area I have described do not incorporate changes proposed in recent public hearings. These are under review and adjustments may be made.

The second system element is communications which is the backbone of the system. VHF-FM coverage of the Sound and approaches will be provided by four stations - in Valdez Harbor, at Potato Point in the Narrows, at Johnstone Point and at Cape Hinchinbrook. There will be total redundancy of equipment at each site.

The third system element is shoreside surveillance which will be conducted by radar from two locations. The port area will be covered from a site near our traffic control center. This station will provide coverage of the port area. Valdez Narrows and Arm will be covered by a radar at Potato Point. The radar to be installed is among the most sophisticated available. It has a number of special technical features and is highly reliable equipment with outstanding range and bearing resolution, as can be seen in this radar picture of San Francisco harbor which clearly shows the individual piers and vessels underway.

Proposed regulations for the Prince William Sound VTS have been drafted and were published in the Federal Register on February 7 this year. Formal Public Hearings were held in Juneau and Anchorage on March 18 and 21 respectively. Public meetings were held in Valdez and Cordova on March 23. Some of the important features of the regulations are:

Mandatory Participation
Communications Procedures
Position Reporting Requirements
Vessel Movement Rules
Emergency Procedures

One section of the regulations will deal with special requirements for oil tankers. These include:

Two Marine Radars
LORAN C Receivers
Rate of Turn Indicator
Tug Assistance

As required by the PWSA, we consulted with various interest groups prior to preparing the draft regulations. In fact, we went considerably further than simple consultation. In February of 1976 we conducted a series

of five public meetings to receive input to the Proposed Rules. These were well attended and provided us with excellent input, much of which is reflected in the Proposed Rules published recently. A transcript of these meetings was prepared and distributed to those who attended. The transcripts were used extensively in preparing a comprehensive preamble which was published with the Proposed Rules.

As has been done with our other operating VTS's an Operating Manual will be published to supplement the Regulations. In addition to a further explanation of such things as: who must participate, one-way traffic, and tug requirements, it will contain information on fishing activity in Prince William Sound, weather reporting, chartlets and sample messages. The first draft of this Manual, based on the Proposed Rules, has just been completed and will be evaluated during the tanker operations.

The entire VTS operation will be monitored and controlled from our Vessel Traffic Center in Valdez proper. Our station, which will be manned by 47 Coast Guardsmen, is located directly across Port Valdez from the Jackson Point Terminal. Construction of the Center and other required structures is complete.

Electronics installation will commence early this spring, and once in operation, communications and radar surveillance will be conducted from the VTC on a 24-hour basis.

Returning to a chart of the area, it is most helpful to consider three geographic areas when examining the measures we have already taken, and are currently investigating, to prevent tanker mishaps. By viewing the system in this manner, you can see how, as a vessel sails closer to Valdez, additional and more elaborate safety measures are taken in a sort of building block process. These three areas are the offshore approaches to the Sound, the central Sound between Hinchinbrook Entrance and Bligh Reef, and the confined waters between Bligh Reef and the Terminal.

Concentrating first on the offshore approaches to the Sound, from a navigational standpoint this is not a particularly difficult landfall to make for the inbound vessel. But there are some hazardous rocky areas off the Coast, namely the area surrounding Middleton Island, Wessels Reef and Seal Rocks.

We have taken, or will take, the following measures to increase navigational safety in the approach area:

Traffic Lanes
Aids to Navigation
Communications
Position Reports
LORAN C

The traffic lanes, being in international waters, are beyond our jurisdiction. However, we will submit the final recommended lanes to IMCO for adoption. By the way, I mentioned earlier that the traffic lanes I would be describing might be adjusted. This is quite certain in the approach lanes. They will be moved further east so that traffic bound to or from the sound will pass northeast of Seal Rocks.

Regarding Aids to Navigation in this sector we have upgraded the buoy marking Wessels Reef and established new lights at Seal Rocks, Bear Cape and Schooner Rock.

Communications coverage will be provided through a VTS VHF-FM remote site at Cape Hinchinbrook as well as a high frequency site on Middleton Island. Vessels will be required to report their position as they approach the Sound.

As I mentioned earlier, the oil tankers will be required to have a LORAN C receiver. Coverage will be excellent in the approach area.

An additional measure we currently have under study for this sector, as well as the other two, is LORAN C retransmission, which would permit direct readout of a vessel's LORAN C readings at the VTC. We will be evaluating this system during the tanker operations.

Moving to the Prince William Sound sector, from Cape Hinchinbrook to Bligh Reef, the following measures will be in effect. Many appear the same as for the approaches. But there are some modifications and some additional measures, as indicated by the asterisks:

Traffic Lanes
Aids to Navigations
Communications
Position Reports
LORAN C
*Regulations
*Pilotage
*Anchorages

I have described the traffic lanes earlier. The difference between these and the approach lanes is that these are in U.S. waters and we will require that they be utilized.

Additionally, we have, as an adjunct to the VTS lanes, recommended tracks for vessels bound to and from

Cordova in order to minimize interference with fishing activities.

As regards Aids to Navigation in this sector, four aids were upgraded and new aids were established at Knowles Head, Goose Island and Glacier Island.

Communications coverage will be provided from Johnstone Point and Potato Point. Position reports will be required.

Again LORAN C equipment is required aboard the oil tankers.

Additional measures are to be employed in this sector and are indicated by an asterisk.

Being now in U.S. waters, all aspects of vessel operation will be guided by the VTS regulations I mentioned earlier.

A pilot will be required commencing at Hinchinbrook Entrance. Vessel masters and mates will obtain pilots endorsement for this stretch of water.

After some tests during the tanker operations, we will designate one or more anchorage areas in the upper Sound where vessels can be held if necessary. Our preliminary plans for anchorages near Knowles Head and Middle Ground Shoal were revised after talking to the fishermen. They have suggested we also consider the area south of Glacier Island and an area southeast of Bligh Island.

Measures under study for this sector include:

LORAN C Retransmission
Aids to Navigation Review
Upgrade Pilot Qualifications

The LORAN C retransmission I have already mentioned.

We are again reviewing the adequacy of the aids to navigation in this sector. During the tanker operations we will conduct a further evaluation of the aids.

Admiral Hayes, of course, has already addressed pilotage.

The third sector is the comparatively confined stretch of water from Bligh Reef to the Terminal. Many of the same measures to be employed in the Sound will also be used in this sector. But there are additional measures as well:

Traffic Lanes
Aids to Navigation

Communications
Position Reports
LORAN C
Regulations
Pilotage
*One-way Traffic
*Radar Surveillance
*Tug Assistance
*System Closure

One-way traffic for tank vessels will be in effect for a four-mile stretch including Valdez Narrows. There will be radar surveillance over the entire sector, from Bligh Reef to the terminal.

The tankers will be required to use tug assistance when docking or undocking at the Jackson Point Terminal, and may be required to use tugs in Valdez Narrows.

A final measure to be implemented for this sector is system closure. High winds - though not nearly as high as have been reported in some circles - have been recorded in Valdez Narrows. It is our present intention to close the Narrows to traffic when the winds exceed 40 knots.

Valdez Narrows has received a good deal of attention recently - particularly the outcropping known as Middle Rock. The Coast Guard's position is that while any rock is a hazard to some degree - just as is the rugged shoreline in the Narrows - Middle Rock is not so significant a hazard as to warrant its removal at a cost estimated to be $18.5 million by the Corps of Engineers. There are a number of reasons for our position.

To begin with, Middle Rock is somewhat misnamed. Currently, the narrowest part of the channel is 900 yards wide, measured between the rock and the east shore. This is actually a conservative figure, as this distance is measured between 10 fathom curves, rather than from beach to beach.

If the rock did not exist - or were removed - the narrowest part of the channel would be 1200 yards - measured between the eastern shore and Bunch Island on the west. Thus the removal of Middle Rock would widen the channel by only 33 percent, not 100 percent as Middle Rock's name would suggest.

I might note that the existing channel width of 900 yards is sufficient to place 18 supertankers side by side.

Secondly, the existing 900 yard wide channel compares quite favorably with many ports throughout the world.

In particular, it is quite roomy when compared to three superports in Europe, all of which handle larger ships and a greater volume of traffic than Valdez will. The slides I'm about to show you are to the same scale as that shown here of Valdez Narrows.

This is Finnart in Scotland. The approach channel is narrower and longer, as can be seen on this chart. This channel is four miles long, with an average width of 800 yards and a minimum width of 375. And unlike Valdez, there are not relatively wide bodies of water on either end of the Narrows.

Another example is Milfordhaven in Wales. Almost all of this five mile channel is less than 450 yards wide, and the minimum width is 300 yards. There is also a very sharp turn in the channel as you can see. Twelve thousand three hundred tankers have called here in the last three years.

Finally, there is Europoort, part of the port complex of Rotterdam. This is the largest port in the world, with 36,000 seagoing vessels calling each year. One thousand nine hundred supertankers called in Europoort last year. Again the channel is longer and narrower than the approach to Valdez. Here is a slide showing Valdez Narrows looking south-southwesterly from the harbor. This is what the outbound laden tanker sees as he departs the port. Again, it is 900 yards wide at the narrowest point.

Here is an aerial view of the Narrows, looking in the same direction. The channel entrance into Europoort is 400 yards wide--shown here between the jetty and buoy. Yet vessels as large as 300K DWT, larger than anything which will call in Valdez, regularly call in Europoort.

It should also be mentioned that in all three of these ports, there is considerably more vessel congestion than will be found in Valdez. There are ten different vessels in this picture looking seaward from the vicinity of the Europoort entrance.

That concludes the VTS briefing.

What Lt. Comdr. Thompson has just explained is the specific Vessel Traffic System for Prince William Sound and Valdez. As I noted earlier, the major considerations in regulating tankers and tanker traffic are the protection of life and property, protection of the marine environment, and facilitation of marine transportation. In developing the Valdez/Prince William Sound System, I have considered safety and environmental protection of equal priority, with facilitation of marine transportation secondary to them. We looked at

every facet of vessel movement through the system to anticipate and evaluate potential problem areas. We have sought and received input from virtually every user group and interested party associated with Prince William Sound and the tanker traffic. We have made a number of improvements through this interchange. In response to the proposed regulations to implement the Vessel Traffic Service, we have received many comments that are still being evaluated prior to preparation of the final regulations.

Two ongoing projects remain to be completed. First, as you all are probably aware, we begin tanker operations with the ARCO Fairbanks this coming week. This million dollar operation will last four weeks and will be divided into three phases. Phase one will last for about two weeks and will have as its primary purpose the training of the masters of all vessels involved in the TAPS trade to qualify them as pilots from Hinchinbrook Entrance to Bligh Reef. At the same time, Coast Guard personnel aboard the tanker and at the radar site at Potato Point will be plotting the vessel, evaluating aids to navigation, communications, and anchorages in the system, and debriefing the masters and pilots regarding their evaluations. Phase two will last for approximately one week and will have as its purpose the training of local pilots in the Bligh Reef to Valdez area. The pilots who already hold pilotage for that area are voluntarily participating in this phase of the training at considerable cost and inconvenience to themselves. In addition, the Coast Guard will continue its system evaluation during this phase. The final Phase will involve dockings at the Alyeska facility, a test of the ballast water treatment system, an oil spill drill, evaluation of tug assistance, and further pilot training. As you can see, these tanker operations will provide an extensive evaluation of the Hitchenbrook to Valdez tanker route, unprecedented opportunity for pilot training, and a real life data base to compare with the results of the simulator study which will be completed soon in the Netherlands.

This second project--the simulation study--is a continuation of the study first undertaken last year by the State of Alaska. It is jointly funded by the Coast Guard, state, and industry at a cost of almost $200,000. The results of this simulator study, which should be available in May, will hopefully provide further information to help fine tune the VTS.

In my professional opinion, by the time tanker traffic commences, we will have an environmentally safe operation which will be as safe as any in the world today.

NATIONAL AND INTERNATIONAL TANKER STANDARDS

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The imminent opening of the Trans-Alaska Pipeline, coupled with the recent spate of tanker accidents off the coast of the United States, have focused public attention upon the adequacy of standards which protect the marine and coastal environment against oil spills. Although interest in this problem has been heightened this past winter, oil tanker regulation has been a subject of controversy for several years. The safety of the marine transport leg of the Pipeline (the "TAPS Trade") has been a matter to which Congress, concerned West Coast states, and the environmental community have given high priority almost since the inception of the Pipeline proposal.

Opening of the Pipeline will result in the tripling of crude oil trade between domestic ports by 1981. The impact of this growth will be primarily upon the waters and shorelines of the Northeast Pacific. The Pipeline will introduce the first major oil pollution into the waters of the Northeast Pacific. The Northeast Pacific is now relatively unpolluted compared to many of the world's oceans, and along the entire tanker route from Alaska to West Coast ports there have been few casualties resulting in pollution. The Department of the Interior estimated in 1972 that in an average year as much as 140,000 barrels of oil may be spilled into the marine environment as a result of tanker casualties along the Trans-Alaska Pipeline tanker rout. This figure appeared in the Department of the Interior, Final Environmental Impact Statement on the Proposed Trans-Alaskan Pipeline 474 (March 1972). Obviously, the risk of a single, catastrophic spill is also very real. Because of the cold temperatures typical of the waters of the Northeast Pacific, the "weathering" of such oil will be retarded, thus magnifying the risk to exposed resources.

Whether current standards are adequate to cope with the potential pollution problem is certainly open to question. This discussion will examine briefly the basic federal law designed to create an environmentally sound marine transportation system, with particular attention to design, construction, equipment, manning, and operation standards. It will focus upon how this law is related to the international agreement process. It will further examine how the federal law has been implemented and how both states and environmental organizations have responded to that implementation. Finally, it will describe pending legislation, as well as President Carter's oil pollution initiatives, which seek to tighten controls over oil tanker operations.

I. The Basic Authority -- the Ports and Waterways Safety Act

The Ports and Waterways Safety Act of 1972, Pub. L. No. 92-340, 33 U.S.C. §§1221 et seq., 46 U.S.C. §391a (the "PWSA"), establishes the basic authority for the United

States Coast Guard (a) to establish and operate vessel traffic services, systems and controls; and (b) to require that vessels be built to higher standards of design, construction and equipment, and subject to higher standards in their operation.

A. Title I of the Ports and Waterways Safety Act, 33 U.S.C. §§1221 et seq., is primarily directed toward authorizing the Coast Guard to regulate the vessel traffic to ensure port safety. See generally H.R. Rep. No. 92-563, 92nd Cong., 1st Sess. (1971); S. Rep. No. 92-724, 92nd Cong., 1st Sess., 1972 U.S. Code, Cong. & Adm. News 2766 (1972) (hereinafter cited as "PWSA Senate Report"). Of particular importance is the authority given to the Coast Guard to establish and operate radar monitored vessel traffic systems to reduce the risk of tanker accidents.

B. Title II of the PWSA, 46 U.S.C. §391a, calls for the Coast Guard to establish "comprehensive minimum standards of design, construction, alteration, repair, maintenance, and operation (of oil tankers) to prevent or mitigate the hazards to life, property and the marine environment." It specifies that minimum standards of design, construction, alteration, and repair shall include but not be limited to

> "standards to improve vessel maneuvering and stopping ability and otherwise reduce the possibility of collision, grounding, or other accidents, to reduce cargo loss following collision, grounding, or other accidents, and to reduce damage to the marine environment by normal vessel operations such as ballasting and deballasting, cargo handling, and other activities."

C. The PWSA establishes firm deadlines for the promulgation of design, construction and equipment standards. As amended by Section 401 of the Trans-Alaska Pipeline Act of 1973, Pub. L. No. 93-153, 87 Stat. 589 (November 16, 1973)(the "Pipeline Act"), the PWSA calls for design, construction and equipment standards to be effective not later than June 30, 1974, with respect to United States flag vessels engaged in the coastwise trade. Rules and regulations for U.S. flag tankers engaged in foreign trade and foreign flag tankers entering the navigable waters of the United States were required to be effective not later than January 1, 1976.

II. Relationship Between the PWSA, the Pipeline Act and the TAPS Trade

A. Representatives of the Department of the Interior assured members of Congress and the public during consideration of the Trans-Alaska Pipeline that oil tankers servicing the Pipeline would be subject to the highest environmental standards. Former Secretary of the Interior, Rogers C. B. Morton, told the Joint Economic Committee on June 22, 1972, "Newly constructed American flag vessels carrying oil from Port Valdez to U.S. ports will be required to have segregated ballast systems, incorporating a double bottom..." Similarly, former Undersecretary of the Interior, John C. Whitaker, testified before the House Interior and Insular Affairs Subcommittee on Public Lands on April 18, 1973, that tankers in the Alaskan trade would be "double-hulled". These commitments were reaffirmed by Secretary Morton in a letter to Goast Guard officials, dated August 22, 1974, in connection with rulemaking proceedings under the PWSA, in which the Secretary stated,

> "The Department of the Interior believes that the regulations' failure to require the incorporation of double bottoms on all new tank vessels entering the Alaskan oil trade represents a serious error which may adversely affect the environment of Alaska, Canada, the northwestern United States, and indirectly, the entire world for decades to come."

B. In 1973, as part of the TAPS Act, the PWSA was amended in two ways: (1) to accelerate the effective date of Title II standards for tankers in the coastwise trade to June 30, 1974; and (2) to direct the Secretary of Transportation to establish a vessel traffic control system for Prince William Sound and Valdez, Alaska, pursuant to Title I of the PWSA. Pipeline Act, Sections 401, 402.

C. The central purpose of the Pipeline Act amendments to the PWSA was to provide for application of the highest standards of environmental protection to the TAPS Trade. As Senator Jackson, one of the sponsors of the amendments, along with Senators Magnuson and Stevens, stated, after detailing the vast damage to the ocean environment which may be caused by marine pollution, "We must... ensure that every step is taken to guarantee that the marine leg of the system is designed to be both safe and pollution-free. This is the purpose of this Amendment." 119 Cong. Rec. 22838 (July 9, 1973). And, in Senator Magnuson's words, the amendments were "basic to the safety of the marine leg of the Alaska system." 119 Cong. Rec. 22837 (July 9, 1973).

D. The common expectation at the time of passage of the Pipeline Act was that new, stringent standards, e.g., double bottoms, segregated ballast, would shortly be made applicable to tankers in the TAPS trade.

III. Relationship Between National Standards and International Standards

A. The problem with the expectation of new standards was that it did not take into account the relationship between national and international standard setting as mandated by the PWSA, and, perhaps more importantly, as perceived by the Coast Guard.

B. Title II of the PWSA establishes a unique scheme, involving transmittal of U.S. rules to "appropriate international forums for consideration as international standards," for relating standards independently developed in the United States to rules and regulations which might be developed internationally. It thus reflects the Congressional conclusion that, all things being equal, multilateral action on marine pollution problems is "preferable" to unilateral initiatives. PWSA Senate Report at 2783. It was hoped, at the time the PWSA was passed, that a comprehensive marine pollution convention would soon be negotiated, obviating the need for independent U.S. standards. PWSA Senate Report at 2788.

C. Although a proposal to require segregated ballast, achieved in part through a double bottom on all tankers larger than 20,000 deadweight tons, was issued on January 26, 1973 (38 Fed. Reg. 2467), it was withdrawn in July 1973 pending the outcome of international negotiations.

IV. The Response of the International Community

A comprehensive marine pollution convention, the International Convention for the Prevention of Pollution From Ships held in London in October-November 1973. This conference was held under the auspices of the Intergovernmental Maritime Consultative Organization (IMCO). The basic thrust of the 1973 Marine Polution Convention was to provide international pollution control standards, particularly in regard to operational discharges. The primary mechanisms for controlling operational discharges are; (a) discharge standards; (b) operational discharge control measures, including installation of oil discharge monitoring and control devices on existing and new tankers; (c) provision of reception facilities in ports; and (d) a requirement of separate tanks for segregated ballast on oil tankers larger than 70,000 deadweight tons to be enforced after January 1976. The 1973 Marine Pollution Convention would supersede the International Convention for the prevention of Pollution of the Sea by Oil (1954).

V. Criticism of the 1973 Marine Pollution Convention

Gaps and inadequacies in the document created by the 1973 Marine Pollution Convention have made it subject to criticism. With the exception of its requirement for segregated ballast tanks on new, large tankers, it does not contain major design and construction innovations for oil tankers. Further, because the segregated ballast requirement only applies to new vessels, the existence of a tanker surplus means that the world tanker fleet will be effectively exempted from the requirement for the next ten to fifteen years. Finally, in the area of accidental pollution prevention, the 1973 Marine Pollution Convention provides little advancement because it contains no provisions for oil tanker controlability. Double bottoms, urged as a requirement by the United States in order to reduce pollution groundings, were rejected at the 1973 conference.

VI. Coast Guard Authority to Establish Standards in Addition to Those Embodied in International Agreement

A. The PWSA provides the Coast Guard with authority to go beyond the standards of the 1973 Marine Pollution Convention or other international agreements in establishing standards for both U.S. tankers and for foreign flag tankers which enter U.S. navigable waters. The PWSA Senate Report states that Congress was "not willing to sacrifice the objective of protection of the marine environment on the altar of ... (the principle of international regulation)." PWSA Senate Report at 2783. Neither the 1973 Marine Pollution Convention, nor any other international agreement to which the United States is a party, restricts United States rights to establish standards for vessels entering its ports or territorial waters.

B. There are no particular reasons against establishing more stringent requirements for coastwise trades, such as the TAPS Trade, because coastwise trade is protected by law from foreign competition, see 46 U.S.C. §883. Any increased costs of construction or operation which may result from the imposition of environmental standards cannot disadvantage the competitive position of U.S. flag oil-tankers in coastwise trade vis-a-vis foreign oil tanker fleets. Moreover, separate standards for coastwise trade would not affect any purported need for uniform standards in international commerce. As Warren Magnuson, principal sponsor of the PWSA, stated in hearings on proposed Coast Guard rules on July 23, 1974, "Mandatory similar treatment of all U.S. flag vessels, whether they operate in domestic or foreign trade, was not the clear intent of Congress."

VII. Coast Guard Implementation of the PWSA

In implementing Title II of the PWSA, the Coast Guard has relied on standards developed under the auspices of IMCO, in particular the 1973 Marine Pollution Convention. Alternate and more stringent regulations have been rejected because the 1973 Marine Pollution Convention did not provide for them. (See the Final Environmental Impact Statement on Regulations For Tank Vessels Engaged in the Carriage of Oil in Domestic Trade: Protection of the Marine Environment 60-62 (August 1975).)

A. Regulations for oil tankers in domestic trade, were issued on October 14, 1975 (40 Fed. Reg. 48279), and January 8, 1976 (41 Fed. Reg. 1479), and codified at 33 C.F.R. Part 157. These regulations essentially apply the provisions of the 1973 Marine Pollution Convention to oil tankers engaged in trade between U.S. ports. They exceed the 1973 Marine Pollution Convention by requiring the allocation of segregated ballast tanks as "defensive space" along the hull of new oil tankers larger than 70,000 deadweight tons. The Coast Guard concluded, in issuing these regulations, that it had no power to distinguish between coastwise and international trade for purposes of standard setting. Because the Coast Guard determined that it was inappropriate to set higher standards for foreign flag vessels, the rule of uniformity required application of standards in coastwise trade which were, as admitted by the Coast Guard, "considerably less" than is desirable or feasible.

B. Regulations for U.S. flag tankers in foreign trade and for foreign flag tankers entering U.S. navigable waters were issued December 13, 1976 (41 Fed. Reg. 54177). These regulations amended 33 C.F.R. Part 157 by extending the standards established for coastwise trade to vessels engaging in international trade.

C. Navigational safety rules for all tankers larger than 1600 gross tons were issued January 31, 1977 (42 Fed. Reg. 5956) and codified at 33 C.F.R. Part 164. These rules and regulations establish certain navigation safety equipment and operational requirements, including radar, steering compasses, gyrocompasses, illuminated rudder angle indicators, etc. Their basic purpose is to "codify existing industry practice."

D. Proposed legislation in progress:

1. Application of segregated ballast requirements to existing tankers, Advance Notice of Proposed Rulemaking issued May 13, 1976 (41 Fed. Reg. 19672).

2. Requiring LORAN-C position finding equipment on tankers larger than 1600 gross tons. Notice of Proposed Rulemaking issued January 31, 1977 (42 Fed. Reg. 5966).

E. Several vessel traffic control systems have been put in place, e.g., in Puget Sound. See 33 C.F.R. Part 161, Subpart B. One has also been proposed for Prince William Sound. See proposed 33 C.F.R. §§161. 301-161.389 (42 Fed. Reg. 7164 (Feb. 7, 1977)).

VIII. The State Response to Federal Regulatory Efforts

A. The Washington State response, R.C.W. 88.16.170 et Seq., enacted by the Washington State legislature in 1975 (1) prohibits tankers larger than 125,000 deadweight tons from entering Puget Sound; (2) requires all oil tankers between 40 and 125,000 deadweight tons entering Puget Sound to take tug escorts or to have certain specified design features; and (3) requires all oil tankers larger than 50,000 deadweight tons to take a Washington State pilot when navigating the Sound. In September 1976, a Three-Judge District Court in the Western District of Washington held that the Washington State legislation was pre-empted by the PWSA. (Atlantic Richfield Company, et al. v. Daniel J. Evans, et al. (Civil Action No. C75-648, W. D. Wash., September 24, 1976).) An injunction subsequently issued by the District Court on November 12, 1976, has been stayed by the Supreme Court pending appeal. On February 28, 1977, the Supreme Court noted probable jurisdiction in the case. (45 U.S.L.W. 3582.) Argument is scheduled for the October Term, 1977. The outcome of this appeal may have bearing on the validity of the Alaskan legislation.

B. Other state efforts include (1) Alaskan legislation, Chapter 266, Laws of Alaska 1976, Chapter 20, §§30.20. 010 et seq., Alaskan Statutes; and (2) Orders of the Board of Environmental Protection of the State of Maine, In Re: The Pittston Company (March 12, 1975; June 4, 1975)(requiring that any oil tankers larger than 30,000 deadweight tons utilizing a new facility to be constructed at Eastport, Maine, by the Pittston Company incorporate double bottoms throughout their cargo length).

C. There has also been state pressure on the federal government, e.g., establishment of the West Coast Oil Ports Group and continuing participation of state and local governments in rulemakings, as well as in hearings before Congress. See, e.g., Hearings Before the

Senate Commerce Committee on the Ports and Waterways Safety Act of 1972, 94th Cong., 2d Sess 12 (Serial No. 94-63)(1976); Hearings Before the Senate Committee on Commerce on Recent Tanker Accidents, 95th Cong., 1st Sess. 129 (Serial No. 95-4)(1977).

IX. Response of the Environmental Community

A. Delay in issuing rules for tankers in coastwise trade results in litigation to compel their promulgation. Natural Resources Defense Council, et al. v. Coleman, et al., Civil Action No. 75-0859 (D.D.C., filed May 27, 1975).

B. Dissatisfaction with the final rules for oil tankers engaged in coastwise trade leads to litigation challenging their adequacy. Natural Resources Defense Council, et al. v. Coleman, et al., Civil Action No. 76-0181 (D.D.C., filed February 2, 1976). This action challenges the adequacy of final Coast Guard rules and regulations for oil tankers in domestic trade on the following grounds: (1) failure to mandate standards to improve oil tanker maneuvering and stopping ability; (2) failure to establish personnel standards; (3) failure to mandate adequate standards to reduce cargo loss following accident; (4) failure to require retrofit of segregated ballast capacity; and (5) failure to distinguish between coastwise and foreign trade. On March 14, 1977, the complaint is supplemented to cover rules for tankers in international trade.

C. Environmental groups also continued to criticize the Coast Guard in Congress. See, e.g., Hearings Before the Senate Commerce Committee on the Ports and Waterways Safety Act of 1972, 94th Cong., 2d Sess. 118 (Serial No. 94-63)(1976).

X. Emerging Initiatives to Combat Oil Pollution

Following the oil tanker accidents this winter, a number of new initiatives have been undertaken:

A. On January 11, 1977, the Department of Transportation issued an Interim Report of its Marine Oil Transportation Task Force, which describes numerous potential actions which can be taken to prevent the environment against oil pollution. See Hearings Before the Senate Commerce Committee on Recent Tanker Accidents, 95th Cong., 1st Sess. 335 (Serial No. 95-4)(1977).

B. New legislation has been introduced to clarify and expand regulatory authority to deal with the tanker pollution problem. The legislation includes S.182, Introduced by Senator Kennedy on January 11, 1977,

S.682, introduced by Senator Magnuson on February 10, 1977, S.568, introduced by Senator Hollings on February 1, 1977, S.715, introduced by Senator Case on February 10, 1977, and S.898, introduced by Senator Brooke on March 3, 1977. All these bills would substantially increase controls over tanker-generated pollution. S.682, the most comprehensive of the bills under consideration, would:

1. Apply stringent national standards to all tankers carrying oil to or between United States ports;
2. Mandate navigation equipment and design and construction standards;
3. Set standards for manning and crew qualification;
4. Expand powers with respect to vessel traffic systems and services;
5. Extend pollution control jurisdiction for certain purposes out 200 miles;
6. Provide for exclusion of substandard tankers; and
7. Strengthen and expand the inspection and enforcement powers of the Coast Guard.

C. On March 18, 1977, in a Message to Congress, President Carter announced the following Administration initiatives: (1) ratification of the 1973 Marine Pollution Convention; (2) double bottoms on all new oil tankers larger than 20,000 deadweight tons; (3) segregated ballast, inert gas systems, collision avoidance radar, and improved steering standards on all tankers larger than 20,000 deadweight tons; (4) improvement of crew standards and training; (5) development of a tanker boarding program and U.S. marine safety information system; and (6) improvement of federal ability to respond to oil pollution emergencies.

XI. Conclusion

The flurry of activity in Congress and the President's Message of March 18 represent a new beginning with respect to tanker regulation. The next several months will see whether these initiatives come to fruition, and whether the TAPS Trade will obtain the protection promised almost five years ago.

REVIEW OF ALASKAN LEGISLATIVE RESPONSES

Senator Chancy Croft
Alaska State Legislature
Senate District E

It is a pleasure to be here today at the second Fisheries Institute being held this year. The first, in Ketchikan approximately a month ago, dealt with the effects of two competing renewable natural resources, as well as the exploration of additional fisheries. In Ketchikan they talked about the effect of logging and timber practices on the fisheries. Here, we are talking about the clash of two resource extractive industries; one of them is renewable -- the fisheries -- and one of them is non-renewable -- the oil. We spent most of yesterday talking about the effect of oil and hydrocarbons on marine environments. I don't care to elaborate on that.

I think it is important to reemphasize that there will be tremendous volumes of oil transported through those fisheries. Even though the two million barrels a day that was initially talked about will probably not be reached within the next several years, 1.2 million barrels a day seems likely at this point. There has been some change in regard to the methods of transporting oil to the lower 48 of the U.S., and I think this change had a considerable effect on the topics we are discussing.

Prior to the closure of the Suez Canal during one of the wars between Israel and the Arab states, the U.S. was mostly dependent on oil that was not transported by tankers, that, in fact, was not imported at all. In addition, the oil that was transported by tankers was transported in small tankers, because only small tankers could go through the Suez Canal. Once that canal was closed, the oil industry's method of transporting major volumes of oil had to change. They had to transport it two and three times the distance they had before, often around the Cape in Africa. As a result, they changed their method and went to much larger tankers. The age of the supertanker would probably have occurred anyway, but it was precipitated by the closure of the Suez Canal. The U.S. began recognizing that larger tankers were coming. The situation came to a head with the oil embargo of 1973, which dramatized the tremendous dependency the U.S. was to have on imported oil. The dependency increased and, for the first time, in 1976, the volume of oil that was imported exceeded the amount of domestic production. That oil which was imported came in mostly by supertankers.

The federal government, with regard to its actions controlling the transport of oil, has been pretty weak. The first act that gave any federal control over the transport of oil was the Tank Vessel Act of 1936. This act was interpreted by the people charged with administering it to mean that they could only consider the effect on people and property and not the effect on the environment. It took a 1972 act on the effect of oil on the environment to clarify the old 1936 act. However, the Coast Guard was the agency

responsible for the administration of the federal act with regard to tankers.

The Coast Guard's attitude toward regulation has been to place the primary emphasis on obtaining uniform standards through voluntary international agreements, rather than trying to adapt to a particular environment or proceeding unilaterally. And I can say, with the people from the Coast Guard here, I'll be glad that they do have equal time to counter but I think their major emphasis has been to try to develop a uniform approach, rather than being particularly sensitive to the unique requirements in a given area. In addition, the Coast Guard has, even after the passage of the Ports and Waterways Act of 1972, viewed its major mission as protecting people and not protecting the area in which people live. I personally do not think you can separate the two, and I think that is part of the problem. To give just one example of that statement: when the Coast Guard regulates the transportation of dangerous chemicals down the Mississippi River, it requires that those chemicals be transported in double-hull vessels and that no part of the container housing the chemicals forms the wall of the vessel that transports it. However, as to transporting oil, which is as toxic to the marine environment as chemicals are to humans, they have no requirement of double-hulls. The situation didn't change even after a lot of people felt that the Coast Guard gave a specific commitment with the passage of the 1973 Pipeline and Right-of-Way Act which stated that there would be double-hulls with regard, at least, to the transport of Alaska crude. The 1973 act by the federal government also imposed a five-cent-a-barrel charge to be paid into a fund. That five cents a barrel is paid whether the oil is transported in a safe or unsafe tanker.

In 1972, coincident with the '72 federal act, the State of Alaska became one of the first states to impose strict liability on people transporting oil. It not only adopted what Washington, Florida and Maine had done with regard to strict liability, but included a unique provision which said that people who are dependent for their livelihood on a resource such as fisheries that is owned by the general populace, can sue for the damage done to that resource. This provision is one that is receiving increasing acceptance. I do not care to dwell on this particular provision because I think most of you are familiar with it. I would like to talk about Senate Bill 406, which is the Tank-Vessel Act, or Tanker Act, which was passed by the Alaska Legislature in the last session. That is a Senate bill, I was the prime sponsor, I wrote it and will take full responsibility for it. Anyone who doesn't like it can blame me. But the original idea was not mine and I want to make sure that everyone knows where it originated. It came from Keith Specking.

I read portions of Supership and some other books, and people on my staff in Juneau did the same thing. We began talking to people about introducing a bill on the subject. The first person I talked to was an attorney in legislative affairs who said, "It is a great

idea, Keith Specking had it the year before." He had introduced House Bills 32 and 33. We took those as a model and introduced two pieces of legislation, Senate Bills 405 and 406, and they became combined into SB 406 that passed the session. It was one passed early in the morning of the last day the legislature was in session. The bill has several significant features. It gives recognition to the law that was passed by the State of Washington. This law, now in court, was declared invalid by a three-judge federal court which enjoined the enforcement of that bill. An appeal is now in the Supreme Court, which has allowed the State of Washington to enforce its law pending the outcome of the appeal. We looked at what Washington had done in 1975. My intent and, I think, Keith's intent, was to draft a bill with the premise in mind that the Washington statute is unconstitutional for several reasons. So we took an approach designed to avoid the constitutional problems presented so squarely in the ARCO case by the Washington statute.

In the first place, our bill requires that certain instruments like Loran-C collision avoidance devises or two radars be placed on vessels. One of these must be in working condition. Now, the argument can be made that this does run contrary to some of the provisions of federal law and that the state has been preempted from enforcing the law. I think there is substantial chance that is true. However, the cost of those devices is so small that I doubt that the oil companies would ever challenge the federal bill in court. The publicity in challenging, compared with the cost of simply complying, would make a challenge unlikely. In addition, the bill provides that vessels of 40 deadweight tons or greater operating in Alaska's coastal waters must be accompanied by a tug. If they are not accompanied by a tug, they must have lateral thrust devices, controllable pitch or stern propellors or a stern horsepower equal to 40 percent of their regular horsepower, and redundant boilers auxiliary propulsion systems. Those requirements are, in effect, imposed on vessels not escorted by tugs. You have to have Loran-C, collision avoidance, and two radars, one of which is operating, you must also have lateral thrust controllable pitch or stern horse-power capability or redundant propulsion system, or at lease some of the aspects of the redundant propulsion system. The tug escort provision is administered by the Department of Environmental Conservation. Ernst Mueller from the department, who is here, can explain what the department is doing with regard to its regulations.

Secondly, the bill gave the Department of Environmental Conservation the ability to come up with traffic regulations and enforce them in coastal waters. In the third place, through implementation of the strict liability bill that was passed the year before, we required proof of financial responsibility of people who are either operating marine terminal facilities or who are operating tankers. If there is a spill or a discharge of oil into the water the people may rest assured that those in charge can respond to any damages incurred.

The most important portion of the entire bill is the requirement of a Certificate of Risk Avoidance coupled with the Coastal Protection Fund. The Certificate of Risk Avoidance requires that both operators of terminal facilities and tankers must obtain that certificate prior

to the time they commence operation or before they renew operation. With regard to both terminals and tankers, they are required to have the capability to clean up any spills which result from their operation. The governor is given emergency powers in the bill in the event that spills occur. There has been some question in the past as to which agency of the state would have the authority to do that. Not only is the governor clearly given the authority to run the state agency, he is given the power in the bill. The Department of Environmental Conservation is given a clean-up capability. It is authorized to hire personnel if necessary, but is directed to perform on a contract basis if possible. A portion of the money paid into the Coastal Protection Fund could be used for research, but the prime purpose of the CPF is to provide a funding mechanism for cleaning up oil spills.

It is not the fact that a fund is created that is significant. It is the fact that the payment into the fund is to be measured by the probability of that activity causing a discharge not on just a simple cents-per-barrel, as was provided for in the Federal Pipeline Right-of-Way Act. In that regard, it is just like a regular insurance premium on your house, on your car, or anything else. The department is going to determine whether you have a good operation or a bad operation and whether you are likely to cause an oil spill or not. The determination will be influenced by the way in which you operate that activity, whether you are a terminal operator or whether you are a vessel owner.

Everyone who operates a vessel or a terminal facility, with a few minor exceptions, has to pay into the fund. All people who operate oil vessels in the State of Alaska have to pay into the fund. In assessing the payments into the fund, the department will consider not only whether they have Loran-C collision avoidance and radar but also whether they have a tug, lateral thrust, controllable pitch, and redundant boilers.

In addition to all of those provisions, the department is to consider whether the vessel has a flue-gas inerting system, the lack of which is one of the major causes of vessel explosions. There is a requirement that all tankers have not only a segregated ballast system when the department is making the determination for the payments into the fund, but that they also have a double-bottom or a double-hull. There is a $30 million limit on the fund and a provision for allocation among people who originally participated in the fund versus those who participated at a later date. The fund could, of course, be used for clean-up purposes, but this is not its primary emphasis. For the first time under any federal or state act, an incentive is provided for people to use better tankers. The 1973 Federal Right-of-Way Act provided the five-cent-per-barrel payment, but it didn't make any difference whether you were using a leaky Greek tanker or the best double-hulled tanker. You still had to pay five cents, so there wasn't any incentive to use the better tanker.

What we are trying to do under the state bill - and it is one of the prime points of the bill - is to provide a very strong incentive for the oil industry to send its best vessels to the State of Alaska.

We don't take the position that the State of Washington did, which was to prohibit altogether certain types of vessels based on size. What we tried to do is say: we want you to send your very best up here, and you can do whatever you want with your other vessels, but just send your best boats to Alaska. Now there is, of course, pretty strong opposition from some elements of the oil industry to it. SOHIO has been particularly concerned about it because they will have to transport the major portion of the crude from the North Slope. Speaking later will be Virgil Keith, along with Walter Parker, Ernie Mueller and Chuck Champion, who gave tremendous assistance to those of us in the legislature who were working on this bill. They may want to comment on a particular problem that SOHIO had which is, basically, that they pay a higher amount into the fund because they don't have double-hulled or double-bottom tankers under construction. ARCO has an immediate problem in that it won't have any double-hulled or double-bottom capability until at least 1979. It will have considerable capacity after that.

SOHIO worked on a substitute bill and presented it to some of us in the legislature earlier in the week, but what they basically say is: we will give you almost everything in the bill, but all we will do is pay you one cent a barrel for the oil, and there won't be any risk-avoidance fund, there won't be any reference to a double-bottom, there won't be any reference to Loran-C, or anything else. It will, in effect, just give you a penny for every barrel of oil that is taken out of the state. If we spill a bunch because we are using bad tankers, then you have got a cent for every barrel that was transported. Now, as I told them, they simply missed the point of what we were trying to do.

The second thing that is important to emphasize is that it is not the size of the fund that is significant. There is just no way - particularly in reference to Prince William Sound in the North Gulf of Alaska - that any fund can maintain a clean marine environment. Whatever advantage there may be in having some clean-up capability, it almost invariably will be outweighed by trying to maximize the prevention of spills. We are better off spending $1 million trying to prevent a spill than having a $100 million fund for trying to clean it up. In fact, in trying to come up with a contingency plan for cleaning up oil spills in this portion of the U.S., I think that one of the prime considerations should be to get rid of the oil as quickly as possible by simply burning it.

During the consideration of Senate Bill 406 in the legislature, there was an interesting discussion with Crowley Environmental Services. I asked the Crowley representative: "What are the limits on your abilities to clean up an oil spill?" I thought that there had been a considerable amount of discussion about the effect of certain size seas or wind conditions. He said: "We can clean up any spill." I said: "What about 10-12 foot seas?" He replied: "We can clean up any spill. We can clean it up on a sea with waves of six to eight feet. After that, just as soon as it gets on the beaches we clean it up there."

I think that really dramatizes the point. Once it gets to the beaches, it is too late.

The third significant thing regarding Senate Bill 406 has to do with the possibility of federal prevention. Now, the intent of the Alaska statute notwithstanding, there are lawyers who will argue, as the Coast Guard argued in the Spring of '76, that our act is unconstitutional. Of course, the Coast Guard is involved on behalf of ARCO in the Supreme Court of the U.S. They are arguing that the State of Washington's act is unconstitutional. There are people who will argue that the Alaskan action, Senate Bill 406, is unconstitutional, because it has been preempted by the federal government. I don't believe it is unconstitutional and we have some rather distinguished attorneys who have reached the same conclusion.

But the fact of the matter remains that it could be preempted. There is no question that if the federal government wants to preempt what we have done they can pass an act to do it and some of the recent proposals by President Carter indicate that the federal government may well do that with regard to our act. SOHIO officials also indicate that even if we were to pass the act they said they could live with, the federal government may preempt it as well.

John Williams, from the Legislative Research Agency, is here. Some of you may want to discuss with him in detail some of President Carter's proposals. While the Carter proposals would probably raise the standards of tanker operations in most of the states of the nation, they will have the effect, if they preempt what we are doing, of lowering them in the State of Alaska. So it is another one of those situations where the majority of the U.S. may be better off if the Carter bill passes, but Alaska won't be.

Those proposals, as well as other proposals that were introduced, are the subject of hearings of the Magnusson Committee (Senator Magnusson, from Washington, is chairman of the Senate Commerce Committee). Representative Specking and I, as well as Representative Gardiner, chairman of the House Judiciary Committee, and others, have worked on a resolution requesting the Magnusson Committee to hold hearings in the State of Alaska. The federal inaction was a little frustrating at first, considering that the legislature unanimously passed our resolution. We now have received assurances that the committee will hold hearings in the State of Alaska. We haven't received the date yet and we don't know how many senators are going to come, how long they are going to be here, or where they are going to go. But we have been assured by both Senator Stevens, as well as Senator Hollings, that the chairman has assured them that there will be hearings in the state. I think that these hearings are something that all of us should watch very closely and many of us should plan to attend them.

The fourth point of significance about the state act is that it dramatizes the question of control in the role of the state. It is clear that the states of Alaska and Washington have some of the best tanker legislation in the U.S. There is a decided possibility that the work of fishermen in both those states, as well as others who did get those bills on the books, will come to naught if the idea of

the federal government running everything prevails. In one regard we are back to where we started and that is: Alaska fought for a long time to get control of its fisheries and we may find out that we are losing control of the fisheries as far as the problem of pre-emption with regard to federal oil tanker legislation is concerned.

Somebody observed that the law is merely the will of the strong, while they are strong. That, basically, is the fifth point of significance with regard to the Alaskan act. What we are really talking about in the clash between two different resource extractive industries (one of which is renewable, one of which is non-renewable) is the status quo. Who is going to change? There is obviously a considerable amount of conflict between the two interests. Are the fishermen going to be required to change their operations, or is the oil industry going to be required to change its operation? In that regard, I think the significance of the Alaska legislation will be greatly enhanced if you can keep it for a period of about five years. If you can keep a requirement on the books that those people transporting oil out of Alaska have to use the very best technology, then they will get committed to it and make the expenditures, as well as have an incentive to persuade others to do the same.

A prime example of how this works is the Kachemak Bay legislation. Standard Oil Company of California testified on the bill this year. Their testimony was exactly opposite to what it had been the year before. Last year, SOCAL was in violent opposition to the Kachemak Bay buy-back. They had their leases, they had paid their money and the wanted to drill. This year they had negotiated for a change and had made a recent agreement with the state. They now knew what they were entitled to. They were going to get $12 million cash, and $9 million credit over the next two years. This year SOCAL testified in support of the bill that they were in violet opposition to last year simply because the status quo had changed. And I think it is rather clear once the major oil companies in the U.S. start using the best tankers available, there is going to be a vested interest on the part of the oil industry to make sure it doesn't return to the sub-standard tanker. So you are going to pick up some strong allies if you can make sure the initial transport of that oil for a period of several years is by very fine tankers. There will be a vested interest by the oil companies as well as the fishing community in using quality tankers for the life of the project.

If the law is the will of the strong while they are strong, it is important to keep in perspective this question of state's rights. Alaska has a huge percentage of the total coastline of the U.S. and one-fourth of one percent of the population of the U.S. I think you can tell how Alaska is going to be treated at the federal level. In terms of political clout we are in pretty bad shape. However, within our own state, fishermen are in a different position. Oil transported through Prince William Sound will have a value three to four, maybe five (depending on the prices) billion dollars a year. It is true that the resource through which it is taken has an annual value of somewhere between 10 and 15 and, maybe, in good years, as high as $20 million by one standard. Oil is therefore much more

valuable. However, it is still true, and will remain true, that there are a lot more fishermen in the State of Alaska than there are oil company operations, so in fighting the battle in the State of Alaska, the fishermen can look forward to a much better result than if they simply rely on the federal government.

WATER CIRCULATION IN PRINCE WILLIAM SOUND AND THE GULF OF ALASKA

Thomas C. Royer
Institute of Marine Science
University of Alaska
Fairbanks, Alaska

In 1970, a dedicated effort to study the southcentral Alaska coastline was begun by the Institute of Marine Science, University of Alaska, Fairbanks. This work coincided with the move of the support facility from Juneau to Seward. Since that time many cruises have been made in this area. Institute personnel have been involved with studies of Port Valdez and the shelf areas in the Gulf of Alaska. The types of studies included the gathering of temperature and salinity data, the development of a remote boat for surveying glacial regions, biological and chemical sampling and remote sensing techniques.

The majority of our work in physical oceanography involves the measurement of the temperature and salinity of the water column. From these temperature and salinity data we can determine the water density and hence infer the currents. We must do most of our sampling from ships. The vessels used in this work range from the R/V *Oceanographer*, operated by NOAA, which is approximately 300 feet in length, -- and weighs about 4,000 tons -- to the University of Alaska's ship *Acona* at 85 feet and 197 tons. We have traditionally gathered water samples using Nansen bottles and measured temperatures with reversing thermometers. A recent alternate method to measure temperatures and salinities is through the use of electronic methods, and is called an STD system.

This system records the temperature and salinity, in a nearly continuous fashion, on magnetic tape aboard the ship.

We began gathering these types of data in the Gulf of Alaska on the station line running out of Seward in 1970. The station line work terminated two years later, though the station closest to shore has been maintained over the years. Since July 1974 through November 1976, the area grid shown here has been occupied on a regular basis (Figure 1). The data we now have indicates that the circulation over the shelf can be separated into at least six different regimes. These regimes display different current speeds, residence times, and driving forces. The Yakutat area has low flow with some eddies and occasional reversals, whereas the central regime is largely under the influence of the Alaska Current. The Alaska Current forms the southern dynamic boundary for all of these regimes. The speeds in the Alaska Current are of the order of 1-1 1/2 knots to the west.

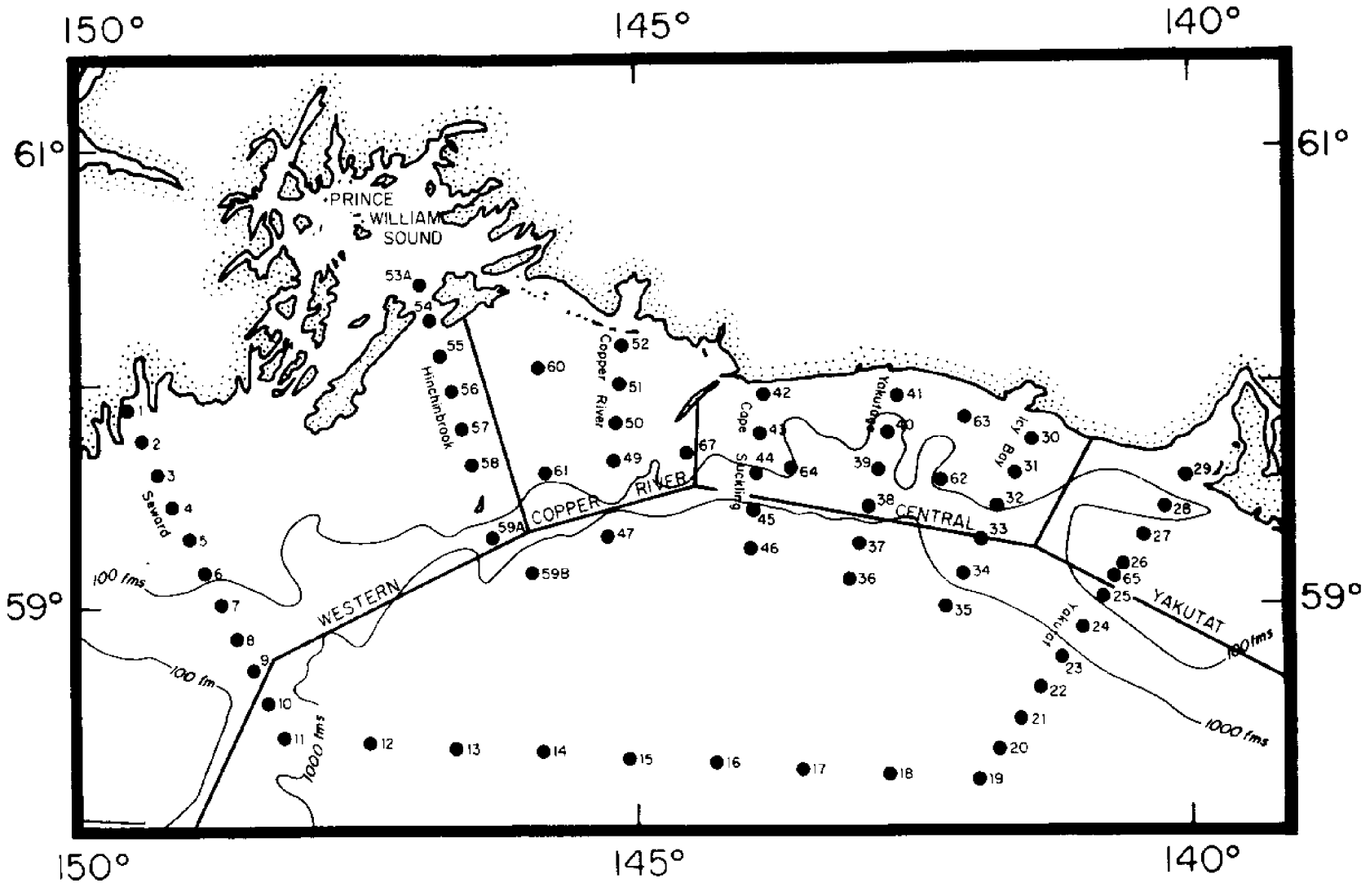


Figure 1. GASSE station locations with flow regimes and transect names.

In the central region the current speeds are from 1/2 to 1 knot uniformily westward. The Copper River regime is dominated by a clockwise gyre to the west of Kayak Island with longshore flow near the coastline. This gyre is a permanent feature of the area and caused a withdrawal of this area from the oil lease sale for the Northeast Gulf of Alaska due to low flow out of the region. After passing through the Copper River regime, the shelf flow has been divided into two flows; with one nearshore and the other well offshore following the Alaska Current. The offshore flow (Figure 2) is deflected southward by Kayak Island and passes to the south of Middleton Island along the shelf break. The remaining portion passes to the north of Middleton Island and either enters Prince William Sound or flows along the coast to the west. The Western regime therefore is characterized by a westward nearshore swift current, low speeds over the shelf and the Alaska Current on the outer boundary.

In addition to the hydrographic work, we also have installed current meter arrays for the direct measurement of the currents. One such installation was at Station 9. The subsurface moored array consists of several current meters anchored to the bottom with an acoustically fired release. The meters have a self-contained recording capability. The current data for Station 9 (Figures 3 and 4) show that, in general, the flow is to the southwest from April to July 1976. However in July there is a reversal that continues until October. We assume that this does not mean a sudden reversal of the entire flow on the shelf but rather a movement offshore of the Alaska Current. Therefore reversals in this area may occur throughout the year.

In this respect, Prince William Sound has been neglected. Unfortunately, this is often true when it comes to oceanographic research in the Sound. However in July 1976, Don Hansen of NOAA in Miami released some drifting buoys in the Gulf of Alaska off Yakutat. These buoys were drogued at 30 m and tracked through the use of satellites.

They follow the generally assumed flow in the eastern part of the Gulf, (Figure 5) enter the gyre behind Kayak Island, join the longshore flow and then enter Prince William Sound. This connects shelf flow with Prince William Sound, since three of the six buoys released entered Prince William Sound.

However, knowledge of the flow within Prince William Sound is extremely limited. Some hydrographic data do exist, gathered as research vessels passed through the region, but only one limited program for the investigation of Prince William Sound itself has been carried out. The National Ocean Survey of NOAA began a study in the summer of 1976 to measure the currents and hydrographic parameters in the sound. This study is a summer study only and will continue this summer. The sparse hydrographic data that we have indicates a counterclockwise sense to the flow within the Sound. There also is deep inflow into the sound on a seasonal basis. We have the time series of data for the station at the mouth of

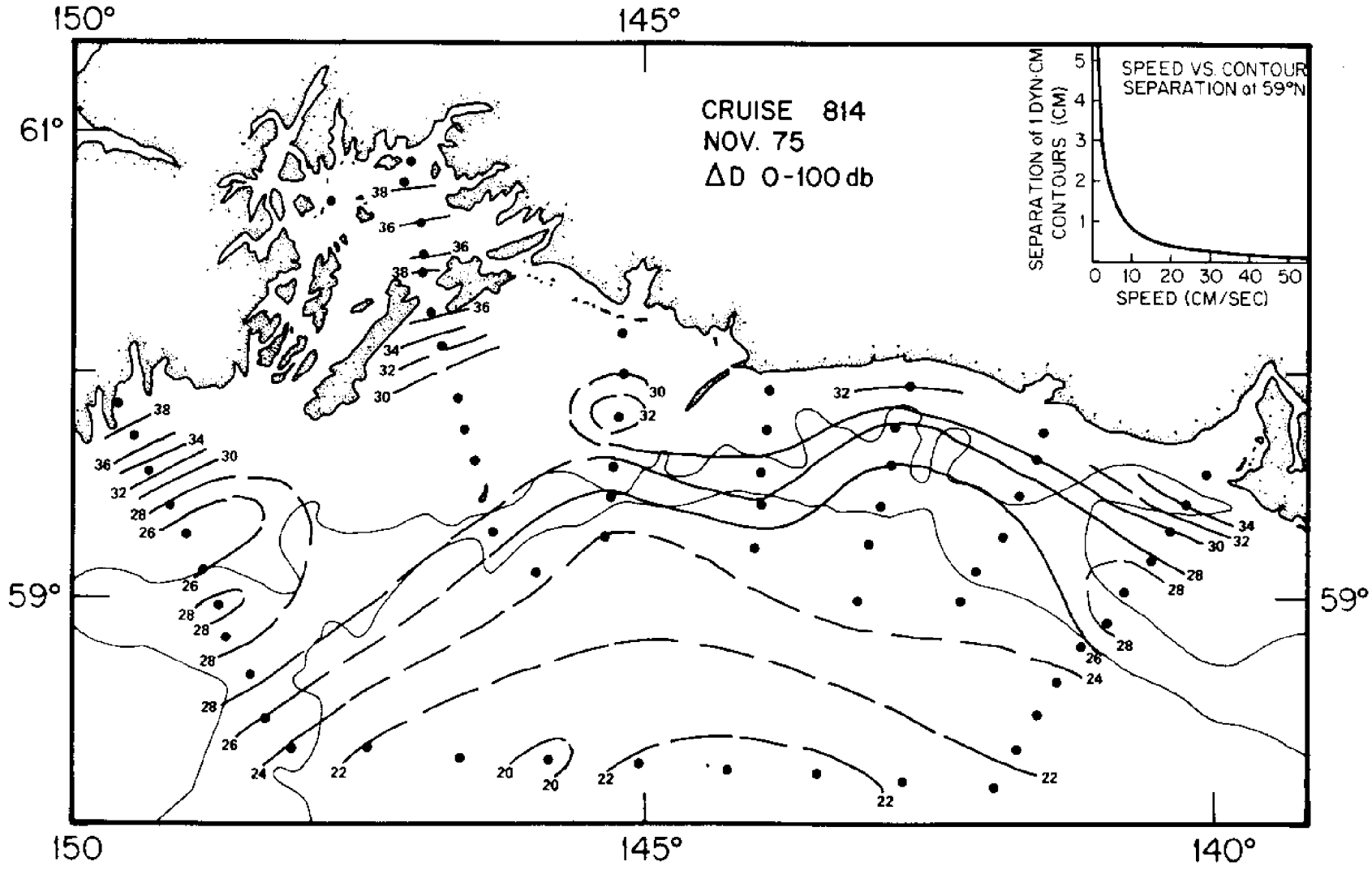


Figure 2. Dynamic topography.

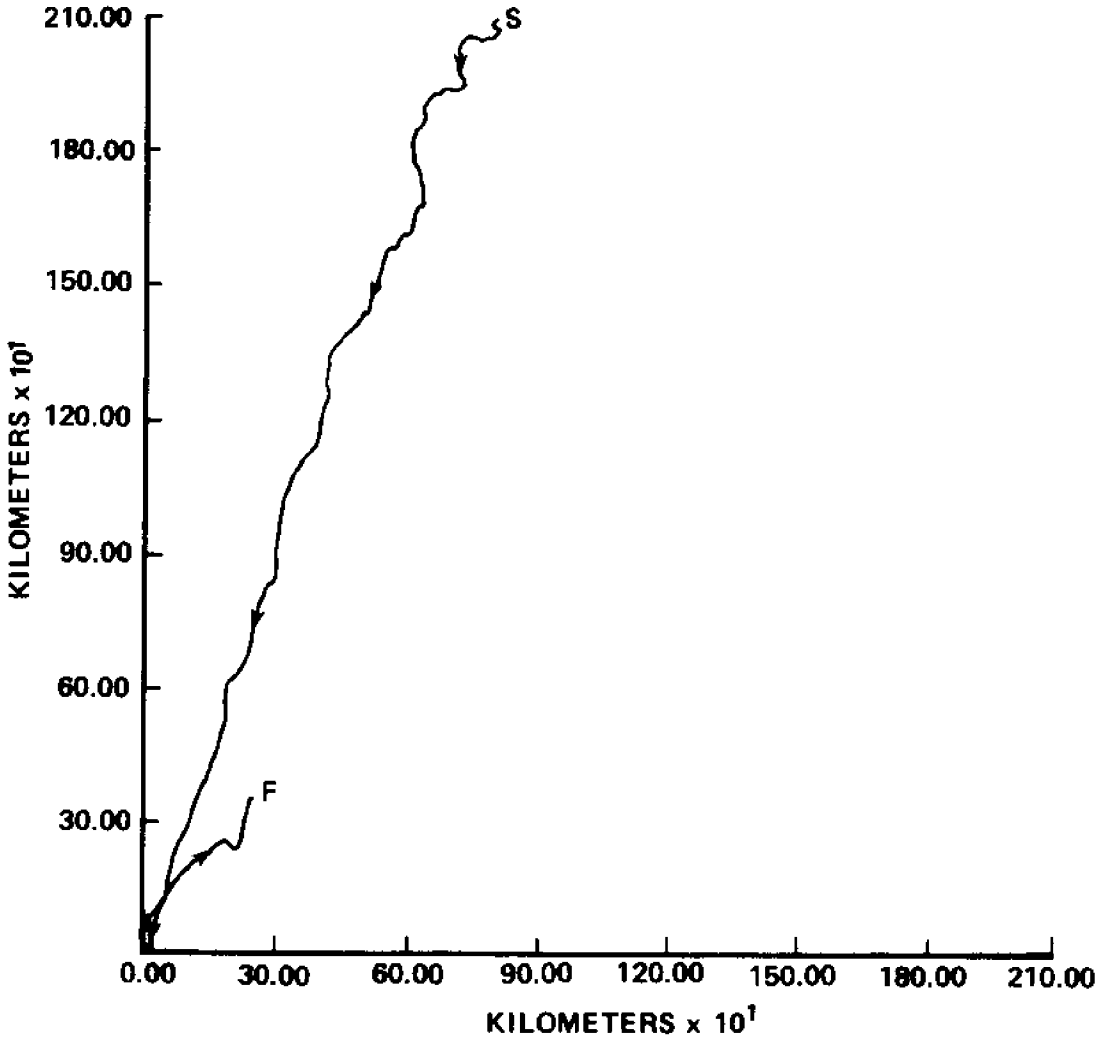
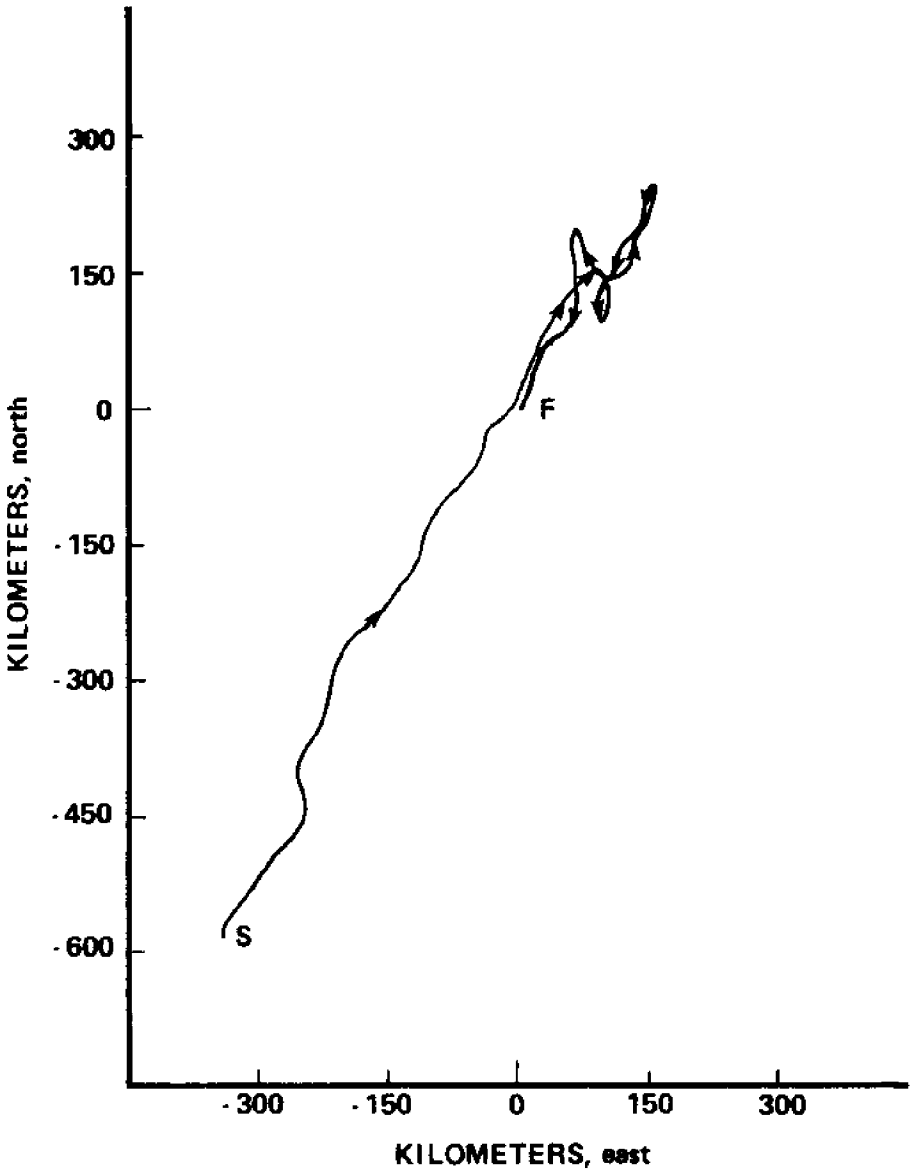


Figure 3. Progressive vector diagram for station 9 at 20 m, April - July, 1976. Southwesterly flow until July when it became northeasterly.



METER NO. 1770 AT 54 M.
STATION GASS 9C. 58 44.76 N, 148 25.13 W.
RECORD FROM 2224 UT 23 JUL TO 0224 UT 4 NOV. 1976.

Figure 4. Progressive vector diagram for station 9 at 20 m, July - November, 1976. Northeasterly flow until October when it became southwesterly.

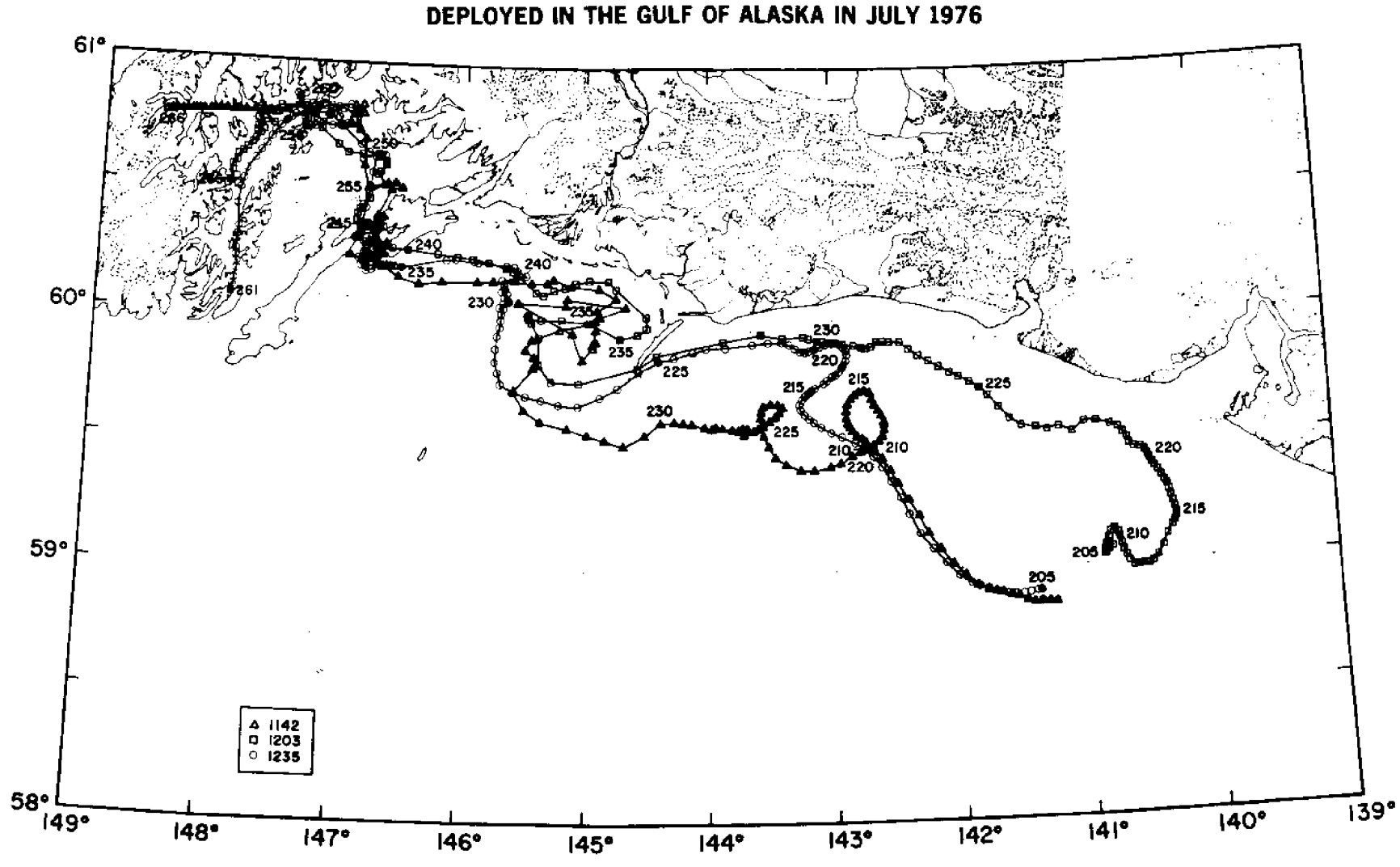


Figure 5. Trajectories from satellite tracked drifting buoys. (Courtesy of D. Hansen, AMOL/NOAA)

Resurrection Bay, which represents conditions similar to those found in Hinchinbrook Entrance. There is a surface and bottom warming in summer. This is accompanied by a decrease in surface density or salinity and increase in bottom salinity. The surface change is due to fresh water runoff. The bottom increase is due to the intrusion of deep water onto the shelf. A similar situation occurs in Prince William Sound where the deep water is renewed at least on an annual basis.

Questions to be answered about Prince William Sound are: (1) "What is the rate of inflow and outflow into the sound and what is its seasonal variability?" (2) "What is the circulation within the Sound and its seasonal variability?" and (3) "What are the important factors influencing the circulation within the Sound, such as wind stress and fresh water outflow? The current reversal on the shelf to the west of Middleton Island should also be better documented, as it probably represents a major circulation feature which could tie the Kodiak and Prince William Sound regions together in a manner opposite to that which was previously assumed.

Our work shows that Prince William Sound would be affected by pollutants released in the Northeastern Gulf of Alaska and possibly by contaminants released in the Northwest Gulf of Alaska to Kodiak. It is expected that the major outflow from the Sound is through Montague Strait along the coast, though this conclusion has yet to be documented. I would like to mention that the anomalous weather conditions over North America and the North Pacific this past winter are causing an increased northward flow in the Alaskan gyre. We have some drifting buoy data showing this effect. Relatively warm upper layers should be expected this summer. This might cause fish to be found at greater depths than usual during the next few months.

HOW REAL TIME SIMULATION WAS UTILIZED IN ASSESSING TANKER OPERATIONS WITHIN PORT VALDEZ AND VALDEZ NARROWS

Virgil F. Keith
(Consultant to State of Alaska)
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In view of the sophisticated techniques utilized to assess other segments of the Trans-Alaska Pipeline System (TAPS), it is not surprising that an equally sophisticated marine tool, real-time simulation, was used to assess the environmental conditions and the effectiveness of tugboats with respect to tanker operations within the waters of Port Valdez and Valdez Narrows.

This presentation will illustrate the original real-time simulation work as carried out at the Netherlands Ship Model Basin for the Office of the Pipeline Coordinator of the State of Alaska. The research program was completed during October, 1976, for a 165,000 DWT tanker and a series of 5,000 HP tugboats under the following conditions:

- Using six experienced VLCC masters/pilots;
- without tugboats, with one tugboat, and with two tugboats;
- under six assumed wind conditions;
- at loaded and ballast drafts;
- under normal and emergency (worst case) procedures.

From the initial Valdez Pilot Study, Figure 1 was developed and given to each master/pilot prior to his run. On the incoming (ballasted) voyages each operator was told to follow the three tracklines between points "A" and "D" and to maintain 11.5 knots for any maneuvers without tugboats and 7.0 knots for any maneuvers with tugboats. Conversely, on the outgoing (fully-loaded) voyages, each operator was instructed to follow the reciprocal tracklines at the same speeds as previously indicated. Figure 2 is typical of a completed run of a loaded transit under zero wind conditions and without the aid of tugboats. Simulator runs displaying ballasted transits, as well as transits with various wind conditions and with tugboat assistance, will also be illustrated within the presentation.

Even though this research program is in itself a marine first for real-time simulation in North America in assessing an actual maritime operation under various conditions, it is my desire to further show that real-time simulation can be a powerful aid in assessing a multitude of more complex maritime operations.

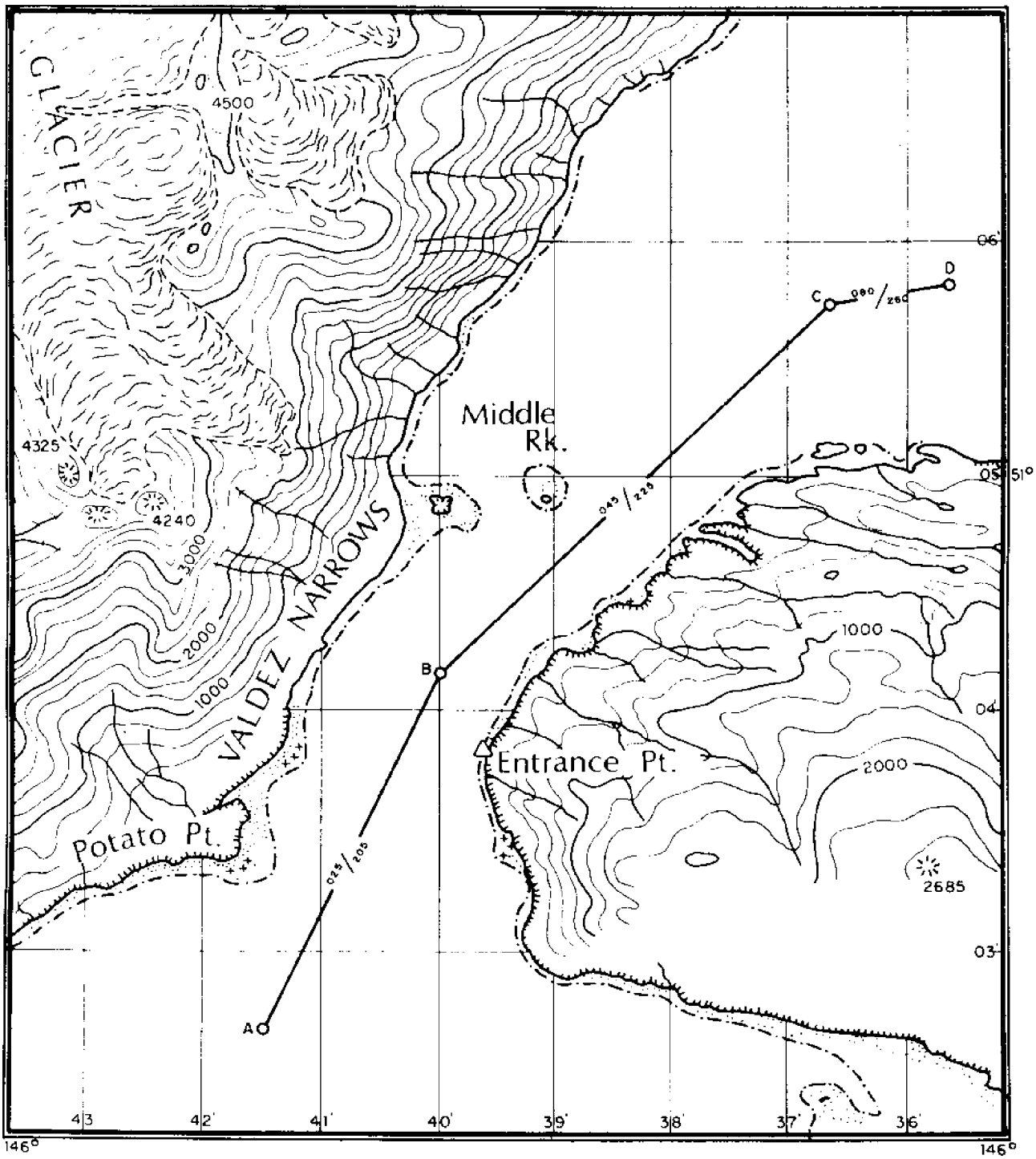

Figure 1. Portion of Chart No. C & CS 8519 illustrating Valdez Narrows and Middle Rock. The tracklines were determined by using a simulator pilot study at the Netherlands Ship Model Basin.

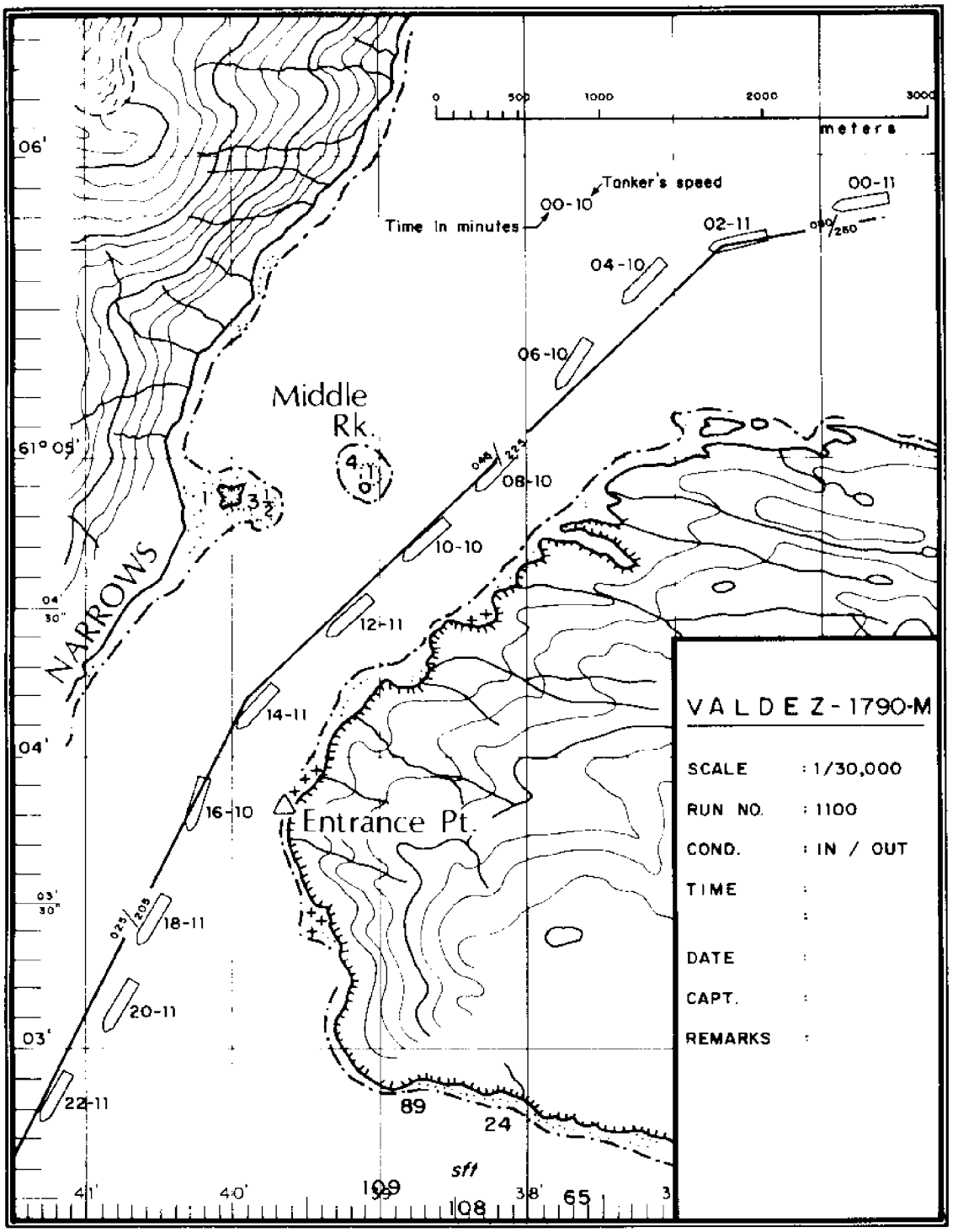

Figure 2. Completed simulator plot of a loaded tanker under zero wind conditions, without the aid of tugboats, departing Valdez, Alaska.

AREAS OF INVESTIGATION

- THE ADEQUACY OF THE CHANNEL WIDTH OF VALDEZ NARROWS, WHICH VARIES FROM 900 TO 1200 YARDS BECAUSE OF THE PRESENCE OF MIDDLE ROCK, FOR THE 165,000 DWT. TANKER, AND THE EFFECT OF BOTH WIND SPEED AND TUGBOAT ASSISTANCE;

- THE DIRECTIONAL INFLUENCE OF THE PREVAILING WINDS WITH RESPECT TO THE SIX (6) ASSUMED BASE WIND SPEEDS AND THE SUPERIMPOSED RANDOM GUSTS;

- OPTIMUM METHODS OF UTILIZING TWO (2) 5,000 HORSEPOWER TUGBOATS IN RELATION TO WIND SPEED AND TANKER DRAFT UNDER BOTH NORMAL AND EMERGENCY CONDITIONS;

- THE MINIMIZATION OF THE CONSEQUENCES OF A WORST CASE MECHANICAL BREAKDOWN ("BLACK-OUT") OF THE 165,000 DWT. TANKER WITHIN VALDEZ NARROWS WITH EITHER ONE OR TWO TUGBOATS AT VARIOUS POINTS OF ATTACHMENT.

OBSERVATIONS

- A ONE-WAY TRAFFIC SYSTEM WITHIN VALDEZ NARROWS IS DESIRABLE:

- OPERATIONS WITHIN PORT VALDEZ OR VALDEZ NARROWS WITH A WIND IN EXCESS OF 40 KNOTS IS UNDESIRABLE:

- THE PRESENCE OF MIDDLE ROCK CREATED A DEFINITE PSYCHOLOGICAL BARRIER TO EVEN EXPERIENCED PILOTS WHEN THEY WERE EXITING FROM PORT VALDEZ ON THE GIVEN TRACKLINE FROM THE TAPS TERMINAL. THE SECOND VALDEZ RESEARCH PROGRAM ASSUMES THAT LOADED TANKERS WOULD HOLD THE NORTH SHORE OF PORT VALDEZ THUS ALLOWING MORE TIME TO "STEADY-UP" BEFORE APPROACHING MIDDLE ROCK AND VALDEZ NARROWS:

- THE PROPOSED TUGBOATS ARE SUITABLE FOR THE VALDEZ MARINE OPERATIONS AND CAN EVEN BE EFFECTIVE IN THE EVENT OF A WORST CASE MECHANICAL BREAKDOWN ONBOARD THE SUBJECT VLCC, PROVIDED THE WINDS ARE LESS THAN 40 KNOTS.

OIL SPILL CLEANUP

J. W. Hart
Alaska Gulf Clean-Up Organization
Anchorage, Alaska

I guess the first thing I want to do is get the name of the organization that I represent straightened out. I am representing the "Gulf of Alaska Clean-Up Organization" and I would like to comment that I do appreciate the opportunity to come and talk a little bit about what we're doing in the area of oil spill preparation. We want to be ready if an oil spill occurs in the northern Gulf of Alaska.

This map indicates the lease sale area in the northern Gulf of Alaska and shows the tracts that we leased in the sale that occurred last April. The purpose of the Organization is to provide cleanup capability for drilling and production operations. I would like to emphasize that our Organization came together to deal with the drilling and production and is not directly associated with tanker operations, although our equipment and expertise would certainly be made available in the event that a tanker spill should occur anywhere in southern Alaska.

Before talking about equipment for the cleanup of oil spills, I'd like to talk just a little bit about the equipment that we're using for our exploration drilling in the GOA. Senator Croft made a comment this morning that he felt that heavy emphasis should be placed on the development of equipment and expertise to prevent spill occurrences in the first place and I think that nobody would more heartily endorse that than the oil industry and the operators that are conducting exploration drilling in the GOA. I think the equipment and expertise that we've brought to Alaska would certainly reinforce the fact that we feel that way, too. I think it's important to point out that there's never been a major oil spill associated with exploration drilling. There have been four major oil spills during the thirty years in which offshore operations have been conducted. These four spills have been from drilling and production platforms, not from exploration drilling. We certainly don't expect that a major spill will occur from our exploration drilling in the Gulf of Alaska. The probability of this happening is remote. The equipment we are using is the newest, the largest, and from a technological standpoint, the most sophisticated in use anywhere in the world. The following photographs are shown to illustrate this. The rig shown here is the Ocean Ranger which is a semi-submersible drilling vessel that Atlantic Richfield Company is operating in the GOA and, just to kind of reinforce the comments that I made, this vessel drilled its first well beginning last summer for ARCO in the Bering Sea and is now drilling its second well for us on project Salome in the GOA. The Ocean Ranger is the largest semi-submersible drilling vessel in the world and performed even better than we anticipated in the harsh weather conditions that we experienced last October and November.

The statement about the quality of the equipment we are using also applies to the ancillary equipment that we used in support of the drilling operations. Helicopters and our supply boats fall into the same category. The helicopters we are using were specifically built for GOA operations and contain the most sophisticated and advanced navigational equipment of any helicopters in civilian use anywhere in the world.

Because of all this, we will be prepared to deal with an oil spill should it occur. There are two possible areas where a spill might occur in conjunction with oil exploration and production. The first of these would be a harbor spill. For our drilling in the GOA, we're operating out of two harbors. Exxon, Texaco, and most likely Gulf are operating out of Seward. ARCO and Shell are operating out of Yakutat. The kind of equipment that we have purchased to allow us to deal with a harbor spill includes booms and skimmers; we also have a boat and lights to allow us to operate at night. About two weeks ago we went to Yakutat and conducted a training exercise where we were dealing with an assumed fuel oil spill at our Monti Bay terminal dock. These are some of the photos we collected in conjunction with that training exercise. This trailer contains about 1,000 feet of containment boom which was specifically designed for harbor operations. The rest of the slides just show the employment of this boom in the skimming operations as they might have occurred had there been a real spill. We're getting ready to pick up the skimmer that we used to collect the oil out of the area contained by the boom. In total, the equipment that the organization has invested in to date to deal with harbor spills has cost $145,000.

The other type of spill that we're gearing up to deal with would be an ocean spill. Again, equipment we have purchased would include booms, skimmers, sorbents, dispersants in this case, and communications. This is a photograph of the open ocean boom equipment that we have. This package is 1,000 feet of self-inflating boom that is packaged so it can be helicopter-lifted. We have something on the order of 6-7,000 feet of this type of boom. I might mention that each of these packages represents $60,000. This is one of the types of skimmers that we can use to deal with a small spill that might occur in the open ocean. Here we come to a photograph of a training exercise that we went through to deal with a simulated spill in the open ocean. In this case, the boom would be deployed from one of our supply boats.

Another item of equipment that we have purchased, a Cyclo-net skimmer, is a free-skimming device that is attached to the side of a supply boat. This actually will be the major effort we would use in the event of a large spill in open ocean. This skimmer works without a boom and, because it is attached to our supply boat, we'd be able to operate effectively in rather high seas.

Another approach and something that has a lot of potential for dealing with a spill in order to prevent oil from actually reaching the beaches would be to apply dispersants. This photo shows the

equipment that will allow us to apply these dispersants from our helicopters. In total to date we've invested $1.5 million for equipment that would be associated with ocean spills.

Another area of activity for the organization is research and development. We have two major programs that we have funded; one is a device called a sock skimmer that Shell research has developed. This device also would be operated in association with a supply boat. Another method that we're studying and funding is the design of a very large Marco-type skimmer. Marco has designed, at this point, a vessel larger than any that they've built for service anywhere else and it's another alternative that we'll be considering. In total, we've committed some $650,000 to date in the area of research and development for oil spill cleanup.

Our activity has reached a level where we've found it necessary to hire a manager for the Organization. Until now our activities have been conducted by, sort of in addition to other duties, members of the companies belonging to the Organization. Just yesterday, as a matter of fact, we reached agreement with a naval officer who is going to retire and become manager of our Organization. In conjunction with this, we are looking at an expense budget for 1977 of approximately $600,000.

Finally, I'd like to comment on the remark Senator Croft made earlier that somebody from Crowley wanted to go ahead and let the oil come ashore on the beaches and then clean it up. I can assure you that I've been in Alaska long enough to have a greater appreciation for the country than that and that I don't think anybody associated with the exploration and possible production activities in the GOA has any intention at all of just letting oil come ashore. We plan to leave the beaches just like we've found them.

Thank you.

TANKER SAFETY AND NAVIGATIONAL STANDARDS

Captain Leonard F. Gearin
Mobil Oil Company
San Pedro, California

Members of the Cordova Fisheries Institute.

My name is Leonard F. Gearin. I am a marine consultant representing the tanker industry on behalf of Mobil Oil Corporation. Mobil's headquarters are located in New York City, with domestic tanker operating offices in Beaumont, Texas, and Terminal Island, California. Mobil's domestic seagoing fleet, consisting of ten owned tankers, trades in the United States Gulf, along the Atlantic Coast and the Pacific Coast to Alaska. In addition, Mobil's subsidiaries own and charter a substantial number of tankers in international trade which comprise a total of 14.2 million DWTs. The tankers in international trade call at ports all over the world. As a result Mobil has a very strong interest in the promotion of maritime safety not only at home but everywhere in the world.

In view of the importance of tanker operations to the welfare of this country and the vital role that the public needs to play in understanding this fact I wish to take the opportunity afforded by this meeting to provide you with an unvarnished assessment of the safety of oil tankers. While there is no such thing in our modern world as zero risk, oil tankers indeed do provide large margins of safety. Though improvements can be and are being made, the process for control and regulation of tanker operation is healthy and is based on a vigorous and open inquiry by many competent and dedicated marine professionals who wish to assure safe tanker operation.

Tanker accidents and oil spills have occurred. Sometimes human error has been the cause; sometimes mechanical malfunctions were responsible. However, responsible tanker operators concerned with crew and safety, and with millions of dollars at stake in their tankers and cargoes, have the highest incentive to reduce the risk of accident to the lowest possible level.

Although numerous experts have reported that there is no hard evidence that oil spills cause long-term damage to the environment, oil pollution is still of great concern to responsible ship owners and operators as well as to the public. The basic question is: What do responsible tanker owners and operators do to minimize the occurrence of accidents? The answer is: They do a great deal. In addition to having their own safety standards which exceed the requirements of all registration jurisdictions, the marine business lives within a myriad of international and national safety rules and regulations. For example, on the international level we are

regulated by the Inter-governmental Maritime Consultative Organization. Known as IMCO this organization is a specialized agency of the United Nations which came into being in 1959 to provide a means for cooperation among governments in the fields of governmental regulations and practices relating to shipping engaged in international trade. It encourages general adoption of the highest practical standards in matters concerning maritime safety and efficiency of navigation and endorses all efforts to prevent and control pollution from ships and other craft. At present, eighteen conventions on ship safety, pollution prevention, and pollution damage liabilities have been adopted by IMCO. Ten have come into force. To date, however, the U.S. government has failed to ratify many of these conventions.

The United States has enacted numerous domestic laws covering vessel safety and oil pollution prevention and compensation. Commercial vessels documented in the United States must be designed and constructed in accordance with specific standards. U.S.C.G. inspection is required during construction and periodically thereafter to insure compliance. To complement the vessel inspection requirements the Coast Guard has promulgated regulations governing standards for licensing and certification of officers and crews as well as for the navigation and operation of U.S. vessels.

In recent years, the Congress, recognizing that regulation of U.S. Flag vessels alone could not achieve the dual objectives of safety of navigation and pollution avoidance in U.S. waters, authorized various federal agencies to issue regulations applicable to both U.S. and foreign flag vessels entering U.S. waters. This legislative authority is contained in two statutes, the Federal Water Pollution Control Act as amended in 1972 and the Ports and Waterways Safety Act of the same year. The primary authority for control of tanker movement and operations in U.S. waters is contained in the Ports and Waterways Safety Act.

Title I of that Act empowers the Coast Guard to establish and operate vessel traffic schemes in areas of traffic congestion and whenever necessary to control vessel movement under hazardous conditions to prevent damage. The implementation of this Act coupled with the "Vessel Bridge-to-Bridge Radiotelephone Act" will greatly minimize the risk of pollution from tanker traffic incidents. Statistical data from the Europort operation which provides control movements of tankers supports this view.

Title II authorized the Coast Guard to issue regulations governing the design, construction, equipment, operation, manning and qualifications of officers and crew of both U.S. and foreign tank ships carrying cargoes within U.S. waters. It further provides for the inspection of such tankers to insure compliance

with U.S. regulations and for the issuance of a Certificate of Inspection. In the case of non-complying foreign tankers the Coast Guard is authorized to deny these vessels entry into our ports. A review of currently applicable federal law and regulation makes it clear that Congress has already delegated to federal agencies considerable authority to promulgate regulations aimed at minimizing casualties and oil pollution caused by substandard or poorly operated tankers in U.S. waters. These laws can be enforced regardless of the flag of the ship. It is this fact that leads us to suggest that it is a duplication of effort for individual states or groups of states to unilaterally impose safety standards for tankers or navigational and traffic control plans. It would be more productive for the state legislatures to fully support the U.S. Coast Guard in its continuing efforts to implement existing federal regulations.

Recently there have been numerous suggestions from government officials and others to install double rudders, double bottoms, and twin propellers on tankers and to require tug assistance in wide stretches of water. While these features might be useful in certain areas, the contribution to navigational safety by such additions would be small in areas such as Valdez Narrows. Because the usefulness of such design features varies significantly from place to place, we do not believe it is appropriate for governments to arbitrarily make them mandatory features on all ships.

The design of tankers is a matter of constant review at international and federal levels. This is where it properly belongs since of necessity ships trade between countries and states. Accordingly we would recommend that the states take full advantage of the expertise residing in the Coast Guard and the American Bureau of Shipping in the matter of ship design, construction and operation. The design criteria for all seagoing ships are closely regulated. Ships are built under the rules of one of several classification societies such as the American Bureau of Shipping, Lloyds Register and Norsky Veritas. These societies strictly regulate structural strength, machinery design, maximum load, equipment requirements, etc. Further design and equipment requirements are subject to international agreement and enforced by national regulatory bodies. Such agreements include the Safety Conventions.

The analogy between F.A.A. regulations of airline traffic over the United States and vessels moving in interstate commerce is a reasonable one. If each of our states imposed different construction and operational requirements the commercial airline industry would be up against a difficult task to continue its present level of service. This is equally true with respect to the world's tanker fleets. Only uniform safety regulations at the federal level in the United States, and internationally through IMCO Conventions, can provide the regulatory framework in which we can continue to move increasing amounts of petroleum in world commerce.

LIABILITY PROBLEMS RESULTING FROM OIL POLLUTION AND SOCIAL AND ECONOMIC IMPACTS ON THE FISHING COMMUNITY

FEDERAL LEGISLATION REGARDING OIL POLLUTION LIABILITY FUNDS

Lt. Comdr. James Ellis
U. S. Coast Guard
Juneau, Alaska

I was talking just before lunch when I got displaced. I mentioned to John Gissburg that I thought that maybe he and Commissioner Mueller were practicing a little State preemption by displacing the federal speakers on the agenda. What I'm going to discuss just very briefly is something that I think we've heard pieces of all morning and that's the question of federal liability legislation. I'm going to look at three different things: the international initiatives that are already in existence regarding liability and a fund to cover liability; the fund established under the Trans-Alaska Pipeline Act; and then finally the latest administration bill related to the creation of what we've heard referred to as the Super Fund.

In the international regime there are two pertinent international conventions. The first is the 1969 Convention on Civil Liability for Oil Pollution Damage. This liability scheme requires vessels to establish financial responsibility up to 2,000 French francs per ton to cover damages resulting from pollution by vessels. That converts roughly to approximately $100 per ton which is the same as our nations liability under the Federal Water Pollution Control Act. This liability goes up to a maximum of about $20 million so that this civil liability was structured very similarly to the liability under the Federal Water Pollution Control Act. In 1971 there was an International Fund Convention. The International Fund Convention established a fund that would cover beyond the shippers liability created under the 1969 Convention and this new fund went up to a total of about $30 million. We've heard discussed the Super Fund legislation that's been considered in Congress over the past two years. The legislation creating a Super Fund would have also implemented these two conventions as part of the legislative scheme. It was decided early this year that the Super Fund would be separated from the implementation of the two International Conventions and now the Administration position is to ratify these two conventions by Congress until the international community raises the limits of liability and the total amount of the Fund. So there will be no action on either one of these conventions until the change that is considered necessary by the United States has been made. As we heard earlier the Trans-Alaska Pipeline Act established a liability scheme. It is divided into three parts. First, there's a straight $50 million strict liability scheme set up along the pipeline right-of-way route. It is involved not in the tanker trade, but on land concerned with any part of the pipeline or terminal facility. Secondly, the bill places strict liability on the permit holders for all costs associated with pollution removal. Finally there is an extensive section which was considered at the time and certainly was, a new initiative to create a liability fund scheme to cover damages resulting from vessel pollution associated with the pipeline. The scheme is basically one of strict liability of the vessel owner or

operator. The limits of liability for the particular scheme is $100 million and the vessel owner or operator is liable for the first $14 million. Beyond that, compensation is derived from the Fund. As we've heard the Fund is funded through a five-cents-per-barrel tax on oil through the pipeline, and it is administered by industry under regulations established by the Department of the Interior.

These regulations, as we've heard, had been promulgated in early February as a draft. The comment period on those regulations closed in March and, as a result of the comments they received, the Department of Interior has undertaken to completely rewrite and revise the draft regulations. The last I've heard is that they may very well come out with a new notice of proposed rule-making or set of draft regulations or comments. Whether they do or not depends on how extensively they finally decide to revise the regulations. It's interesting to note that this fund applies only to vessels engaged in transporting oil between Valdez and U.S. ports. Thus, if by some chance it becomes necessary, as it appears may be likely, that some of this oil may go foreign it would require a change to the act to include this provision in the liability scheme or foreign vessels would not be covered under this particular liability scheme.

Finally, I want to touch for a minute, and in a little more detail than the previous speakers, on the presently pending Super Fund legislation. As we've heard, there are a number of bills presently pending in Congress in both the House and the Senate. There are variations in almost all of these bills. The one that I'm going to concentrate on is the new bill that has just been submitted this past week by the Department of Transportation on behalf of the President to the Congress. In a recent announcement on tankers, the President supported the enactment of some sort of liability fund legislation and the result of that is the new bill that has been given to Congress. This differs very little from the previous administration's bill which we've heard referred to as H.R. 3711. However, there are a few changes and I'll try to note them as I go through. Basically, this new bill establishes a fund with an upper limit of $200 million. All that $200 million means, however, is that that is the most cash-on-hand they're going to put into the Fund. The liability of the Fund is absolute beyond $200 million. But if you go over $200 million for a particular spill, the Fund must borrow money and then repay the money that they borrowed out of monies collected after the particular incident. The Fund is to be administered by the Department of Transportation (this is one change that was made in the new administration bill).

All costs of administering the Fund are to be paid out of monies collected by the Fund. Since there is to be no support through appropriations for these costs, the operation of this Super Fund is financed by a 3 cent per barrel maximum, collection of penalties and fines under the various pollution laws administered by the federal government and any other monies collected by the Fund through subrogation after they've had to pay out in any case of liability. It allows for claims for damages or economic loss in the following areas. The first area covered is removal costs. Anyone who has any cost associated with removal of oil resulting from a spill can collect from the Fund. It covers injury to or destruction of real property with any spill, loss of use

of real or personal property, injury to or destruction of natural resources, loss of use of natural resources, and loss of profits or impairment of earning capacity due to injury or destruction of real personal property or natural resources. This final provision is obviously the key for the fisherman. Finally, there is loss of tax revenue to the state or federal government resulting from an oil spill. To claim for the loss of profit from the use of natural resources a person has to show one of two things: (1) that he used that resource in the ordinary course of his business, or (2) that 25 percent of his earnings are derived from activity associated with that resource.

Now the scheme of this fund is basically one of establishing a liability for the owner or operator of the vessel or facility. On top of that if you exceed the limitations of their liability then the fund picks up the rest. The liability established in the act is $150 per ton for vessels that do not carry oil. So that any vessel has to establish financial responsibility up to $150 per ton. For vessels that do carry oil, the limitation is $500,000 or $300 per ton, whichever is greatest. This is another change in the recent administration bill. Originally there was a limitation of $30 million of liability for any owner or operator. This is no longer in existence in the bill. For instance, if you had the largest tankers that are now projected for the TAPS trade, their upper liability based on $300 per gross ton is probably around $45 million. Above that figure of liability that is put on the owner/operator, the Fund would pay the rest. For onshore or offshore facilities, the limitation of liability is $50 million across the board unless the Secretary of Transportation determines that a lesser amount if appropriate. This would be for the smaller outlying onshore facilities of which we have many around the State of Alaska.

Finally the bill requires a certificate of financial responsibility to cover owner/operator liability. We've heard several people express concern about the owner/operator of a vessel or facility skating out from under his liability after an incident. The certificate of financial responsibility is designed to prevent this. Any person who is the owner or operator of a vessel is going to have to have on record a certificate of financial responsibility. For a large oil company it would show that they have the finances to cover their liability, or for anyone else, they would have to have some sort of bonding or letter of commitment from a financial institution that would cover their liability. The intent is to make sure that when there is an incident, the money is available to pay that liability.

When there's a spill or incident the person who is responsible for the spill notifies the Secretary of Transportation and then he is required to advertise the fact that he is responsible for the spill and state how people can present claims to him for payment. In any case where there is a spill, the person who is responsible for the spill, the owner/operator of the vessel or facility, will be the person who is responsible to collect and pay the claims up to the limit of his liability. The claims settlement provision provides

what is designed and hoped to be a very fast way to get money to the people who suffer damages. It provides that if you present a claim and your claim is not paid in 60 days, then you have the right, by the owner or operator who is responsible, to go directly to the Fund to obtain the payment for your claim, or you have the option to go directly into court and sue the person responsible for payment. It would seem that probably the most expeditious way would be to go directly to the Fund for payment.

If you go to the Fund for payment and you can't reach an agreement with the Fund as to the amount of your damages and if the Fund does not pay you within 60 days, then the Secretary of Transportation is required to set up a board to hear claims and determine the appropriate amount. It's interesting to note that in adjusting these claims and investigating, the law requires the Secretary to use the private sources, insurance companies, insurance adjusters or state agencies. So it's very conceivable that the Secretary of Transportation could contact with the appropriate state agencies to actually oversee the assessment of damages and liability resulting from a particular incident. Finally one of the things we've heard the most about obviously is preemption. I think Barbara Heller in her comments pretty much covered the question of preemption. Its a very volatile issue. Of the bills in Congress about half of them presently being considered would preempt the state, about half would not preempt the state. How it's going to come down is hard to say because basically it appears that the Senate favors no preemption and the House favors preemption. So it could be a question that's not going to be settled until they get to a conference committee. I think that another important factor is that if the Super Fund is enacted, it will absorb the TAPS Fund, so that you will have only one funding scheme. Any monies collected for the TAPS Fund prior to the establishing of the Super Fund would go into the Super Fund. It would also suck up the funds established under the Deep Water Ports Act. Finally, I think it's safe to say the assessment of most everyone is that it's virtually a sure thing that we're going to have fund legislation enacted by this Congress. Exactly what form it's going to take is hard to say.

My understanding from talking to the people from my legislative section in Washington is that the President felt that he had fairly broad base support for the latest legislation that he had introduced and they felt that the bill that is finally enacted will probably be pretty much along those lines.

NORTH SEA OIL - A POSSIBLE COROLLARY FOR ALASKA OCS

Ronald J. Morris
Field Office Supervisor
National Marine Fisheries Service
Anchorage, Alaska

One of the National Marine Fisheries Service's tasks is to protect living marine resource habitats. Its Environmental Assessment Division, of which I am a member, reviews any federally permitted activity which may affect resources for which the Service is responsible. I personally have been reviewing federal OCS and state offshore oil activities that require federal permits. During the past three years, the National Marine Fisheries Service has recommended various types of stipulations to try to protect the living marine resources which could be affected by oil exploration activities.

With the discovery of oil and subsequent production in Alaskan waters in mind, I attended a meeting on North Sea oil in Stavenger, Norway, and a site review of the North Scottish coastal area impacted by offshore oil activities. Since the North Sea oil fields are geographically similar to our state's, it is logical to examine them for an insight into our future. Today, I would like to share with you my notes and photographs on the effect that North Sea oil activities have had on United Kingdom and Norwegian fishermen. However, my abbreviated trip does not qualify me as an expert on North Sea oil activities. One of the goals of my trip was to try to see firsthand what problems had surfaced in coastal communities which supported commercial fishing and OCS activities with the idea that these problems might be prevented in Alaska. My purpose in sharing this experience and data with you today, is to make you aware of the problems I encountered and hopefully prevent them from occurring in Prince William Sound communities if oil is discovered in the Gulf of Alaska.

The North Sea has a known recoverable oil reserve of 17.5 billion barrels. At the moment, we don't have a handle on the actual reserves in the only active OCS sale area, (the NE Gulf of Alaska), because no oil has been found. However, USGS estimates range from five to ten billion barrels of oil. That amount of oil is about half of what the North Sea is known to have. About 45 production platforms are planned for the North Sea between Scotland and Norway and an estimated 1,600 wells will be drilled. BLM estimates for the NE Gulf of Alaska area are for about 20 platforms and 800 wells. Using North Sea cost data $10 billion will be spent for production facilities and expenditures associated with platforms if the five to ten billion barrel range is found. The American Petroleum Institute figures that 80 percent of the production costs are in platform manufacturing and construction.

Stavenger, Norway is the center of Norwegian North Sea OCS and is referred to as the Houston or Kuwait of northeast Europe. Its climate is warmer than you'd imagine because of the Gulf Stream. Sea conditions are analogous to those in the Gulf of Alaska with severe weather limiting marine construction to the period between April and September.

There are 1,800 Americans living in Stavenger, working for oil-related industries, principally Phillips Petroleum Company. As far as I could gather from talking to Norwegians, including the president of the Southern Norwegian Trawling Association, it is not oil pollution, but a problem of littering and lost fishing grounds which cause concern for commercial fishermen. Estimates for ground losses range anywhere from 15 to 85 percent of the Norwegian continental shelf.

The loss is brought about by litter dumping, placement of platforms, or abandoned wells which are capped above the sea floor. Examples of extreme cases of littering range from an Aberdeen fisherman dragging up a D-9 cat in his trawl, to a 55 gallon drum of paint dropping on deck, bursting open, and ruining an entire catch. Abandoned oil wells which protrude above the sea floor and snag trawling gear also are a problem.

Presently, the Southern Norwegian Trawling Association estimates each hole drilled on the continental shelf, of which there are approximately 700, pollutes or occupies a radius of two nautical miles. Norwegian law prohibits littering and leaving abandoned wells, so there obviously is an enforcement problem. Since the U.S. has similar laws and regulations against littering and abandoned wells, the North Sea difficulties in controlling litter should be reviewed with an eye toward strengthening our enforcement capabilities when production platforms are constructed and operate in our waters.

I think that some sort of statewide protection association needs to be formed to protect commercial fishermen before we get into the developmental stage of the NE Gulf of Alaska. If there are going to be damage claims brought about because of gear loss, littering, or loss of fishing grounds, some sort of forum needs to be established so we don't repeat the situation we had in Kachemak Bay three or four years ago when seismic operators damaged crab pots. On the subject of water quality, Norway has a water pollution act but it never promulgated any water quality standards for marine waters. On the other hand, we have draft standards but they've never been promulgated. A member of the Norwegian petroleum directorate told me that his country is looking to the U.S. and the Environmental Protection Agency as a standard bearer for any future water quality criteria they develop. I wonder if a major spill at EKOFISH will make them come about more quickly.

<u>On Baseline Data</u>

No drilling has occurred above 61° in the OCS area of Norway. Right now, the government is contemplating spending $1 million

for one year of research to gather biological data in this area. In comparison, the U.S. is doing far more than some of the European countries have done regarding OCS research. We are spending some $24 million a year.

Oil Pollution

The United Kingdom estimates that approximately $1 million will be needed to deal with oil pollution off their shores each year. They are estimating that up to 16,000 tons of oil can be spilled off the UK shores in any given year. If tons or barrels tend to confuse you, remember that there are about seven and one-half barrels per ton of oil.

CITIZEN PARTICIPATION: THE ROLE OF THE RADICAL SKEPTIC

Frank Tupper
Kachemak Bay Area
Homer, Alaska

Although I am most pleased to be in Cordova attending this conference, I find a certain sadness that seems all too pervasive. Cries of "help" are being sounded from every quarter in this the last frontier, which some have called with prophetic tones, "The Last Orgy". Those of us who seek to live in Alaska and not merely exist here are having various projects thrust down our throats. The threat to our coastal marine ecosystem and our basic lifestyle, posed by the prospect of increased oil activities, specifically tanker traffic, is but one of the issues that requires a public response.

What baffles the hell out of me is a recurring question: How long are the people and the resources going to stand for this insulting and degrading intrusion? Where are the questioners and the doubters? Where are the radical skeptics who ask the basic questions of "Why? Who said so? What about quality?", etc.? The need for strong public resistance is long overdue and in great demand. As Victor Hugo stated "Stronger than all armies is an idea whose time has come." I mourn if destruction or even the remote possibility of threat to our natural surroundings is a byproduct of civilization, progress and growth, for such need not be the case. It is time to rally and identify our values along the shores of change, that are not merely overflowing with quantity. It is a time to close ranks at all public sectors and send up an unmistakeable message. We can ill afford to take action after the fact. The wisdom of history is written for us to study and then to take considered action.

Along the shores of Kachemak Bay, citizens are awakening from their tranquil and once remote natural womb, for an abortion is being committed and it is far from therapeutic. We were told that, "Oil in Kachemak Bay would mean more jobs, more goods and more services." In 1973 the public process was perverted and leases in the midst of a marine habitat and the largest shellfish breeding grounds in the world were virtually given away to industry.

The prospect of less, rather than more, dawned on the real sleeping giant, the people. Yet after four years of open if not hostile opposition, we still find that we are the ones pressing the issue to halt and keep hands off. The lies, the laxness, and the lethargy practiced by industry and government have been the lowest of insults and must serve as the ultimate lesson stemming from the Kachemak Bay fiasco. The issue before us this

weekend is limited to tankers and the marine environment. Of course, there is a broader issue that also needs to be explored by using the human energy of inquiry and consideration, then action. During this conference the focus of attention must be on the arousal of interest by the public sector. In a recent conversation with the manager of the Alaska OCS Office, Ed Hoffman, he said that I represented a "special interest group." He was most correct, for I work with the most special group of great importance and interest...the people.

Let us for a moment focus the light on the topic of economics but with a broader scope. Economic growth is not the sole measure of social progress. Consumption of goods and resources does not of its own accord make us any better off. I share with others the contention that we the public are being economically brainwashed to believe that growth mania and consumption are synonymous with progress. This is the economics of self-destruction like cancer which also expands and consumes. To destroy our fisheries, our lifestyle, our dignity and our natural integrity under the banner of progress is an insidious crime that must be arrested. In our rush to develop and expand, we seem to be in abundance with the word "quantity" while sadly lacking in "quality". The concept that people have feelings, and ideas as to how they would like to live seems to be left in the dust of the rush and the basic question is rarely asked even by those who are losing at the public end of the shaft. It is an assumption foisted on us by the negligence of the public sector in taking the initiative. We must cease to be lulled to sleep by technical engineers who base their arguments on a cost-benefit ratio calculated to promote the business of some self-serving client whose interests are on Wall Street, and not in Wrangell. A healthy and renewable fishery is in the long run far more important than the oil reserves within the continental shelf and is certainly not worth risking to the hazard presented by increased human and mechanical tanker errors.

In a comparative study the U.S.G.S. stated that the ultimate yield of the Georges Bank oil would provide only enough oil to satisfy the U.S. consumption for 10-35 days based at 1973 rates of consumption. How can that even compare to a healthy fishing ground yield of perpetual protein?

"Jobs" is a "buzz word" for those who wish to threaten personal security in the relation of jobs in the Georges Bank area. However in a comparative study of jobs, it was stated that 2000-5000 oil-related jobs could be gained in OCS development. Yet in the wake of a disaster such a development in this fisheries-rich area could affect 30,000 fishing-related jobs.

In terms of economics the principal natural resource available to coastal communities could well be destroyed through pollution brought about by massive construction, superports, oil spills and service centers. And at what price and for what purpose?

Huge monetary profits are being raked off for a selected few, at great expense to many. Would it not be better to live 1,000 years with Alaska's coastal resources and to be content than to rapidly increase our monetary wealth through the acquisition of things for the short run? Environmental quality must be the bridegroom of industry in the marriage of our quality of economic progress. Fortunately, leadership is being exerted at the national level, it would appear, when President Carter proclaimed that "we Americans must learn that we do not have to sacrifice our environment, or what's left of it, to the economy of our nation."

Now we must face an issue that concerns me greatly: the laws and liabilities governing our actions. If laws are to have any redeeming value, they must, of course, stem from the needs of the public sector and be rigidly enforced.

We cringe when, in the media, we learn that a felon convicted of an offense goes off scot free. We say it is a mockery of the judicial and ethical process. Yet how can we scream so loudly on that point, while every day persons, not some non-human corporate entity, rape and kill those resources, air, water and communities that are so essential for our survival? What action do we take when:

1. the former Secretary of the Interior leases the Atlantic OCS tracts in violation of the public process and N.E.P.A. as Judge Weinstein's recent decision indicates;

2. tankers willfully jettison toxic crude oil upon our waters and marine resources and receive, at the most, a mere financial penalty;

3. an Alaskan commissioner of D.N.R. perverts the law of due public process and turns a deaf ear on citizens protestations and leases Kachemak Bay;

4. Admiral William Siler, Commandant of the Coast Guard makes an arbitrary and capricious decision not to enforce safety standards of foreign vessels, even though he has been empowered to do so since 1972, because <u>he</u> did not want to cause trouble abroad.

Is this not a mockery? Is this not criminal? When we the public are deliverately misled by "facts of convenience" at public hearings, who brings these persons to account to the public and corrects the errors? The semantics are always changing. Just as we get accustomed to a new set of initials or words, they are changed. An illustration of this problem is the maze of public confusion brought about by initials such as BLM, OCS, EIS, NEPA, DEC, DEQ, NOAA. Why, in my part of the Kenai Peninsula, when we heard that NOAA (Noah) was coming to study man's effect on the waters of our area, 3,476 agnostics started attending the Baptist church? It is little wonder why action is slow from the public arena. There is little room

for resistance from a confused and uninformed public which few dare consult, except by way of the referendum, which always turns out as predicted because it is rigged by greedy politicians, voted on by the demoralized masses and tabulated by opportunists.

Citizens must take the initiative and demand of their representatives that we commence playing "political hardball" with industry and the various regulatory agencies. We must demand the very best at the very least. It is absurd, if not obscene, when people like you and me must go to court to fight for the public's interest against public violators because the state or federal government defaults or acquiesces its mandated role, duty and obligation. In some situations, however, many agencies lack the necessary appropriations to enforce the law. This renders them ineffective and makes a mockery of the law.

One of the frailties that seems evident in modern man is greed. Therefore, we need to develop measures to protect ourselves from each other. These measures must be based upon a complete awareness of the situation. Most citizens do not know the rudiments of civic inquiry. They feel alien to the process of which they are, or should be, an integral part. Timing and the lack of public information only drive us further from the process. Without this information the public already reflects the usual attitude of powerlessness, apathy, lethargy, and disillusionment, finally ending in cynicism. The salve of passification and words of pap, the isolation of critics and skeptics within our total social structure by referring to them as "nuts" or "cranks," and the utterances from our leaders who say "I don't want to scare you" do a grave disservice to us all and is a dereliction of mandated duties of the highest betrayal. We need to have the holy and unholy hell scared out of us for it is only at such times that we respond. Our selfish interests are at stake and what might have been considered "heresy" or "overreacting" by some so-called crackpot yesterday, is now, or will be, the guiding wisdom. This is assuming it is not too late to save our coastal communities and resources.

Our desire for a good and rewarding society has been diverted into institutions, industries, unions, and governments, who can be past masters at the fine art of diffusing responsibility and accountability and avoiding being touched by the same moral standards that the individual is. We must cease doing things merely because they are popular or self-gratifying. We must take the risk and do things that are necessary. We cannot separate problems associated with energy production, extraction and consumption from those of our biotic resources. We must also not isolate these problems from the higher question: How will this action affect the ultimate quality of our life?

Every spill of oil upon our waters, no matter who is responsible, diminishes the earth's capacity to sustain human and non-human life; the arguments of resource exploiters not withstanding. The net effect is a gradual, cumulative and mostly irreversible impoverishment of our earth. The facts as viewed wholistically suggest that we have reached a point where a spiriling increase and waste of our

energy and resources will significantly reduce the length and quality of man's life, and endanger his very existence. Those who would have us believe that environmental pollution, energy, economics and tanker spills are separate afflictions corrected through separate analysis and solutions, gravely mislead us either intentionally or not. The symptom of the dilemma is confusion and the result is loss of strength and confidence in ourselves. Following this point through, the proponent of a solution to one of these problems, who overlooks the wholistic view, inevitably becomes an opponent of the other approaches. This allows policy stagnation, discourages remedial action, and causes public frustration.

In the case of an oil spill in Upper Cook Inlet, we find federal and state agencies, who are responsible for clean and safe actions upon the sea, slow to respond. They await further word from headquarters to proceed, fail to pass the word along to other agencies and then bureaucratically rest on the letter of prescribed lines of responsibility rather than seizing the initiative of an emergency situation. This allows the culprit to virtually sink out of sight. The credibility that governments and industry seek from the public sector is established not through conciliation, but by firm policies that are unmistakably understood by all and enforced when violated. I might ask: How has a nation profited if it has gained a million barrels of oil a day or a billion dollars a day, if it has lost its soul forever? There are alternatives to energy, to shabby tanker operations, and to most of our human activities. There are, however, no alternatives to the sea and its resources or our collective moral obligations.

The answers concerning responsibility and liability for contamination of our environment continue to be most evasive. That evasiveness can be ended. President Carter has proposed a $200 million oil spill compensation fund whose purpose is to offer aid to the victims of oil spills. In addition to pursuing direct compensation from the industry to repay those tax dollars, the industry must not be allowed to bury their responsibilities in corporate write-offs, or pass the expense along in the form of higher prices to the consumer. No, this expense should come right off the top of the profit margin and be deducted from the salaries of corporate managers and the dividends of shareholders. This might encourage some action from those who share the guilt. If penalties were accessed in such a manner, perhaps they would provide the necessary incentive for the oil companies to clean up their act. On the other hand, I might suggest that direct incarceration of the top brass in the same manner as people of lower socio/economic status would be effective. Remember the days of the public stockade? It provided, I think, a necessary reminder.

We, the people, who ultimately must make these decisions, and who suffer the ultimate consequences, should be incensed. We must strongly react by speaking up and taking the initiative to destroy the actions and mute the words of arrogance, exaggerated

self-confidence, and false pride, which ultimately destroy us. The Greeks had a fitting word for these stupid humanistic actions that are not to be found in the animal world..."Hubris".

Perhaps we can learn that through open and honest dialogues, and all-encompassing vision we can collectively end the sad note that seems to intone that such limits of scope are beyond our grasp. We have gone too far over the edge to have any hope and we can put an end to the problem of learning humility only through disaster.

We need not settle for the "best of a bad deal." Not by a long shot. It is time to ask for a new deck of cards, and a new dealer.

At this time I might mention to you, the people of Cordova, that there are those of us who are committed to the integrity of our coastal communities. Recently some of us from the Southcentral area of Alaska banded together to form a Citizens Coalition of Coastal Communities dedicated to the survival of our homelands and resistance from any and all forces that would seek to "rob" us. If you are interested in joining forces, please see me at the next break in this conference. As Konrad Lorenz said..."A morality which encourages man to detach himself from his animal origins and regards all nature as subject to him, does not offer our best hopes for the future." I think if this quote is accurate, and all evidence I have come to experience seems to indicate that this is so, we then are openly courting a cultural and biological disaster, and I for one am willing to fight to see that this does not happen. Are you committed?

Thank you for the opportunity to speak with you today.

OIL SPILL LIABILITY AND COMPENSATION IN THE UNITED STATES

Donald E. Cornett
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Marine Department
Exxon Company, U.S.A.
(Speaking on behalf of API and AIMS)
Houston, Texas

The American Petroleum Institute (API) is an association of representatives of all phases of the oil industry. The American Institute of Merchant Shipping (AIMS) is an association representing about 70 percent of all U. S. flag ocean-going vessels. This includes all types of cargo carriers including oil tankers. Exxon Corporation is the largest of the fifty fully integrated oil companies and accounts for approximately 10 percent of all production, refining, and sales of the U. S. petroleum industry.

Our department operates Exxon's 17 U. S. flag tankers and about 100 towboats and barges. The organizations I represent are acutely aware of the numerous problems associated with oil spills in the United States and we support solution of those problems through enactment of H.R. 3711, the proposed National Oil Spill Liability and Compensation Act. We know the problems that arise when funds are not available for cleanup and claims settlement after a major spill. H.R. 3711 solves that problem by providing a $200 million fund for prompt payment of costs of cleanup claims, and resources injuries not promptly paid by the spiller. It further provides for extending the funds available to cover any costs in excess of $200 million.

We are aware of the need for oil spill legislation to provide protection for all citizens from all sources of oil spills. The national legislation does this by imposing liability and providing compensation for spills from tankers, barges, terminals, refineries, drilling rigs, production platforms, pipelines, trains, and trucks, and it even covers spills of unknown origin.

We recognize the necessity of keeping the responsibility for spills on the spiller and at the same time making claim settlements prompt and equitable for the damaged parties. H.R. 3711 does this by requiring the spiller to accept or deny liability for a spill promptly. If he denies liability, the fund accepts claims directly and makes prompt settlements. In such cases, the fund will sue the spiller to recover costs if in the fund administrator's judgment the spiller was liable. If he accepts liability, he must settle claims promptly or the claimant may go to the fund. This procedure should also serve to minimize bureaucracy and thereby reduce eventual consumer costs.

There are other problems which H.R. 3711 solves. In the United States, we are experiencing a proliferation of oil spill liability and compensation fund laws at both the state and federal levels. Congress has legislated $100 million funds for the marine leg of TAPS and for deepwater ports. It is also proposing a $200 million fund for the OCS. Each law modifys in some special way, the existing liability limits of the Federal Water Pollution Control Act.

The state legislatures have been very active in this phase of the law. At last count, a half dozen states had legislated tax-built compensation funds aggregating about $100 million and that much or more has been proposed. Some states have oil spill laws with unlimited liability for cleanup and damages but no provision for defenses in cases where the spill is caused by some outside force completely beyond the owner's or operator's control. This patchwork of laws and funds does not serve the country well. There are many states where compensation for oil spill damage claims is not readily available. In other states owners and operators of facilities and vessels must assume uninsurable liability to continue in business. In those cases where insurance can be bought, the increased costs caused the consumers' oil bills to go up. The patchwork creates a special problem for vessels which, by nature, travel from state to state and thus may be subject to several different liability regimes in a single voyage.

Let me give you an example. As I mentioned earlier, spills of Trans-Alaska Pipeline oil will be covered by the $100 million fund in the TAPS Act. The State of Alaska has legislated another fund of $30 million built by risk charges assessed against the ships carrying the oil that will cover the same spills. California proposes to build a $100 million fund from taxes on oil handled in that state. So a shipload of North Slope oil would get taxed three times, and be at most times, double-covered.

H.R. 3711 solves this problem of multiple coverage by establishing a uniform oil spill liability regime for the United States at a level sufficient to encourage the utmost care on the part of owners and operators as well as allow them to stay in business. It backs up their liability with unlimited liability from the fund. To accomplish this uniformity of liability and remove any need for other multi-million dollar funds, H.R. 3711 repeals existing federal funds and preempts state oil spill liability laws and compensation funds.

The following is a brief summary of the bill's provisions:

- A $200 million fund built by a one-time 3¢/bbl tax on all domestic crude oil received at refineries and all oil received at terminals for import or export.

- Compensation for costs of cleanup, third party damages, and resources injuries from spills of oil of any kind from any source if not otherwise

compensated for by the spiller. Of importance to fishermen is the provision for loss of income due to fish or shellfish damage from oil spills occurring anywhere within the new 200-mile fisheries zone. Individual states would have difficulty in providing the same coverage.

- Liability limits are the lesser of $300/gross ton or $30 million for oil cargo vessels with a minimum of $250,000 if costs are that high and up to $50 million for terminals (this tripling of liability limits imposes undue burden on small barge operators).

- The spiller has "front line" responsibility for cleanup and claims settlement.

- State oil spill liability laws and funds are preempted and federal laws and funds amended to repeal sections providing oil spill liability and compensation.

We are aware that preemption of state laws does not enjoy unanimous support. However, it is obvious after analysis that it is necessary both to alleviate the patchwork law problem and to ease the unnecessary burdens on industry and, ultimately, on the consumer. Several states which have recently established new laws and funds or are in the process, have recognized this necessity and provided for their laws to change or be nullified if a federal law is enacted. We believe this federal legislation will pass during this Congress. It has very broad support. Markup of H.R. 3711 is scheduled to be completed in the House Merchant Marine and Fisheries Committee's Coast Guard Subcommittee tomorrow. These was strong support expressed for H.R. 3711 in the hearings although certain modifications were desired. I would like to quote from the statement of one environmental advocate who testified on behalf of the Sierra Club, the National Audubon Society, the Friends of the Earth, the Natural Resources Defense Council, and the Environmental Defense Fund:

> "We appeared before you, as you are aware, a little over a year ago, concerning the same legislation. Our views concerning the legislation today are essentially the same as they were then, and that is, this legislation should be passed. We should have legislation with a federal, sensible compensation fund for oil spill liability."

In a letter to Congressman Biaggi, Chairman of the Subcommittee, Mr. Frank Ikard, President of the American Petroleum Institute, expressed strong support for the concepts enbodied in this legislation. The American Institute of Merchant Shipping Vice-President, Mr. Al May, testified:

> "We believe that H.R. 3711 offers a sound approach for dealing with the compensation problem through

> the concept of a single, national fund, raised by a simple per barrel tax on oil and administered by an existing federal government organizational unit such as the Department of Transportation."

In summary, the oil and shipping industries understand the problems and we strongly favor the proposed National Oil Spill Liability and Compensation Act as the solution. We have supported it from the outset and urge you to add your support to this timely, constructive legislation. Thank you.

LIABILITY AS IT RELATES TO MARINE POLLUTION

Ernst W. Mueller
Commissioner
Alaska Department of Environmental Conservation
Juneau, Alaska

I may depart a bit from the topic assigned to me in the program, because of some of the things that I've heard over the last few days. I have been led to believe that there is a misunderstanding of how the decision-making process goes on in government, and how we relate as managers and bureaucrats to the question of liability. We attempt to tie together the effects of oil on aquatic organisms and people, to develop regulatory structures to control oil, and then try, in the event of an oil spill, to make sure those people who are victims, as well as the environment, are made whole.

In order to do this, I should explain to you the kinds of processes those who have set the rules and regulations concerning oil pollution have gone through. Over the last 40 or 45 years water pollution has been controlled by state and national governments. In the early years of water pollution control, we looked not to the complex problems that we see today, but to very simple problems. That is, if you wandered up the creek and found a few dead fish that smelled bad, and a pipe, you got a big cork or a subpoena and tried to solve the problem that way. Subsequently a very complex theory of federal and state laws have developed that relate the quality of water back to the offender.

We found over a period of years that attempting to utilize water quality-related approaches to solving environmental degradation problems didn't work. Cases in point include such things as the reserve mining problem down in Minnesota, which was first noticed shortly after the mine went in 12 to 13 years ago; and as far as I am aware, the problem has not yet been solved. The asbestos disposed of by reserve mining into Lake Superior became the center of a national controversy. Is asbestos a water pollutant? Does it affect human health? Is the asbestos in your drinking water good for you, or bad for you? We can go on with that kind of an argument until either the investigators all die of old age or the mine shuts down because there is not longer any mineral there to mine. So as a result of that kind of a problem, in 1972 the Congress decided to take the next step and that is to go out and define water pollution as an economic evil, regardless of whether or not it can be proven to be harmful. And, how are we going to control this? The only way we can control this economic evil is through a certain level of technology.

The Federal Water Pollution Control Act of 1972 works to ensure that the water itself is clean, but also, most importantly, establishes a minimum level of treatment technology regardless of

the quality of the receiving waters. That is to say, a particular industry, regardless of where it discharges, is required to use the best available technology. As you all know, that standard has caused a great deal of controversy, a controversy that has resulted in some interesting court decisions and in some heated arguments between industry, the Federal Government and the states. There is one step further in this process that can take place and it concerns a philosophy that was developed in toxic substances legislation which was passed last fall. It states that an industry cannot conduct an operation that results in the production of a new chemical, unless it can prove that it is not detrimental to the environment and to human health. That throws the burden of proof completely on industry and away from government. Initially, we were trying to tie these standards solely to environmental quality and the burden of proof was on government. I think this is a constructive step because, after all, industry is attempting to utilize the environment as a depository for the wastes it generates and, therefore, it should be required to not only use the best available control technology, but demonstrate that the resultant discharge is not detrimental to the environment or to human health.

Now the Alaska Legislature and the Congress have made a decision on oil pollution in that same context. They have established a policy that the threat of oil pollution to our waters will be eliminated regardless of whether the pollution is measurable, regardless of how many hundreds of millions of dollars of scientific research have indicated one way or the other that oil pollution in some places may not be extremely biologically damaging. We are going to end the debate and establish the policy that oil pollution is an economic and environmental evil, and that there will be attempts by government at all levels to ensure, to the best of our abilities, that there isn't any oil discharged into the water. So, in that context, philosophically at least, we should be required to utilize the best available pollution control technology to control oil pollution.

I think that yesterday there was a discussion mentioned about the trade-off between segregated ballast and ballast water treatment. That is a very simple example of the difference between the traditional approach to pollution control and this new approach. That is, that if we are able to cast into the system the best available pollution control technology, we would not build a huge ballast water treatment facility capable of treating 42 million gallons of dirty ballast, which is potentially 50 percent of the total volume of the vessels, but we would be able to require that every one of those tankers will have a maximum available segregated ballast capability, and we will then be able to scale that ballast water treatment facility down to a relatively small size. And that's the kind of test that we in State Government are trying to use when analyzing oil transportation systems.

Now the other test that we have to use, in my opinion, is to consider the entire system. We can't consider only an oil tanker. We can't consider only a pipeline. We can't simply consider a terminal facility or a tank or a well, or any of these pieces of the oil transportation system. We must examine the system holistically. Government allowed us to do this only very recently. In the past, we ended up with projects like refineries being established at the whim of a planning and zoning commission. We have pipelines being regulated sometimes by the Office of Pipeline Safety, sometimes by the Federal Power Commission, sometimes by state and local governments, and other times by nobody. I think one of the key elements of the National Environmental Policy Act of 1969 is that it enables us, as the public and as government, to look at a project *in toto*. We didn't do that with the Trans Alaska pipeline, at least to the extent it could have been done, but the means are now there. As a result, we can see today there's a tie-in from the time that oil comes out of the ground at Prudhoe Bay and runs through this very complex system, until it gets to Midland, Texas, or wherever it is going by a series of mixed transportation routes, and is subsequently refined and distributed.

As a result of looking at this as a system, we can plan better for pollution control technology. If we had known then what we know now, that there was not going to be a reception facility in California and a pipeline overland to Midland, Texas, but that a 300,000 deadweight ton Panamanian tanker would be leased to anchor off the west coast of Panama, and tankers would be taken from Valdez and off-load Alaska oil onto the Panamanian tanker, then onto another little tanker that would slide through the Panama Canal and to the Gulf of Mexico, I think we would have planned our transportation system a little bit differently. As John Williams and I were discussing earlier, maybe at that point we would have decided not to build a terminal at Valdez, we would have decided to build an Alaska-Canada pipeline instead. But we weren't employing the holistic approach that needs to be used with any large energy development facility.

One of the things that we found out as a result of planning on how to transport oil to the Gulf of Mexico is the fact that we're going to get some of it back. Ballast water will be in cargo tanks on these non-segregated ballast tankers when they are unloading. That ballast water will be run through the Panama Canal and loaded onto the bigger tankers and they'll bring it back to Alaska to run into the 42-million-gallon-a-day ballast water treatment system. Then it will be treated and go into Prince William Sound. So, those are some things that are only now being understood as a result of the fact that in 1971 or '72 or '73, when this project was being debated, nobody looked at this question in terms of a system, even though we had the National Environmental Policy Act with us.

The other thing we need to look at, as Alaskans who have been living with this damned pipeline for the last seven or eight years, is to examine the oil industry and the Federal Government

and see what kind of promises where made to those who objected to the project, which I think, includes many of the people of Cordova, to make them back off a little bit and let the project be built. We heard earlier about the structure of the tank vessel fleet, and that there were promises made to the Congress by the Nixon Administration. But here's another one. We see, as the oil industry becomes involved with a massive economic investment in Alaska, that all of a sudden enormous potential risks from oil spills were recognized by the industry.

Before the Congress right now is H. R. 3711 and about half a dozen other approaches to oil pollution compensation and liability legislation. Now, I think we, as Alaskans, have to be a little parochial when we look at this new Federal legislation and have to say, "What is this going to do for us?" I don't think it is fair to just say, "Well, preemption of state jurisdiction is bad," because we may end up with something that is better than the current mix of federal and state law.

One of the things that has happened, I think it was mentioned earlier, is the fact that the Limitation of Liability Act was applied to vessel accidents, so that if you sue you may not be able to recover very much. In the Torrey Canyon incident, for example, I believe they filed for limitation of liability and the liability was assessed at something like $50. The countries of England and France were able to recover by a very simple maneuver, and that is that the next vessel owned by that company that came into port was seized. The country utilized that age-old form of recovery known as piracy in order to get the damages that they felt were necessary. We are not an independent nation; I think piracy would be a little difficult. We might be able to slow them down a little bit, but I doubt that we would be able to recover.

Let's take a look at what we see from the state government standpoint in terms of law and what we would like to see changed. When the Trans-Alaska Pipeline Authorization Act was being debated in Congress, the Trans-Alaska Liability Act Fund was established at $100 million to compensate for damages from oil pollution from vessels carrying TAP oil to U. S. ports. The proposed regulations that the Department of Interior has promulgated to cover the fund would establish a Board of Directors as being representatives of the Secretary of Interior and representatives of the owners of the Trans Alaska Pipeline. Now this might be the exact language of the law, but our attorneys think there might be a little more flexibility. Interestingly enough, the Trans Alaska Pipeline, as a common carrier, will carry out oil. We as Alaskans will have a certain amount of oil going through the pipeline. It may be loaded on the tankers that the State of Alaska charters or sold to an oil company at Valdez, or some other point.

We, as the State of Alaska, therefore, are paying our x cents per barrel into the Trans-Alaska Pipeline Fund. We are not represented on the Board of Directors of the Trans-Alaska Pipeline Fund Corporation, so we feel discriminated against because

Exxon, ARCO, Sohio, and all the other owners of the Trans Alaska Pipeline are represented on the Board of Directors. The Secretary of the Interior is represented by the fact that this pipeline traverses a lot of federal land even though the fund would not compensate for damages resulting from spills onto these lands. The State of Alaska finds itself in the odd position of being the regulator and the oil company at the same time, so we try to use whatever muscle there is in either direction to get maximum environmental protection.

But anyway, as this project developed, one of the promises that was made by Congress in the Trans-Alaska Pipeline Authorization Act was that the oil companies would be strictly liable without regard to fault, within certain defenses, for the damages to everybody. The State of Alaska was in the process at that time, and had been for years, of clarifying its own liability legislation with regard to oil spills.

One of the issues we were very concerned about was preemption in the Trans-Alaska Pipeline Authorization Act. And so, in the floor debates in the Senate, Senator Stevens, who carried much of that bill along with Senator Gravel, expressed this concern. He said, in a long speech relating to the responsibility of the state, "I make these points, Mr. President, to assure my colleagues that the State of Alaska sees its responsibilities of this kind quite clearly, and to solicit your assurance that nothing in this bill in any way limits the exercise of the state's legal and jurisdictional power to carry out these responsibilities." This included, along with other responsibilities, the issue of liability. Senator Jackson, Chairman of the Senate Interior Committee, expressly labeled this issue. "As you will notice in Section 204(c)9, a stated disclaimer of preemption is made and made there only to emphasize the point, even in that comprehensive liability section, I believe the conference report anticipates the appropriate exercise of state power and responsibility to make certain this large and important project is completed and operated in the public interest." In further debate, Senator Magnuson made the same argument.

The point is that when the Trans-Alaska Pipeline Authorization Act was passed, the oil industry at that point was willing to make a lot of sacrifices to move the oil. People in the United States were willing to make some sacrifices because there was an energy crisis. And so we were made some promises, and one of those promises was that the Congress was not going to preempt state legislation, and strict liability from spills of oil into the environment was to be imposed, at least around Alaska. Now we see in H. R. 3711 a slow erosion of that promise, and a definite preemption of state authority.

I think we as Alaskans have to stand up and say, "Hey, this is what was said when you guys wanted to build this damned pipeline, and now that it's almost over and you're running oil through

it, you're starting to back down." I think that what has happened here is that the oil industry went back to Congress and is pressuring them to renege on these promises. That is exactly what the gentlemen from Exxon stated; the industry is now strongly supporting preemption of state authorities. They strongly support it for two reasons. One of them is that it would preempt the states' funds, which in the aggregate are not that much money; they're about $100 million throughout the United States. They vary quite a bit in costs to the industry, and probably the least offensive is Alaska's. But it would also preempt other areas of jurisdiction. It would take away the state's authority to put strict liability limitations on the industry. Also taken away would be the state courts' jurisdiction over oil pollution liability. If you read the language in 3711, it preempts the state court's jurisdiction in matters of common law, as well as the statutory law that we in Alaska have to protect us from oil pollution damages.

I think that those of us who work with Alaskan courts, particularly now with some of the recent insurance cases, know that our courts are going to be a hell of a lot more sympathetic on balance to the interests of the fishermen than they are to the interests of an oil company. By contrast a federal judge may not be so sympathetic. While surely there are administrative processes that could expedite settlements, when it comes down to the nitty gritty, the oil industry lawyers are on retainers, and they're all willing to spend the extra time to drag the issue out in courts. Once it gets into the courts, I think that you can see very easily that it could go on for years, until such a point at which the court costs involved may exceed any potential claims. So, what we're concerned about here is that the state retain jurisdiction over this matter, especially in the matter in which you are most closely involved, and that is to be able to go to your judge and your lawyer down here in the nearest State Superior Court and attack the polluter.

The other issue I think that involves us is that the renewable resources impacted by oil development here in Alaska, are uniquely state resources, they belong to us, they're fishermen's fish and the people of Alaska's fish. They do not necessarily represent the proprietary interests of the remainder of the United States. So we feel that we are uniquely qualified to protect those resources. Sure, we need some general backup, help, and assistance from the federal government, particularly from administrative agencies like the Coast Guard; but we feel that since we are the ones who suffer the loss, we're the ones who should make the fundamental strong decisions on environmental protection systems.

Let me review for you several of the changes in liability limitations and liability law that the state has made, and also let me explain a little about a bill which is before the legislature that Keith Specking mentioned last night. The State of Alaska is kind of unique in the ability that it gives to certain parties to recover for oil pollution damage. I think that has been

established because Alaska as a government recognizes the value of its natural resources, particularly of its renewable natural resources. It is our objective to ensure that the people who are damaged by loss of these resources are made whole again promptly. We have a unique section in our law that establishes strict liability without regard to fault for damages to persons, or property, public or private, caused by the entry of the pollutant. Now there are certain defenses, but the defenses are starting to narrow. Particularly they're narrow when you read the caveats written into the law. First of all, when pollution results from an act of war the polluter is not liable for damages. I should mention that acts of war are a similar defense in other legislation, but one redeeming feature in the proposed amendments by the Carter Administration to H. R. 3711 is that an act of war has to be demonstrated as the sole cause of the pollution incident in order to be a defense. That means that if there's a war and you run your oil tanker aground, the two acts are not necessarily tied together.

Another defense is an intentional act or negligent act of a third party other than a party (or its employees) in privity of contract with, or employed by, the person. This leads us to the theory described earlier and that is the need for some degree of vicarious liability. If you are an oil company and you own oil, and contract with a carrier to transport that oil, potentially, you're liable if that carrier runs aground. The idea of that is to prevent ourselves from the kind of problem that is common with oil tanker owners. That is, if you can find out who they are--and sometimes that takes a long time as we found out up here with Sealift Pacific--you find that there is often times a corporation which owns one vessel. The first thing they do when that tank vessel starts to break up is to declare bankruptcy. There is then no entity against which to proceed. So in this state the law allows you to proceed against another entity, this is, the owner of the oil. As John Gissberg said, such a situation is not uncommon in the field of liability.

The other element that is a defense is negligence on the part of the United States Government or the State of Alaska. If we drive the ferry Bartlett into the side of the ARCO Fairbanks and oil leaks out, it is our fault, not the oil company's. The third defense is an act of God, an event of nature unforeseeable in kind or degree. The defenses dissolve if the spiller of the oil fails to get out there and clean it up. That is, if the Bartlett runs into the ARCO Fairbanks and the ARCO Fairbanks leaks oil and they don't clean it up, the ARCO Fairbanks operators are liable. They could then potentially subrogate the state as the person who caused that particular incident. This solves one of the problems that John Gissberg was talking about earlier with tug boats. That puts the burden back on the spiller of the oil to recover his costs from the tug boat operator who caused the spill. Potentially, the oil owner's financial capability would be such that he could stand to delay such recovery, whereas a fisherman would not be able to stand the delay.

Damages in Alaska also include loss of income, loss of the means of producing income, and the loss of economic benefit; and that's the key to the fishermen's interest. It is not only the fact that you potentially have loss of nets and can recover them, or have oil on your boat, which will then be cleaned. You can also recover the potential loss of income from not being able to fish, either as a result of damage to fishing equipment and supplies, or from damage to the fish resource itself.

Although the development of means, both legal and institutional, to recover oil spill liability, is important, the key to oil pollution control is prevention. Throughout this process, we've looked at developing an oil transportation system that represents the best available pollution control technology method that I described to you earlier. I must admit that we have been a little negligent in Alaska in developing these systems. We are in the process right now of developing a capability for inspecting and insuring that the terminals and pipelines in the state are operated in a safe manner. The reason I think it is a problem is that our experience indicates that pipeline systems in the subarctic tend to fail rather dramatically. The Haines to Fairbanks oil pipeline, over its 20-year history, had over 150 oil spills, some of which were quite large. This has emphasized the need to develop a comprehensive monitoring system on all pipelines and, as well, all oil transfer facilities. Wherever we've had an opportunity, and I am sure that the same is true for the Coast Guard and the Environmental Protection Agency, we have looked at containment systems, such as those in Japan mentioned by John Gissberg.

Let me give you an example of the kinds of problems we have had with oil terminal facilities, both in terms of their susceptibility to oil spills, and our ability to clean them up. Containment berms are not always effective, particularly in areas of high rainfall such as Southeast Alaska. If an impermeable berm is placed around an oil storage facility, the berm fills full of water and it does not really serve as a complete containment facility. Sometimes a valve is left open to allow the water (and potentially the oil) to drain out. A gravel base can be left in the bottom and the berm constructed of a concrete wall. Then, if there is an oil spill, it could begin to leak out of the gravel base, but a berm would still be there to contain the spill. A layer of water can easily be pumped into this containment. The oil will float on top of the water and remain inside to be pumped out. That's exactly what happened in a large gasoline spill at Skagway.

In 1975, a slight landslide in Skagway took a chunk out of an oil tank and squirted approximately 300,000 gallons of gasoline out of the tank. The force of that gasoline moving out of the tank was so great that it went right over the berm, hit the ground and washed out the railroad tracks nearby. It immediately leaked into a nearby small boat harbor. The force went down a little and the fuel began to be retained in the berm. When the federal and state people arrived, we found that people

were letting the oil leak from underneath the berm into little puddles down the hill from the tanks. We recommended that they bring a fire truck in and fill the bottom of the berm full of water to keep the gasoline from leaking. Well, they didn't want to do that, as that meant they would have to clean it up and pump it out, and they didn't have any explosion-proof equipment. All they were doing at that time was bailing with Clorox bottles cut in half, and pouring the gas into 55-gallon drums. It was a pretty pathetic industrial response to an oil pollution incident.

This is the sort of thing that the state is looking at so that we can improve the capability of industry and government in responding to oil pollution incidents, so that each facility has a more-or-less comprehensive system to prevent, contain, and clean up oil and petroleum spills. Fortunately, we are going to end up with a much better system with the Trans Alaska Pipeline system than in rural areas in Alaska where there isn't anything but Clorox bottles and 55-gallon drums.

Finally, I would like to review a bill we now have pending in the legislature. As many of us here know, it is extremely difficult to assess the loss of natural resources resulting from an oil spill. Maybe it is easier for a fisherman to collect for his loss, particularly if he has all his records. But if the state wishes to collect on behalf of its natural resources from the position that we represent the people at large and would like to collect a certain amount of dollars to compensate the people at large for the loss of their natural resources, the arguments get a little tougher. We have to go out and establish a price for every fish that was lost and for every other damaged resource. It would be extremely difficult, if not impossible, in the event of a major oil spill, to absolutely qualify in economic terms the cost of these natural resources. Aesthetic values or recreation values which may be lost are not often considered in true economic terms, and to some it may be an insult to attempt to quantify them. Loss of these values becomes a "What is the price of happiness" argument.

What we have suggested in the form of legislation, and have gotten a little bit of disagreement from the industry over, is that we recognize the impossibility of determining these damages. What we will do is develop a regulatory process to assess a civil penalty based on projected costs to the environment. What this legislation proposes is to assess a per barrel civil penalty on each barrel of oil spilled that was not cleaned up. The amount of penalty would range from zero to a mandated ceiling, and would be predetermined based on the toxicity, degradability, and dispersal characteristics of the oil, and the sensitivity of the receiving environment.

What this would do is require the state to conduct a study and essentially classify the various environments of the state, and establish by regulation that oil spilled in Prince William Sound,

for example, is worth so much a barrel in terms of a civil penalty. Oil spilled in another area would potentially result in a different civil penalty. It is a unique approach to the state's ability to recover for damages to these natural resources. We are getting some flack on it, as you may have read in the paper; I don't know whether it will pass or not, but it is a creative way to solve the problem of damage assessment.

Now the money collected by this system can be used for mitigation. For example, for Prince William Sound it might be used to build a fish hatchery. Or if no amount of mitigation is capable of recovery as a result of a very severe blow to the environment, a fish hatchery might be built some place else, as was done in the case of the oil spill in Massachusetts. We are trying to develop a legal system that allows the environment to recover damages, almost like the environment was standing in court with the state representing it.

Thank you for this opportunity to share some of my views with you.

COLLECTING COMPENSATION FOR OIL POLLUTION DAMAGE TO FISHERIES RESOURCES IN ALASKA

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In 1971 I submitted a paper to the Alaska Science Conference on The Need for a Governmental Compensation Fund for Damage to Marine Resources. At that time there were two main obstacles to fishermen who hoped to recover damages for the destruction brought about by massive oil spills. The first was that all fish and other wild creatures were considered to be common public property in public ownership and no individual could make a claim for any damage that was done to the fish because he had no personal proprietary interest in the resource.

The second reason was the ancient Limitation of Liability Act which was enacted by the United States Congress in 1851. This law was designed to promote the American shipping industry by providing an incentive for American boat owners to build ships and get them out on the ocean. In those days there was no effective insurance plan for the marine industry so the limitation law provided that, if a vessel collided with another vessel, the liability of the owner would be limited to the value of his vessel and the cargo on board after the accident. Now 126 years later, the exception is still effective even though land-based industries have to accept responsibility for the injury their activity inflicts on others. Naturally, the act affects even giant oil tankers in spite of the fact that oil was not even withdrawn from the ground or put onto the oceans until more than 50 years after the act was passed. The inadequacies with this statute were exposed after the Santa Barbara oil incident in 1969 and, finally, in 1972 there came amendments to the Federal Water Pollution Control Act to provide that, for purposes of cleanup, the government agencies which spent money in cleanup operations could be compensated by the tanker owners. A more significant step forward was embodied in the Trans-Alaska Pipeline Authorization Act which in Section 204(c)(1) provides that there will be a strict liability to the vessel owner and operator "without regard to fault...for all damages...sustained by any person... as a result of discharges of oil from such vessel." This section is to be implemented by a special fund and the disbursements from the fund are to be made in accordance with regulations proposed by the Department of the Interior. The draft regulations have been published and the State of Alaska has found them to be extremely inadequate. We have made comments to that effect and, to date, the fund regulation has not yet been approved.

In addition to the Trans-Alaska Pipeline Act, Congress is studying several comprehensive oil pollution funds so other fishermen and

other people could make claims for the damage they might suffer as a result of spills in other parts of the country. Since such a new statute could affect the TAPS section on liability, it should be closely monitored as it moves through Congress.

The fishermen and the concerned citizens of the State of Alaska went through a long battle to guarantee that we would be able to register effective claims for damages in the event of an oil spill. However, our success will be meaningful only to the degree we perfect our skills in making claims for compensation. I note that, in talking about how to obtain money, I don't disagree with the notion that prevention should be our primary objective, but I cannot in any way accept the thesis of a former speaker that there will be no adverse effects to Prince William Sound shellfish and other fisheries resources from an oil spill. Our failure to thoroughly prepare now for the fateful day when oil does wash our shores and contaminates our fishing grounds would be as foolish and potentially disasterous as a skipper heading to sea without lifesaving equipment.

In the case of perfecting our right to compensation for oil pollution damage, I believe lack of advance planning could be the single most important factor which might deny us the full benefits of recovery and compensation which were achieved during the last five years of intensive struggle. Yet the nature of Alaskan fishermen is not to immediately initiate a legal action when problems arise. Therefore, we now lack the experience common to other business enterprises in Alaska which are more frequently involved in litigation. As a result, we need to consider the procedures involved in actually registering a claim for damage to our fisheries interests.

Therefore, I would like to offer the hypothetical example of how a large marine insurance company might go about analyzing claims for damages if one of the vessels it insured spilled oil which adversely affected fishermen's interests. For purposes of this portrayal, I ask you to imagine a minor incident which may have occurred in Japan --a country with a long history of compensating fishermen for damages to the proprietary rights in coastal fisheries held by local fisheries cooperatives. The narrative is assembled from discussions with Japanese fishermen during a recent two year legal research consultation in Japan.

The expert marine surveyor might report back to his company (probably in London) as follows:

> "Whilst the tanker *Nihon Maru* 800 tons gross, Captain T. Sakano, recently entered into the tanker trade, and loaded with approximately 10,000 barrels of cargo fuel oil, was proceeding to Nagoya from Chiba, at approximately 23:45 hours on 3 May 1973, the vessel came into collision on the starboard stern with the M/V *Meridian*, 12,000 tons gross, which was also proceeding to Nagoya. Later at approximately 00:15 hours on 4 May 1973, the tanker *Nihon Maru* was stated to have been completely sunk. The M/V *Meridian* arrived in Nagoya at approximately 06:48 on 4 May 1973, showing fresh signs of indents and/or scratches on the bow and starboard shell platings.

As a result of the casualty, a quantity of cargo oil spilled out through the broken hull of the sunken vessel the *Nihon Maru* at the sea bottom at a depth of approximately 150 feet. Temporary stoppage of the spillage was carried out from 5 May as far as the weather permitted, by special divers from the Underwater Salvage Company, Limited, with great difficulty in strong tidal currents in such deep sea and was stated to be finally completed on 31 May about four weeks later.

During the above period, the oil was continuously spilling out and although the quantity was gradually reduced day by day, approximately 6,000 barrels which was later assessed as noted below, of heavy oil finally spilled out.

Counter measures were, therefore, dealt with under the supervision of the concerned authorities in order to avoid and minimize oil pollution, by means of chemical cleansers, oil absorbants, etc. The oil, however, spread and drifted toward various fishing districts and covered a very large area which was reported by the local Maritime Safety Board as follows:

(Several pages are then necessary to discuss the coves and harbors that were actually affected and the report continues.)

The oil also reached Shima Island, which in the surveyors opinion, taking into consideration the complex back currents against the black stream of oil which was influenced by many inlets on the coastline, the tidal currents in the spot and wind direction during the above-noted period, possibly drifted to these other districts.

In the circumstances, sea surface and shore line located along and at the patch of the drifting oil suffered heavily from the oil pollution."

Then the surveyor ends his introduction and reviews tidal conditions, the current patterns in the area and the weather conditions, taken every three hours from the moment interested parties were able to begin investigating the spill until the time the fishermen re-entered their fisheries.

The weather is given with particular reference to the wind speed, the direction of the wind and the kind of fog cover, so that the behavior of the oil could be better understood by the surveyor.

In Japan fishermen can't freely fish in adjacent areas, so mitigation of damages is not a factor considered by the surveyor. In the event of a Prince William Sound spill, where the area is enclosed and fishing often very local, mitigation may not be an alternative either.

The refloating of the *Nihon Maru* finally succeeded on June 1973. The oil remaining on board had been sealed up and was transferred

to another coastal tanker for forwarding to Chiba. The quantity calculated by the surveyor is stated to be 6,000 barrels of fuel at a specific temperature.

After reviewing the surface extent of the accident, the surveyor considers the damage that was actually done and his summary of how the actual damages were evaluated shows how much money was to be paid to the fishermen.

> "In the above circumstances, many places suffered from oil pollution during the first week of the accident and even thereafter oil drifting was observed at the shore adjacent to the vicinity and in other districts. Most of the fishing boats belonging to the local fishermen were under suspension of fishing for several days during the period of the oil pollution, cleaning, removal and preventative operations related to the drifting oil. Heavy damage was sustained due to the contamination from the oil to marine resources including fin fish, shellfish and seaweeds. The clam resources in particular were seriously affected because it was just the season for their harvest."

At this point in the report the surveyor offers photographs which were taken during regular intervals of the investigation. He testifies that in consulting with the concerned fishermen he carefully inspected and investigated the extent of the damage to their fisheries. There was considerable discussion with the fishermen and their representatives. The surveyor reviewed recent trends of the fishery, the present condition of the market, the recorded amount of gross earnings and expenditure of each affected fisherman for the most recent one month period and for the comparable period for three years previous to the accident. The loss or decrease to the marine products and catches were then estimated. He also examined damage caused by contamination of equipment, and found total damage to be $1,247,378.92.

The report's review of each fisherman's damage claim shows the method of evaluation as follows:

A. Damage to cultivated fishery recources:

1. Name of fishery resources affected.
2. Estimated quantities of the affected resources (on product or dry basis).
3. Average unit price of the products.
4. Percentage of the cost of production.

Loss: (b) x (c) x (1-d)

B. Loss due to rejection of catch or depreciation of market price of the affected fish/catches, etc. (including public fear of possible contamination):

1. Kind of fishing.
2. Name of fish/catches, etc.

3. Quantity of fish/catches rejected or depreciated based on historical catch and market records.
4. Average unit price of the sound or the depreciation of the average unit price.

Loss: (c) x (d)

C. Loss by suspension of fishing:

1. Kind of fishing (number of fishing boats, etc.)
2. Name of fish/resources.
3. Expected average gross proceeds per day.
4. Necessary expenses for fishing per day (fuel/ fish foods/ice/sale commission, etc.).
5. Period (number of days) suspended in view of scheduled openings, etc.

Loss: (c - d) x (e)

Note: Item (c) is generally assessed on the basis of the quantity of the catches/products in May, 1972 (last year) and the average unit price in the period between 27 April and 3 May 1973 (the latest week).

D. Oil damage to fishing tools/nets/boats, etc.:

1. Name/kind of fishing tools, etc.
2. Quantities of tools, etc. affected.
3. Extent of the damage (serviceable after washing/ partial loss/total loss).

Loss: Washing charge or partial loss value or total loss value.

Note: Valuations were made on the basis of the purchase prices of the tools, etc. in question, taking into consideration the period used and the normal durable years.

E. Loss of sales commissions, expert consultants, etc.

The first calculation (A) considers the quantity of the affected resource and an average price for that particular product. We have some experience in the United States in computing damages for immature fisheries resources. For example, the State of Washington, which has a law under which the state can recover damages for fish kills, publishes a handbook on evaluation of fish kills to use as a guideline in presenting claims to responsible parties. Increasing experience in Alaska in rearing salmon could provide the basis for a similar booklet in Alaska.

The second calculation by the surveyor (B) refers to the loss incurred when buyers refuse to accept fish or the market price of the affected resource slips. Particular attention is given the fact that public fear of possible contamination affects prices in not only the immediate area but also in adjacent districts where purchasers are

also frightened away from fish markets by unfavorable news accounts. The main reference in these calculations are the historical records that fishermen and the fisheries cooperatives keep on the actual market price, and distance from the site of the spill.

The payment to the individual fishermen who cannot participate in the fishery (C) is determined by looking to their average expected gross proceeds per day of fishing. This is determined in light of the scheduled openings of the fishery and how many days and hours are available for fishing. Expenses are then deducted. In Japan each fisherman who was affected was, of course, active in that fishery during the previous year. Consequently, the problem of the beginning fisherman who is preparing to enter the fishery for the first time and doesn't have a record of fishing is avoided. In such cases, American courts will generally deny all recovery as too speculative. We may be starting to overcome this problem in some of our Alaska fisheries as limited entry is implemented because fishermen post an annual fishing record in specific areas. This will permit an accurate record of past success during several fishing cycles.

Item (D) reviews oil damage to the fishermen's equipment. The surveyor's lengthy report describes the details of oil contamination to gillnets, gillnet floats, ropes, the boat itself, steel buoys, flashing light buoys, glass balls, pots and accessories, box nets, etc. Hundreds of items are listed that have been subject to the fishermen's claims. Further there are two other items of special interest. One is the time the fishermen themselves actually put into the cleanup effort.

The fishermen may not be able to fish, but they're not resigned to merely sit by and watch the oil slop around the beaches. Instead they actively participate in the cleanup. Consequently thousands of people may be scurrying around the waterfront ladling the gooey oil. They keep time sheets and charge the responsible party for their 15-20 daily hours of cleanup work. Naturally, the fishermen would pitch in and help cleanup even if the responsible party were not paying for their efforts but they will not disclaim a payment which would otherwise go to outside hired hands brought in to do the same work. Ship owners are pleased by the conscientious response of the fishermen and neither side gets a windfall benefit: the fishermen work for their extra compensation and the company doesn't get a free cleanup corps.

The fishermen have a strong distaste for a chemical response to cleanup; they feel that the best method is physical removal with the most important factor being response time. Effective contingency planning and stockpiling equipment allows thousands of concerned fishermen and citizens to begin cleanup immediately.

The second item of special interest in this report is payment for expert consultants who assisted fishermen in investigating the behavior of the oil and determining the extent of the damage that

was inflicted. They also helped in presenting the claims to the insurer.

This particular case is also unusual because the insurance company was a foreign firm. As a result, even though the spill occurred in May, compensation wasn't actually paid until November of the next year. Normally in Japan partial compensation is almost instantaneous to help the fishermen meet continuing expenses. For example, even if they can't go out and fish, they still have to pay on the boat's mortgage. Full compensation is also achieved rather rapidly. Thus, when some 200,000 barrels of oil spilled down over beaches in the Mizushima area in December 1974, fishermen were paid some money almost immediately and by the spring of 1975, according to a confidential report, approximately $47 million had been paid to fishermen. The fishermen and the companies are naturally reluctant to divulge exact figures and in the Mizushima tank 271 rupture there were apparently additional payments to the owners of coastal resorts and to fish peddlers whose sales plummeted.

I had a chance also to visit the industrial park in Mizushima about a year and a half after the accident with the Fisheries Committee of the Japan Federal Bar Association. As a result of that opportunity I'd like to mention three factors which I think promoted the immediate payment response from the offending oil company.

First was the meticulous advance preparation, both before and during the oil spill, that the fishermen themselves undertook. The national fisheries cooperative provides each local unit with standardized report forms so that all information that is collected by the fishermen can be uniformly compiled and efficiently evaluated prior to formal presentation to the company. This uniformity and itemization require substantiated claims and avoid speculation or reliance upon pure guesses that would be subject to summary dismissal.

Several forms are common; first, there are personal claims for losses occasioned by interference to the fishery. These reference the fisherman's past history in that particular fishery.

Another form recites the behavior of the oil after the spill. In fire-drill fashion, the fishermen had been preassigned to certain duty stations along the coast. Most of these sites were relatively near their homes. I think in Prince William Sound we might very well want to consider where we would dispatch our fishermen to record the behavior of oil if we had an oil spill emergency. Everybody else is going to be involved in trying to cleanup the mess and we may not be diligent in keeping the kind of information which will support claims for compensation. For example, someone might contend oil couldn't invade area X, but if we have the wind records and some photographs, our testimony would be reliable.

The second subitem in advance preparation was a coordinated cleanup effort which documented the number of hours that a person worked and the special equipment that he had to purchase, etc. This expense was charged to the company responsible for the spill. Such

advance preparation permits a well-prepared skilled and effective presentation to the polluter. If the initial presentation is effective and avoids guesses and speculations, a favorable response can generally be expected. The second factor relates to negotiating attitudes. Interestingly, in the United States the skills of the attorney are often the basis of settlement but in Japan there is an unusual mutual trust on the side of the company, the tanker operators, the oil companies, and the fishermen. Consequently the companies seem to have no reason to fear that any fisherman is going to make an inflated claim of damage and the fishermen similarly show little apprehension that the company is going to try to cheat them; consequently, both sides make an honest presentation.

In the United States, plaintiff and defendant are often orders of magnitude apart and lengthy litigation with substantial attorneys' fees frequently precedes payment to the injured party. I am optimistic that we can avoid this common scenario in oil spill liability matters. For the most part the fisherman is a person out there making a living under very difficult conditions and he's not going to come in and try to grab a windfall so that he can run away from the State of Alaska like so many others do with money they've been able to collect. I sincerely feel that this meeting offers great potential for establishing the kind of a relationship that will avoid prolonged litigation and extended negotiations which lead to hard feelings. With the right attitude by oil companies and fishermen we can effectively utilize the new right to make effective claims for damage to our fishery resources.

The last of the three factors that was important in Japan for permitting rapid compensation was the consistently favorable public support and immediate media coverage that was given to fishermen's plight. In the Mizushima spill there were two facts that led to extreme adverse publicity for the companies involved. In the first place, in spite of titanic expenses incurred to construct the massive industrial park, the 600,000 tank ruptured and a narrow ladder fell down and broke the retaining wall built around the facility. After personally observing the fragile cinder block retaining wall, I'm almost afraid to go and see what we are relying on in Valdez. No one had thought of the strength of the retaining wall--they just relied on its existence.

In the second place, the oil company initially rejected the fishermen's offer of help. Always mindful of the spill hazard, the fishermen had prepared a plan and about a hundred boats surged from dockside on the other side of a promontory to arrive at the site of the oil spill. At that time the oil was escaping the small channel where a simple boom could have earlier been floated to confine it. Therefore, the fishermen suggested they use their boats to partially block the oil's entry into the main part of the bay. According to the head of the fisheries cooperative, the company resisted because of the fact that they did not want to have to pay the fishermen for cleaning off their blackened boats after oil contamination. The company was still confident that they had the problem under control. It took long hours after the fishermen knew something was seriously

wrong for the oil company to admit that drastic action was needed. It was an unfortunately slow response, a typical failure to admit the severity of a disaster. It was also a failure which led to vigorous condemnation in the press and on television and radio. The public outrage which followed guaranteed a favorable settlement to the fishermen.

From these examples, let's reflect on Prince William Sound and consider what we should be doing now to prepare for the fateful day when we do have an oil spill. Most important is thorough documentation. It should have begun by now and to a certain extent all fishermen have already been involved in such preparations by your vast reservoirs of knowledge and experience. Now you must perfect a systematic summary of fishing records in order to be able to have the complete documentation that is necessary for a formal claim. In Japan the fishermen themselves are responsible for collection of their fish statistics and the whole array of other data, but in Alaska we have the Department of Fish and Game and their statistical records since statehood. In addition, federal agencies and university research groups maintain additional information.

To complement these data, each person should have a standard information sheet of past fishing. Truly accurate log books are sometimes neglected and we often rely on memory; however, the written record is much more impressive than the recall by memory, and it will be much more persuasive. Therefore, a special fishing log book indicating where our past fishing has been concentrated could be useful because it is always difficult to remember fishing efforts in each of the many areas in which our vessels have operated. A written record provides a confidence in our beliefs that is resistant to the most stubborn cross examination.

I also suggest each fishermen's group assign one person to accumulate photographic records; nothing speaks better than good photograph and movie records. In addition, each vessel ought to be equipped with various kinds of measuring tapes, thermometers, wind gauges, etc. to substantiate oceanographic and weather conditions at the time of the spill. If such equipment cannot become standard, it should at least be available for dispatch to the spill site without delay. We could also assign named fishermen to other specific responsibilities.

In all instances standardization promotes accurate recording and efficient computing of all information. As a starter we should have forms to cover: (1) damage to the resource, (2) economic loss occasioned by inability to fish, (3) cleanup work, (4) oil damage to vessels and equipment, (5) investigation costs.

A final suggestion recognizes the necessity of a working relationship with the press. Valdez and Seward are distant from major state and national news desks and news people stationed in our state rarely have time for travel to outlying communities.

Consequently they will probably have to depend on a description of the incident from the public relations department of the offending oil company. Nevertheless this need not be a one-way street and fishermen should begin establishing contacts with representatives of radio, television, and newspapers. Then our story will be relayed to the interested public in an unbiased fashion and delaying tactics based upon an absence of immediate, dramatic fish kills can be neutralized by an effective educational program on oil spill dangers.

A number of other significant topics remain for your consideration but time prevents further discussion today. Possibly a future meeting could encompass damages to resources not commercially utilized, mitigation of damages, liquidated damages, etc.

I have tried to focus on what fishermen can do with our newly-acquired right to be compensated when our fisheries resources are subjected to oil pollution. No one is going to do as thorough a job as we can. We fought persistently to guarantee the TAPS Act; including a provision for compensation. Now we must make sure the law remains intact and becomes the effective tool for which it was designed.

Questions from the Floor

Question: One of the items that you brought up was the fact of keeping records. The ADF&G keep those records for us. Every time we make a delivery we get a pink sheet which we sign. On that sheet it tells how many fish we delivered, where we were, what time of day it was delivered and the boat number. The Coast Guard also keeps records regarding the weather conditions that were prevailing at any given day in any particular area where you may have been. Of course, many of us do keep little logs of our own from year to year that we refer to just for our own information as to where we were when we caught some fish the previous year and whether or not we want to go back again. I don't think that the type of records that you are talking about here would be necessary for us to establish the average income for any given week or any given month or any period of a year.

Answer: That is a valid point; you might want to check into the availability of these records and how long ADF&G keeps them and where they are. Weather information is often general and we could supplement this on a more accurate area and time basis insofar as fishermen do keep records these should be maintained in a safe, secure filing system.

Question: In the example you gave from Japan, there was reimbursement made for lost fishing season that year and damage to gear. Is there any legal precedent for liability to damage when an entire bay's salmon run is destroyed. That year class could become extinct. The same type of thing that happened with the earthquake out here. Some land lifted and there are areas that haven't had fish since 1964. Is there any legal precedent for continuing reimbursement to fishermen who traditionally fished in a bay that no longer has fish?

Answer: There is no useful decision reported in the United States, but I can relate what is done in Japan. In a typical example, a coastal land fill of several square miles will permanently destroy traditional fishing grounds. There seems to be two kinds of responses provided. First, the fishermen could be provided with an alternate fishery. In such a case, the polluter would be responsible for purchasing the right to fish in a new area or trying to rehabilitate the resource. Since the financial burden of such an attempt is often open-ended, the second alternative--a lump sum payment--is more common. This is possible in Japan because the fishermen are the only claimants with a legal interest to the resources of the coastal environment. Under the TAPS Act there are other persons that have legitimate interests in pollution to coastal waters. Also, in Alaska we would have to evaluate other facts such as cycles of peak salmon harvests, the odd/even year runs, etc. I suspect historical scientific records will be critical in establishing such claims and our job will be making sure that we can mobilize them and get them organized.

ECONOMIC CONSIDERATIONS FOR OIL SPILL LIABILITY PROGRAMS

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It is generally recognized that an effective civil liability program is an important feature of vessel-source oil pollution, because a major oil spill can wreak havoc upon the localities' ecosystem and economy.

A growing realization by members of Congress of the enormity of such damage has spawned a receptive atmosphere for Congressional action in respect to oil spill liability and tanker-safety design standards.

At present, most American parties who suffer damages from oil pollution from privately owned ships are legally dependent for compensation upon court suits in civil court. For many reasons, the recovery through civil litigation for vessel-source oil pollution is inadequate or non-existent. First, an injured party often cannot identify the source of the discharged oil, so no court action can be filed. If the damaged plaintiff can get jurisdiction over an identified, polluting vessel, the plaintiff must carry the burden of proof that the defendant's vessel caused the damage. If the plaintiff's cause of action brings in negligence, he must prove that the oil was discharged negligently or intentionally, or that the oil spill resulted from an "unseaworthy" condition of the defending vessel.

A private plaintiff rarely is able to sustain successfully the burden of proof. A shore-bound claimant usually cannot prove negligent seamanship of the vessel's crew or officers, since he has no friendly witnesses from the tanker. It is indeed rare for the plaintiff to be able to prove unseaworthiness from faulty ship construction, especially since most tankers are built abroad. If the "negligence" or "unseaworthiness" claims fail, no greater success can be expected from a trespass action. Modern court law holds a trespass actionable only if the plaintiff proves an intentional or negligent intrusion on the land or if the source of damage was, by legal definition, an abnormally dangerous activity. As indicated, negligent trespass is difficult to prove against vessels, and the courts have not declared marine transportation of oil to be an ultra-hazardous enterprise. A private nuisance cause of action confronts the same difficulties discussed above and usually requires a showing that the plaintiff's injury is distinct in kind from that of the public generally.

Even if a private plaintiff does establish one of the above causes of action against a vessel which discharged oil, the owner can often escape liability by invoking one or a number of valid defenses. For example, the shipowner might attribute the oil spill to an "act of God" such as lightning or hurricane. In many jurisdictions a defendant can also avoid liability in whole, or in part, by successfully asserting other defenses, including contributory negligence, assumption of the risk and, in maritime law and in certain other jurisdictions, comparative negligence. Even if the injured plaintiff manages to gain a judgment against the owner of a polluting vessel, the federal limitation of Liability Act of 1851, as amended, usually restricts recovery to the value of the vessel and pending freight after the voyage has ended. If the oil-discharging ship has been destroyed or badly damaged during the voyage, the injured plaintiff may be left with no hope of compensation.

While the oil shipping interests often do not pay significant damages for oil pollution, the oil cargo interests are even less susceptible to court liability. Common law actions of trespass, negligence, and nuisance cannot reach the oil companies when their cargos are spilled from vessels, and oil companies are not parties to admiralty court actions for unseaworthiness. Because the legal position of the polluter is inherently strong and the resources of many private claimants are inadequate to sustain protracted court contests, private victims of pollution must negotiate their settlements from weak positions which make full recoveries unlikely.

The underlying economic dilemma of environmental protection is that it sometimes pays to pollute. For example, it costs less for a manufacturer to either accidentally or purposely dump harmful wastes into the air or the water than to take the effort to process them. It costs less to produce electricity if the power company can use the air and water to absorb waste gases and heat. It costs local officials more lost votes if they support higher taxes to build a sewage treatment plant, than it does if they allow industry to continue to pollute the water used by towns and cities downstream. It costs a houseowner less to burn his grass clippings in a backyard incinerator than to pay to have them hauled away. To the polluter, pollution may mean lower costs or higher profits; to employees and customers, it may mean higher wages or less expensive products.

Why does the economic problem exist? What dysfunctions in our economic system encourage these things? It seems that the environmental "cost" of polluting activities carries no price tag and is not considered by the private decision-makers who are responsible for these activities.

The effects are known as economic externalities. Externalities such as water pollution are imposed, large, social costs that are not private costs for the polluter, in this case the marine shipper of oil. Only a part of the full social costs are private costs which influence private decisions in the corporation. Without economic and legal sanctions, the decision-maker has

no natural incentive to spend money to reduce harmful externalities. The fertilizer processor who dumps his chemical wastes upstream from an adjacent fish hatchery rather than spend money for pollution control becomes wealthy and clean while his fishery neighbor becomes impoverished and unhealthy.

If the legal system allows the damages caused by a decision-maker's externalities to fall upon one person or upon identifiable groups of people or organizations, and the source of the effects is known, existing legal remedies are applicable. An individual can sue in the court of law or equity, collect for past damages, and either collect liquidated damages at a present value for all future damages, or seek a court order requiring a fertilizer processor to cease and desist from his dumping of chemical waste. If the damages that are involved are less than the cost of pollution control, the processor probably will choose to pay liquidated damages and will continue to dump his chemical waste. The economic effect of this arrangement is the same as it would have been if the adverse side-effects had fallen upon the decision-maker in the first place. The payment of damages causes just the right quantity of resources to be devoted to pollution control, even though the effects of the pollution are external to the decision-maker.

There are negative economic side-effects arising from pollution control which sometime are mentioned but not always spelled out in the literature. For example, pollution control standards of regional or national scope may prevent low-income or under-industrialized areas, that are well-equipped with water resources, from using these resources to attract new industries. Forbidding residents of low-income areas from trading a reduction in the quality of their environment for industrial employment may remove the only basis by which they can compete with more developed areas. But to permit low-in-come areas to so compete for industry is to reduce the incentive for industrialized areas to enforce pollution control standards. This risks the loss of existing or potential new industries to regions of the country which are concerned with a lesser control of pollution.

Incentivies for adoption of pollution control standards may provide either a positive or negative impetus for the development of more effective waste-treatment technology. For example, a strong federal subsidy or tax concession program to encourage construction of sewage treatment facilities produces heavy short-term investment in facilities utilizing existing technology. Where such incentives are available for only a short period of time, or where there is fear that they will be withdrawn in the future when the problem becomes less current, investment in research to improve methods of waste treatment will be discouraged. Conversely, where it is likely that subsidies for waste treatment facilities will be available in the future, research on an improved technology will be stimulated but municipalities and industrial firms will postpone any construction of facilities that they would have otherwise carried out at their own expense.

It must be apparent that the costs to society of environmental protection is the sum of expenses incurred to prevent environmental damage plus the expenses incurred through not preventing environmental damage. The expense of preventing environmental damage is easily measured; it is the total expense incurred by public and private parties to prevent damage caused by polluting products. The expense incurred from environmental damage not prevented is much more difficult to identify and to measure. The expense of pollution is the money value of the damages caused by polluting products after they are released into the environment. This component of the equation is equivalent to the welfare cost of pollution, the dollar value of the reduction of public welfare from pollution damage that is not prevented. This includes the cost of foregone or lower earnings due as a consequence of polluting incidents. The motel operator who must cancel reservations to tourists arriving by boats which are prohibited from entering specific ports as a consequence of a polluting incident, loses revenue as does the charter operator who is prohibited from exercising his privilege to take clients out on fishing trips because of a prohibition on marine traffic resulting from a polluting incident.

It sometimes is argued that a direct tax on pollutants can serve as a lever for bargaining for pollution rights. A direct tax does allow firms to maintain some degree of flexibility in finding the most efficient way to minimize their pollution and hence minimize their tax loads. However, cost-incorporating taxes are subject to a number of criticisms. It generally is desirable to minimize the degree to which taxation is used to control behavior rather than raise revenue. It also is argued that the tax on one person, based on the cost or damage to another, will always produce an unstable equilibrium. It is not clear how one would design a tax system which, if based on pollutants emitted, would not be subject to locational bias and arbitrariness. Finally, once an estimate of the total cost of pollution is made, the cost must be apportioned among polluters. However, the actual contribution of any one firm will depend on interactions among the pollutants, on direction of prevailing winds, on the current velocities, the biotic activity of the biome affected, etc. Any equitable tax would thus have to encompass so many variables as to be unworkable or would itself produce locational difficulties through its application.

If everyone had the same income, it would be equitable to tax individuals who use goods that lead to pollution of the environment either to pay the cost of restoring environmental quality or to compensate others for the damages caused them. But in a world where incomes are not equally distributed, such a tax leads to material goods (which comprise a relatively larger part of the budget of the poor) becoming more expensive relative to services (which comprise a larger part in the budgets of the rich). This means the taxation of staple goods used by the poor to pay for protection of the recreational amenities of the rich.

The need to internalize costs does not necessarily require that producers bear the total burden. Since the public benefits from clean air in a productive industrial sector, it is sometimes argued that the public should pay some part of the costs of controlling the pollution. A simple form of economic incentive to abate pollution would take the form of subsidy payments to stimulate reduction of the emissions over the long run. Subsidies might be geared to a percentage reduction from total potential emissions, to an absolute reduction, or to the attainment of an emissions standard set by a government regulation. A subsidy system can be thought of as equivalent to a tax and can be utilized with external benefits in the same way a direct tax is utilized with external costs. A second economic alternative is one which provides tax credits for capital investment in pollution abatement facilities and allowed depreciation for such equipment. A third alternative often used in conjunction with subsidy or tax credit arrangements is the imposition of an affluent fee system under which the polluter is made to bear the costs of his disposal directly. A schedule of emission fees based on the amount of damage done to the environment is applied to a discharge into the atmosphere or the water. Charges can also be imposed as a purely punitive measure without any relation to the damages actually done, or to the cost of treatment.

As we have already noted, much of our environmental degradation arises because a price system is not applied to many of our natural resources. Fresh air and clean water are resources that are converted in a productive process in the same way that coal and steel are converted. But while a price related to the cost of production is charged for fuel and raw materials, our air and water resources can, in most cases, be used without payment for the privilege. The problem exists because people use costly materials to a high degree of efficiency and apply very little care to the use of resources which are free. The economists respond to this problem by claiming that there is no excuse for supplying scarce resources free, that these resources should be available only at an appropriate price. Specifically, an economist calls for an extension of a tax or fee system, one that does not necessarily increase the overall burden of taxes, but rather gives industry the opportunity to minimize its tax loads by behaving in a way consistent with social goals. An affluent fee system attempts to minimize the costs of pollution damage and pollution abatement by requiring a polluter to pay a periodic fee based on the amount of his affluence. One approach is to set a fee to produce that amount of affluent yielding a minimum total cost of pollution plus cost of pollution control.

Alternatively, fees could be based on the cost of treating the discharged waste and returning it to its natural state. This is practical with liquid waste, but impractical with air pollutants, because of the difficulty of treating gaseous waste. The affluent fees might also be imposed on a purely punitive level

without relation to the cost of pollution or the cost of pollution control. However, this would induce individual polluters to undertake abatement in excess of the minimal total cost for pollution abatement.

Most commonly, however, affluent fees are based on some rough estimate of the average damage done to the environment and its members by a specific pollutant. For example, California state officials might conduct an investigation with respect to the Sacramento river basin and conclude that 20,000 pounds of phosphates per month were being discharged into the river system by processing plants causing damages estimated at $50,000 per month to water supplies, navigation, individual firms, and public recreation along the 90 miles of waterway before the water flowed into the Pacific Ocean. The state government would then levy an excise tax of $2.50 per pound of discharge of phosphates into the river. Some polluting firms, aware of the technology currently available, would purchase abatement equipment to reduce their tax burden to near zero. Other firms would find such equipment unavailable and would respond by maintaining their existing production techniques but carrying a heavy emission fee burden. Some firms would choose to undertake some abatement and to pay some fees. In total, society would approach what was described as an optimal level of pollution; that level at which, to produce a dollar's worth of satisfaction in a less polluted environment, it would be necessary to spend resources that were currently yielding more than a dollar's worth of social satisfaction in the current economy.

It should be noted that while the affluent fee system makes it unnecessary for an outside body to dictate to a polluter what abatement technology, if any, he should use, it does not remove the necessity of estimating the cost of harm caused by specific affluence. Theoretically, the affluent fee should be set equal to the cost of the marginal amount of harm done by the final unit of pollutant introduced into the environment.

REVIEW OF FEDERAL LEGISLATION

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You have heard today about the Limitation of Liability Act which was established in 1851 and which limits the shipowner's liability for damages to the value of the ship's cargo at the end of the voyage. Following the Torrey Canyon spill, the shipowner and operator invoked this law in the American courts to limit the liability of the shipowners to $50, the value of the one remaining lifeboat at the end of the voyage. One of the principal problems with the law is that the more serious the accident, the less liability for the shipowner and operator. That is still the key law on the books, as we said earlier, concerning damages for spills.

The Water Quality Improvement Act was passed by Congress in 1970. Enactment followed three years of debate in the Congress. It holds vessel owners and operators liable for government clean-up costs up to the lesser of $100 a ton or $14 million. Spillers may escape liability for spills due to acts of war, God, governmental negligence or a third party, regardless of whether or not the third party was negligent.

A $35 million revolving fund was set up. It was originally appropriated at $20 million. It is administered by the Coast Guard, and I was told this morning by the Coast Guard that last fall the level of that fund was down to about $600,000.

The OCS Act which was originally passed in 1953 had no specific provisions for liability but, after the Santa Barbara blowout in 1969, Secretary Hickel issued regulations pursuant to the Act, placing no-fault unlimited liability upon lessees for clean-up and damage costs. He got quite a bit of criticism from the industry about that, so he deleted the damage claims liability from the regulations. There are currently OCS amendments pending in Congress. They passed both Houses last year and then the conference report got tied up, but it is now expected that a bill will pass. These amendments set strong liability limits that are similar to those in the comprehensive liability bill that is pending, and whether or not they pass as part of the OCS amendments will depend on the outlook for passage of the comprehensive bill.

I am sure you are all familiar with the TAPS Act. It imposes liability upon shipowners and operators carrying Alaskan oil for clean-up and damage costs up to $14 million. You can see that the $14 million limit runs through just about everything that has

been passed over the last six or seven years or so, and nobody really knows where the $14 million came from. Under the TAPS Act claims exceeding that amount are covered by a $100 million fund which is created by a five cent per barrel fee on Alaskan oil transported by vessel. The Interior Department is in the process of redrafting the regulations that were proposed in the Federal Register.

The Deepwater Ports Act passed in 1974 imposed strict liability upon shipowners and operators carrying oil to or from deep water ports, with a limit of $150 a ton or $20 million. It is a stronger provision in that it is the first law where compensation for damages could exceed the value of the fund. The fund is established at $100 million, but if damages are more than $100 million, the fund can borrow and pay out whatever the total damages are. There are also a number of states which have unlimited liability laws.

There are also international agreements. TOVALOP (Tank Owners Voluntary Agreement concerning Liability for Oil Pollution) came about primarily as a result of three major tanker casualties in 1967 and 1968. IMCO, the Intergovernmental Maritime Consultative Organization, began developing an international convention regarding shipowner liability. Sensing that some change was coming about, the oil industry created a voluntary liability program and called it TOVALOP.

There are a number of other agreements such as the Civil Liabilities Convention, CRISTAL, and the International Fund Convention. Members agree either to clean up their spills or to reimburse national governments for clean-up costs, up to the lesser of $100/ton of the ship or $10 million, in the event of negligence. These are either set up internationally through IMCO or voluntarily by the oil companies. It is interesting to note that the international funds parallel very closely the funds that were set up by these companies.

Insurance schemes are also common. These companies have groups called P&I Clubs (protection and indemnity associations). P&I Clubs consist of the traditional marine liability insurers based in London. They cover some 85 percent of the world's ocean-going tankers. Although P&I Clubs do not impose a limit on other marine liabilities, they do limit oil pollution coverage. Premium rates are based on a fleet's total tonnage and its overall loss experience.

ITIA is the International Tanker Indemnity Association. Several major companies established ITIA in order to provide insurance coverage for TOVALOP members. ITIA, which currently insures something like ten percent of the TOVALOP membership, offers policies covering both legal liability and TOVALOP liability.

The Water Quality Insurance Syndicate was set up after the Water Quality Improvement Act was passed. It was formed by 27 American Marine Insurance Companies in order to spread the

risk created by the Water Quality Improvement Act. It primarily serves small American tankers involved in the coastal trade, not the ocean-going trade.

I could go on. I have mentioned only tankers. There is a whole other set of mechanisms and groups for offshore and onshore facilities, etc. This analysis should give you some idea why we talk about a "patchwork quilt" regarding liability.

I would like to discuss the reasons for a comprehensive law and for oil spill liability laws in general. Before I do that I would like to respond to something that was said earlier about the inability, or the inadvisability, of the United States to take unilateral action on some of these issues because other nations may retaliate in some way. The oil industry is an important international industry, but it is only one of many. We regulate the airlines unilaterally. The coast guard unilaterally regulates, with very strong standards, LNG tankers coming into this country. So far we have seen no retaliation, and there is no reason to expect other nations to be against either design standards or a strong liability law. There are three main reasons, as I see it, for oil spill liability laws: (1) an incentive to prevent spills, (2) to encourage rapid and thorough cleanup, and (3) to immediately compensate people who are damaged by a spill.

In regard to the prevention incentive, the companies already have a pretty strong incentive to prevent spills. The incentive increases rapidly as the price of oil rises. The loss of a tanker of oil, especially the size tankers we're talking about in the Alaskan trade, is a tremendous loss that should not be underestimated. If to that you add multi-million dollar liabilities for cleaning up the damage caused by a spill, then investing in crew training and better equipment and the best possible procedures suddenly looks very economical. The role of liability as an incentive to prevent accidents is something that has been underestimated, maybe even overlooked. In addition, high liability limits discourage companies from undertaking ventures in areas that are very, very risky, were they may believe an accident is inevitable and it may cost them $100 million or $200 million.

The second reason I mentioned was rapid cleanup. When spills do occur the liability law can motivate the spiller to clean up as quickly and thoroughly as possible in order, (1) to prevent the government from moving in and cleaning up at greater cost (and everybody knows that anything the government does costs more than anything anybody else does); and (2) to minimize damages and, therefore, the cost of the spill.

The third reason for oil spill liability laws is that they enable damage victims to be compensated quickly, without the threat of endless time spent in courts. They also expand the base for compensation to some of the areas mentioned earlier - like loss of income - which aren't covered under existing common law.

There is a general consensus (it's been a long time coming) among government and environmentalists and the industry about the need for a comprehensive bill. The agreement on how to get from here to there hasn't been quite so easy to come by. I might add, incidentally, that in the negotiations that went on during the last few weeks, before the President sent his message to Congress about the oil spill liability and tanker standards, the situation in Alaska was very much a part of that discussion, and the pending legislation here in Alaska was carefully considered.

Despite the general consensus, there are arguments against both high or unlimited liability limits, especially on the basis that it is uninsurable. We hear, for example that it will drive the independent companies out of business. I don't think that is true. We've had experience with this in the past. The P&I Clubs issue, as I mentioned earlier, unlimited liability policies for all non-pollution liabilities like crew claims and cargo damage. They should be able, if not eager, to include pollution liability within their overall unlimited liability insurance program. In the past, insurance coverage has expanded to meet new legal requirements. After the Santa Barbara spill in 1969 commercial insurers excluded pollution coverage from their policies for offshore facilities. In response the oil industry created its own insurance company called Oil Insurance Limited, OIL. Then suddenly, seeing the potential loss of a substantial income, the commercial insurers decided that they could cover pollution liability after all. The same thing has happened time and again in the airline industry. In 1970, when jumbo jets were about to come into use, the commercial insurers said they couldn't cover the legal liability of $75,000 per passenger for the 747's. Industry began to set up its own insurance company and the commercial market expanded to meet the industry's needs even before the airlines' mutual got off the ground. Unlimited liability requirements have been in effect for several years without any adverse effect on small business.

On the federal level, OCS regulations imposing unlimited cleanup liability have been in force since 1969 under an OCS order. The participation of independents in OCS activity, although not huge, has nevertheless increased rather than decreased since then. In addition, four states have been successfully administering unlimited liability oil spill laws. They are Maine, Massachusetts, Washington and Oregon. They haven't noticed any adverse impacts upon the oil industry, whether the companies are majors or independents.

The last thing I would like to mention is the role of the states. That is clearly a concern, as well it should be. There are some areas where states may be more effective than the federal government. State officials in many instances will no doubt be more qualified to evaluate local damages, especially in environmentally unique areas. In some cases, they may be able to act more quickly than federal agencies in responding to spills. Pre-emption is clearly a big issue. It was stated earlier that it is "obvious" that pre-emption is necessary. Well some people think it is

obvious that it's necessary and some people think it's obvious that it's undesirable. When we started the debate on oil spill liability a couple of years ago, there were two extremes. There were those who wanted total pre-emption of all state authority, including the ability to set liability limits, to establish funds, and so on. On the other hand there were people who opposed any pre-emption at all.

The legislation that is now pending in Congress (and President Carter's bill) is a compromise. It allows some pre-emption and it disallows some pre-emption. It requires states to accept federal certificates of responsibility. The rationale for that is that it minimizes the compliance cost to industry. It also prevents the states from levying fees on a per barrel tax basis for the purpose of creating state funds. This lowers the cost to the consumer. It was mentioned earlier that each state fund is only $100 million, but if you have 30 coastal states with $100 million in each state, it ties up a lot of money and, if it duplicates what may be paid out for damages in other instances, it may not be necessary. However, the bill does permit states to impose their own liability limits on the companies, at whatever level they think is necessary or desirable. It does allow the states to set up funds through appropriations, rather than a per barrel fee, in order to undertake cleanup operations and to compensate any damage victims who would not be compensated under the federal law.

This legislation is a compromise, but it satifies a lot of the objections on both sides. The role of the states, not only in the whole liability scheme but with regard to tanker standards and almost every other energy issue, whether it involved transportation, production, or whatever, has been and will continue to be a source of controversy. However, we now have an Administration and Secretary of Interior who are committed to working as closely as possible with states and local governments, and that is a commitment that is going to be kept.

KEYNOTE AND SYNTHESIS

Representative Keith Specking
Alaska State Legislature
House District 5

Mr. Chairman and distinguished guests of the Cordova Fisheries Institute: I'm extremely pleased and honored to be able to participate in this Institute. I am honored because of the star-studded roster of speakers and participants who are here for this weekend.

A few days ago I saw a bumper sticker that stated, "Remember when water was clean and sex was dirty?" Most of us never really believed the latter part of that statement but we know that the part about the water was true. However, we have now come to realize that there are many forces at work that have dramatically changed that condition, especially in Prince William Sound. I suspect that most of us are here only because of our intense desire to retain the highest quality of water possible in Prince William Sound as well as in the rest of Alaska's coastal waters. This decade has wrought enormous changes in Alaska and its coastal waters. These changes have created hitherto unforeseen potential for altering the marine environment from its present relatively pure state to one that could be inhospitable for marine life.

I would like to fantasize a bit and consider the following situation which might become a reality here in Prince William Sound.

An extremely harsh winter in the middle west and eastern part of the United States results in President Carter determining that additional crude oil is sorely needed on the east coast. He convinces the United States Congress that an exemption should be given from the Jones Act so that foreign flag VLCCs may proceed to Prince William Sound and to the Valdez pipeline terminus to load with crude and then head back to the east coast.

Coupled with the cold winter outside, Alaska has an unusually warm winter. The water temperatures both in many of the fresh water and estuarine areas are a degree or two above normal and the time of the year is early April.

The VLCC, the Medula, in command of Captain S. Q. Head, has completed loading its tanks with Prudhoe Bay crude and prepares to head south through Valdez Narrows on her long trip around the

horn to the east coast. There is a full southeast gale blowing when the Medula leaves her anchorage and heads through the Valdez Narrows and into Valdez arm. Because of the high velocity southeast winds that are striking the Medula on her port side, Captain Head makes a mental correction for the dog-leg in the traffic lane off Bligh Island. Somewhere in the directions given to the Quartermaster a misunderstanding occurs and the Medula runs hard aground on Bligh Reef.

With a grinding lurch the huge tanker shudders and seems to slowly come to a halt. But the weight of almost 210,000 tons of Prudhoe Bay crude is simply not to be stopped until most of the port side tanks on the huge tanker rupture.

Perhaps at this point, the best thing that could occur would be a fire that could burn off the oily mass that is belching to the surface. However, the extreme weather and southeast winds quickly start the mass of oil up Valdez arm towards Tatitlek Narrows, Galena Bay, Jack Bay and Port Valdez itself.

Regretably, because of the failure of the vessel traffic system in Prince William Sound to maintain overall Prince William Sound monitoring, and the lack of the requirement for Loran C retransmission, the vessel traffic control in Valdez is not immediately aware of the disaster that has occurred.

Additionally, the need to bring a helicopter from Kodiak means that even if the weather was not so vicious, it will be some time before any aerial surveillance of the wreck can be made.

As the tide continues to fall, the great ship which has come to rest on a sloping bottom begins to list. An additional problem has been created for the Master because of the failure of his radar to immediately pick up the marker on Bligh Reef.

I would like to note here that a problem such as this probably would not have occurred if a more fail-safe system in Prince William Sound is adopted.

This is not a very pretty picture to paint, but I believe it is realistic because it has happened in other parts of the world.

Additionally, I believe situations such as the national emergency created by undue cold weather could result in tankers other than those that are normally in the TAPS trade running into the Valdez terminal for loads of crude to be taken either to the East Coast of the United States or possibly to other parts of the world.

In any event, it is through the contemplation of such possibilities that I believe we must view the various remedies that are available to us, not only from the standpoint of affixing liability and

collecting damages, but also from that of rehabilitating the fishery and preventing future catastropies of this nature. I should point out that it would be a luxury from a legislative standpoint if we needed only to consider the potential for disaster and the remedies that might be taken, both preventative and rehabilitative, in Prince William Sound only.

Our concern must embrace the entire coast of Alaska. The assumption of additional responsibilities for management of fisheries resources within the 200-mile limit increased the burden of stewardship that is placed on Alaskan shoulders by some 350,000 square miles. Perhaps it would only be proper that we view the concerns and activities that we are addressing here in the context of Prince William Sound and use it as the test case for the coastal waters of the entire State of Alaska.

Here in Prince William Sound we have been witnessing the whole panoply of interrelated action concerning coastal resources. During the arduous period in which we agonized over the threats posed by the construction of the Alaska oil pipeline, it was difficult to identify the great variety of related activities that might have required attention.

The present near-completion of that pipeline and the development of a vessel guidance system focuses upon our positive movement into rehabilitative effort. Issues such as the limited entry concept, the coastal zone management problems, and marine environmental research are all issues that have received a substantial amount of public participation right here. Truly Prince William Sound and Cordova have been the focal point for discussion of these issues. Just reading the agenda for this Cordova Fisheries Institute makes us realize how complicated and interrelated these various issues are. As a legislator, I feel that I have the most exciting district in Alaska to represent. For the past year, I've been rather deeply involved in matters that concern the Law of the Sea and Japanese and Korean Fisheries treaty negotiations. I was also an advisor to the International North Pacific Fisheries Commission, advisor to the North Pacific Fisheries Management Council, and at times representative of the governor in international negotiations.

Current legislative involvement includes development of nonprofit regional hatchery corporation legislation and funding for those projects, development of the Prince William Sound vessel traffic guidance system, oil spill liability legislation, funding of the real time simulation of tanker operations study, and development of Alaskan fisheries policy. I should add that as a legislator, I have chosen to focus a substantial amount of my attention on these issues because of my keen interest in them. I hasten to add that my role is purely political. You are the experts. I must take the data and decisions that you provide and attempt to convince my colleagues of the desirability of the particular project at hand based on the input that comes from you.

I would like to comment that during the development of the North Pacific Fishery Management Council it has been very apparent that the State of Alaska and the National Marine Fishery Service have a highly developed regulatory management and research system in place and that this enabled the North Pacific Fisheries Management Council to very effectively and quickly assume its role in management of the huge new area created by the extended jurisdiction act. The impact of oil development upon these huge areas will be significant. The size and increase in numbers of VLCCs can influence the cleanliness of even such a huge body of water as is now within our stewardship.

The oil industry has provided a very limited amount of effort in addressing the environmental problems and hazards related to the rapid development of that oil resource in Alaska. In my view, they have addressed this issue only superficially. All of us remember the trailer that was parked at Valdez for a rather brief period doing "base line" studies. In my view many of these studies have been done only to support a view that oil, water and fish were indeed very compatible. Recently, during a committee hearing on an oil spill liability bill, I criticized an oil lobbyist who referred to the need for liability legislation as "frivolous." I should hasten to add that when we are discussing tax matters with oil industry representatives they hasten to indicate that Alaska and the oil industry should really be viewed as partners in the development of this resource. I only wish that they would be more interested in becoming partners in the financing of some positive marine research and rehabilitation efforts. Then, perhaps, I could believe them when they express interest in our fisheries resource.

It is comforting to note that Alaskans have been very supportive and protective of the Alaskan fishery. They have demonstrated this by their support of the elimination of fish traps at the time of statehood. They have also supported the fishery with their support of limited entry and through their adoption of the recent $29,000,000 bond issue for fisheries rehabilitation.

In summing up, I would like to state that one of the challenges that we face is the protection and management of our fisheries resources in such a manner that we can continue to earn the support of all segments of the population who use this resource. This broad base support is needed not only if we are going to be able to continue with rehabilitation programs but, additionally, if we are going to attain our goal of keeping Alaskan waters clean so that our fisheries may thrive.

Dick Janson, President
Alaska Native Federation

Yesterday, I sat through a discussion period, and it was kind of boring to me because I couldn't understand the terminology. A lot of the talk concerned experiments, such as feeding oil to fish and finding out what happens to them. Well, we accidentally had that kind of an experiment on our boat. My brother used one of our pots to clean the base of our engine and he dumped the oil out, cleaned the pot real well, and our cook boiled some fish in it. Believe me, the fish weren't palatable. I don't think fish would be palatable no matter where they get the oil from. However, don't take it out of the crankcase if you want to make fish palatable.

The two themes of the conference are tanker traffic and OCS. I'd like to make a few comments on tanker traffic. If you've fished around this area, you know that we have a lot of beaches that are sandy. We also have a lot of sand islands. These islands generally border the surf. In other words, the sea from the Gulf comes in on top of these beaches. One of the concerns I have is that if there is a storm, and you have a real catastrophe, oil is going to be pounded into the sand before you can get out and clean it up. I think if you listened to the people talk about oil spill cleanup and related subjects, you have noted that no one has addressed the question of what do you do when the wind is blowing over 40 knot and boats are icing down. What do you do out there if you happen to lose a boat at that time? We hear a great deal about prevention--I don't think you have to talk to Cordova fishermen about prevention when it comes to oil--but we talk about it anyway. One of the thoughts that the Native organizations have in relation to prevention of oil spill is a salvage tug. When you look at the size of those tankers which are going to go from Valdez to the West Coast and you look around the country, try to figure out where you're going to get a salvage tug big enough to stop one of those babies if they stop out in the middle of the Gulf with the wind blowing. The small harbor tugs can't handle a tanker in a rough sea.

They have large tugs on the East Coast but they don't have them on the West Coast. Even if the West Coast did have them, what good would it do in San Francisco if the break down was off Egg Island, or as you go past the Southeastern islands such as Vancouver Island, Admiralty Island, or any of the islands down there?

Look at the design of the tankers (single screw). I've always had the opinion that as long as you're on a boat there's a safety factor in having two engines. You always have hope that one will run. Sometimes both of them will go out, but generally speaking you can keep one going. I even feel the same way when I'm in the air. The more engines they have running, the better I feel. I don't care for single-engine airplanes.

Then we'd have to get into the comment on the cleanup. You should be prepared to clean up immediately. This is one of the best ways of preventing damage. It's going to take a large amount of equipment stationed all over the place to be able to clean up properly any place the spill may occur. If you have a spill at Hinchinbrook Entrance, you should have equipment right on shore ready to go out and do the job. It's going to take a lot of containers to carry back the debris. A lot of absorbants are going to be needed and it will take a lot of booms to contain a big oil spill. All of that equipment has to be available and should be available on shore.

We saw Crowley's idea of a great big ship that carries everything and is ready to go at a moment's notice. I think that ship would cost somewhere in the neighborhood of $5 million to $10 million. Are you going to get the oil companies to pay the daily rate which would have to be charged to put that money into such a ship? Even if we had one, where would you station it so that it would be within two hours of any kind of catastrophe? Those are the things that the Native corporations have been talking about. We talk about them because if there's an opportunity we want a part of the action, you know, the money-making part. Our people are marine-oriented and we can put together a package about as well as anyone. However, these are the problems to which answers must be found before you sell yourself or you're going to wind up in trouble. If you say that you can clean up an oil spill in winds of over 50 to 60 knots an hour, I think you're going to be proven wrong. We should all be working on the problem until we come up with more technology.

Now to swing over to the OCS. Our corporation put on a seminar a couple of weeks ago primarily directed at the village corporations, village people, and the Native villages in the area. We had people from all walks of life at the seminar giving information. The reason we put on the seminar was to give information that's available to the village people for planning purposes. Some of the people in the villages are against any OCS development, some are for it, and some want to make money with it. No matter what you want to do, you need a plan. You have to have information in order to plan. This was the second of two seminars we've had for OCS development. To give you an idea of what happens in these areas, and it may even help a little in Cordova, I'll give you a thumbnail description of what has happened and what is now happening among the Native groups.

The first village to feel the impact of OCS was Yakutat. The Yak-Tat-Kwan played a very large role in what happened in Yakutat. The oil people came and bought equipment, an old cannery, and so forth right in downtown Yakutat. The impact was going to be right smack in the middle of the Native village and they didn't want it. They didn't want the impact in their villages, so they started raising a fuss about it. The ultimate end of it was that the village got land from the state further out on the other side of the bay and are developing an industrial park. The oil companies are leasing that ground from them. The Natives have removed the oil companies from within their own villages. The impact on Yakutat has lessened quite a bit from what it would have been if the villagers had not raised a fuss about it.

Then we have another village named English Bay (you've probably read about it in the news). They state that they don't want any development whatsoever and that they would cancel any oil lease offshore. Their attitude is that they don't mind if OCS development goes on, but they don't want to be involved in it. They want to keep their villages the same as they are today. They feel that if they are able to do so that in ten or twenty years from now they will still have their old fashioned village and everyone will be pleased to visit an old-fashioned village. I think they have a point.

Just four miles up the bay from English Bay, we have another village called Port Graham. They are interested in making money off OCS. They don't want people moving into their village, but they have other lands they're willing to lease to oil companies or anybody that wants to develop offshore. They have boats that they're willing to lease and they have men that are willing to work. They are not opposing OCS and they're willing to help out. English Bay, their sister village, is opposed to OCS and opposes any involvement of their village in any type of development.

Now we move down to Koniag. The Koniag region and all the villages of Koniag have formed one company, or corporation. Incidently, during the selection of land the tracking station they call Chiniak was turned over to the Koniag Corporation. It has a lot of facilities and is in a pretty strategic location at one end of Kodiak. The Koniag people are offering to lease this ground to the oil companies for development of a harbor. These companies will have the facilities, the theatre, the staging areas, and everything you want right in one location. It's far enough away from the city of Kodiak and the villages of Koniag that it would not make a great impact on the people on shore.

This is the kind of thinking that's going on among the Natives today with regard to OCS. I feel that they are using the information they have gathered through our seminars and using it wisely. Anyone with any information they would like to give is welcome to come to our next seminar. We're after information. Alaska Native Federation is a non-profit foundation that is strictly in the business of dis-seminating information, and education. Once in a while we meddle around with charity too, but not often. We're not very charitable. Thank you.

OIL IMPACT AND RENEWABLE AQUATIC RESOURCES

Dr. Charles Konigsberg
Concerned Citizen
Anchorage, Alaska

I am here at this conference primarily because I came to Cordova six or seven years ago to participate in one of the initial hearings regarding the TAPS - oil pipeline controversy. Otherwise I don't think I'd have come this time. By that I mean there's some question as to the ultimate meaning and value of such conferences, a subject I'd like to explore in a bit more detail in a moment. I'm here because I'm encouraged by the fact that the Cordova fishermen are involved once again; and we had one hell of a "good time" several years ago when the fishermen were so strongly in opposition, legally and politically, to what they felt would be a threatening intrusion on a way of life that was (and is) so important to them. It's really very encouraging that the fishermen are involved again! I hope that this is only the beginning of another phase, a new phase, and that the fishermen of this community, in cooperation with concerned people of other coastal communities, will undertake other initiatives to insure that our destiny is not, contrary to Pat Dobey's observations today, at the mercy of one major multinational industry.

I believe we all can agree that one value of such conferences is that at least some relevant issues are exposed, whether the particulars of whatever is presented have lasting impact or not. And yet, as I sat through these three days of meetings, with the exception of the past hour, I have had a profoundly uneasy feeling about it all... and I have been wondering why. After all, I've been listening to what we usually call "expert testimony": presentations on research projects -- data, facts, and findings; reports on technological developments, legal approaches and legislative measures, insurance/liability matters; etc. We received much information of a learned and informative nature, presented by practiced and sincere people and all of it seemed to convey an idea or sense of something "positive", something "creative", didn't it? I'm sure that I wasn't the only one feeling uneasy. But why the uneasiness? These past three days have had that air of "authenticity" to them, haven't they?

I think that, Frank Tupper's talk excepted, the reason I felt so uneasy is that somehow it didn't all add up, didn't all hang together and I think it should. It all has to come together to provide the kind of meaning that is both sensible and revealing to the ordinary human being. In short, the range and character of the interacting relationships must be exposed and explored. (Consider, for example, what the difference in this institute would be if it were being conducted in the perspective of established Coastal Zone policy and planning.)

One of the reasons that conferences such as these fail to provide that kind of adding up and meaning is, I think, because we allow ourselves to be entrapped by what has been called the "devil of suboptimization." Each particular group and each particular person doing his thing, separately. Although he is doing his best at it, he does so in a way that is unrelated to what others are doing and unrelated to the larger whole of which, I'm sure we'd all agree, we are all parts. Kenneth Boulding argued that it is this devil of sub-optimization that is the true devil of our civilizations.[1]

Allied with that devil, if not basic to it, is the false notion of "objectivity", which some of us challenged, you'll remember, following the panel discussion the first night here. There is no such thing as "being objective." Everything one thinks, says and does is influenced by the mind of that individual and that alone makes it a very subjective process. Now, the problem is that we can talk ourselves into a psychology of "objectivity" -- that each one is simply a scientist, a Coast Guardsman, a fisherman, an industry employee, a bureaucrat, or whatever. But this obscures the problem. It also further obscures and makes more dangerous the results of one's work because it leads one to think and perhaps truly believe that he or she can deal with a given subject or project as though it is somehow distinct and separate from all those other projects on which other people are working.

I repeat that there is no such thing as "objectivity." There may be varing levels and degrees of subjectivity but no "objectivity." And things do all hang together; they all interact, they are all interrelated. And I think that these conferences must deal with that reality in a way which most of them fail to do.

What links the subject areas of this institute all together -- Frank Tupper made the point, eloquently -- is that they affect, and thus they are, elements or components of our culture or way of life. These past few days of presentations and discussion have reflected, even considering the various ways they have been presented, matters which together represent a vast and threatening intrusion of one way of life on another. The presentations were not on a series of distinct subject areas and projects, delivered by persons in their supposedly separate, professional capacities. They are elements in the cultural intrusion of one way of life on another, in this case on the fishing community of Cordova. Should we not call a thing by its right name?

And what this conference further reflects is that invariably accompanying such intrusions are crimes of varying character and magnitude. These are crimes and ought to be called by their right name, however we might feel about the way penalties for such crimes should be assessed and applied.

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[1] K. Boulding. "I have recently discovered the real name of the devil, which is something terribly important to know. The real name of the devil is suboptimization, finding out the best way to do something which should not be done at all...the deep, crucial problem of social organization is how to prevent people from doing their best when the best in the particular, in the small, is not the best in the large..."

It is a very basic question.[1] In my view, the most fundamental crime of all is the one inadvertently revealed by Donald Cornett of EXXON in his statement that the oil industry sees itself as a unique global entity to which non-existent global principles ought to apply. (The implication is that they see themselves as accountable and responsible to no one but themselves.)

Now one thing this also tells me is that we're in the process of homogenizing the world. Not only is Alaska being "Californicated." The oil industry represents the cutting edge -- I'm not trying to be cute -- of the Californication of the world (clearly, a high energy-consumption process). It's a question of values, of course, as to whether one thinks this is good or bad. I happen to think it's reprehensible, because the one lesson I've learned in life so far is that it is diversity that makes life rich for me. Indeed, don't we proclaim it in the adage "Variety is the spice of life?" Yet the oil industry, America, western culture generally, is busily homogenizing the world. If you think this is good then once it has happened you have to ask yourself the question "Where do we go from here?" What an incredibly dull world it's going to be when it is all homogenized.[2]

It's not a matter of personalities when I take issue with Pat Dobey on the supposed inevitability of all this, but I believe we have every power, through government -- if only that power is exercised wisely -- not only to slow the process down, but even more. That's true whether we're talking of the impact of oil development or something else. The world is as we see it. And if we change our perception of the world, it is in fact different. (Take smoke, for example. To the businessman it indicates a thriving economic enterprise. To the conservationist it's pollution and thus a sign of something he doesn't like.) It's all in how we look at it. We have the capability to do whatever we choose to do about these things because there is the power within each of us to change our perception of things.

My daughter's junior high school social studies class recently had a presentation on the pipeline by a representative of Alyeska. The pupils were subsequently tested on the subject. About a week or two later, the class heard a presentation on ocean-drilling rigs complete with a model of a semi-submersible. Now are we to believe that that presentation was done merely for educative purposes and solely out of a spirit of public service? Rather, it was done by people who realize that nothing is "inevitable", that if they want their view of the world to dominate, then they have to propagandize it and otherwise act on it. And that's what they are doing in the public schools and elsewhere in Anchorage.

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1 There is available an excellent report by Yupiktak Bista entitled "Does One Way of Life Have to Die So Another Can Live?"

2 Robert Frost. "Homogenized -- that's where the cream can't rise to the top."

I'm not speaking of "evil" or "conspiratorial" individuals. These people are simply doing their thing, as was correctly pointed out earlier. But if they can do their thing, you and I can do our thing.

There is simply nothing inevitable about what's going on. I don't want to see the world homogenized and I don't what to see Cordova and Alaska lose their identity, and their quality, in the process.

Let's face it: this isn't just "Cordova '77". The reason this conference has come about is because of what we all know happened way back in the 60's. Those of us involved in the fighting and the hassling from '68-'69 on were saying the same things then that we are trying to say now; we were warning others of the consequences. This is not a case of "We told you so" but rather, a reminder that not enough people were listening closely. Much more could have been done about what has happened since, had we only listened better. So, let's listen more carefully now; let's take the lessons of conferences such as this more to heart; and let's do better in the future.

Allow me to caution you, fishermen of Cordova. Conferences like these, because of the manner in which they come about, and in the terms of which they are conducted, are weapons of the one culture against the other. The terms of discourse are dictated by those who represent the culture of business and industry which now wants to intrude itself on Alaska. There is, moreover, some question in my mind whether this institute is not affirming and reinforcing the intended dominance of that culture. That was a caution. I'm not sure that it means there should never be another conference. But you must recognize the danger that the very tools you use to participate may be working against you. You may win but you lose while you are making your protest.

Remember how we hassled about all these things back in '68-'69 and were told that the project would be "like a string laid across your backyard" -- that 800-mile length of pipe. Well, here we are seven or eight years later, and it sure as hell is no "string." And it's not in the "backyard." It's in our lives. It's been, rather, more like an incision by an inexperienced surgeon -- that's the proper simile. Let's hope that the "stitches" don't pull out. We don't know yet. That's what this conference hopes to prevent. And let's hope that if there is to be another incision into the body of Alaska, that it's done more expertly, with more sensitivity to the fact that it is a living organism which is being operated upon and not just a "backyard" where some string is being laid. The question should now perhaps be: ought there to be any more such incisions? My feeling is that I hope not, because it's to such a dubious, wasteful purpose, as was pointed out by Frank Tupper earlier today.

What has happened to us here is simply that some people wanted to get some oil from Northern Alaska and now we're all paying the consequences and the costs. Alaska has been turned upside down and

inside out. Why? For what? I don't think it's an irreversible process. It doesn't have to be this way. I think it means that we have to have an exercise of will, in state government particulary, to a degree that has not yet occurred. We also need the spur of an aroused public, including the fishermen of Cordova. We can do what we choose to do.

I guess some people would call what has happened "progress." But the best definition of progress I've heard is that it is "man's ability to complicate simplicity."[1] That's what we've been doing. We're just complicating what has otherwise been such a beautifully-operating natural world system, in which we surely have a role to play. It is not, I think, the role some are trying to impose on us. (We should keep in mind, in reference to an earlier comment, that not only does the Bible say that man should have dominion over the earth but that we should also replenish this earth!

I have the impression that what we're involved in is a process of so rearranging the world that we don't have to live in it. That's essentially what modern technology is all about: a way of rearranging the world so that we don't have to experience it.

From this perspective it is interesting to note that during the pipeline debate, in '69 or '70, it was E. L. Patton of Alyeska who put it as well as anyone has. Patton said: "In many respects the questions raised by this project are the questions of 20th century civilization itself." I believe that's true. Twentieth century civilization, energized primarily by oil, is in deep trouble and I don't think that the dying gasp of the so-called "high energy" civilization ought to preclude future options for the remnants of humanity who might remain. Alaska represents such options. Indeed there is some question as to whether such a high energy civilization qualifies for the title of "civilization" in its true meaning.

For me, the high point of this conference was the slide presentation by Rick Rosenthal. Weren't those pictures really something? Why did we feel so damned good when we saw those superb pictures on the screen? I think virtually everyone felt good to see that beautiful photographic presentation of various forms of sea life. Why? Not just because of the technical aspects, I'm sure. Was it because, perhaps, we glimpsed a bit of our own roots there -- roots that we sense, that we feel, are slipping away or being pulled out from under us? And if that's the case: Why? Someone please tell me, What for? Why does that kind of world have to give way to the kind of world that most everyone here has been talking about these past three days, the kind of world in which it is judged that the only life form worthy of being held sacred is that which walks on two legs and calls itself mankind.

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[1] George Woodell. "We have been moving away from a world that runs itself...to one that requires constant tinkering that is malignant in that each act of repair generates a need for further repairs to avert problems generated at compound interest."

Hey there! Whatever gave us the right to decide that all creatures, all forms of life but our own have to be "managed"? Isn't it time we took ourselves in hand, especially here in Alaska? The Cordova fishermen represent to me today, as they did seven years ago, a group of people who are saying, whatever the economic dimension of their argument may be, "Hey! Listen! There's more to life than technological artifacts, and the creatures of the sea, which we harvest, have their role in life as do the two-legged creatures."

What I should like to offer as my final comment is the proposal that we take all the money that is represented by the ambitions of those in attendance here and give it to Rick Rosenthal to make more undersea films.

Thank you very much.

AFTERWORD

During the concluding discussion by members of the audience, one gentleman suggested that perhaps it was "professors who were homogenizing the world." Ah, if only they had such influence! But, how could they? They disagree so much amongst themselves, as they should. More importantly, however, was the implication that this gentleman didn't want to be "lectured" to. Interesting. Which does he prefer: a "lecture" that is out in the open for him to analyze, to accept or reject, or the sort of lecturing by cultural forces such as I have only begun to sketch. These are cultural influences that so subtly yet so powerfully, condition our thought and behavior that we don't even recognize them or how hard at work they are.

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