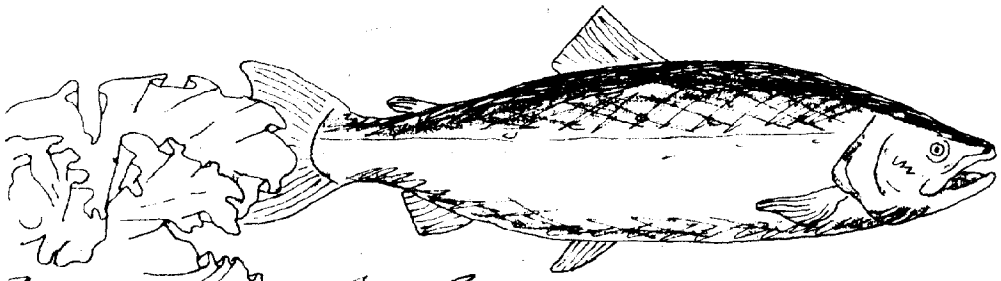
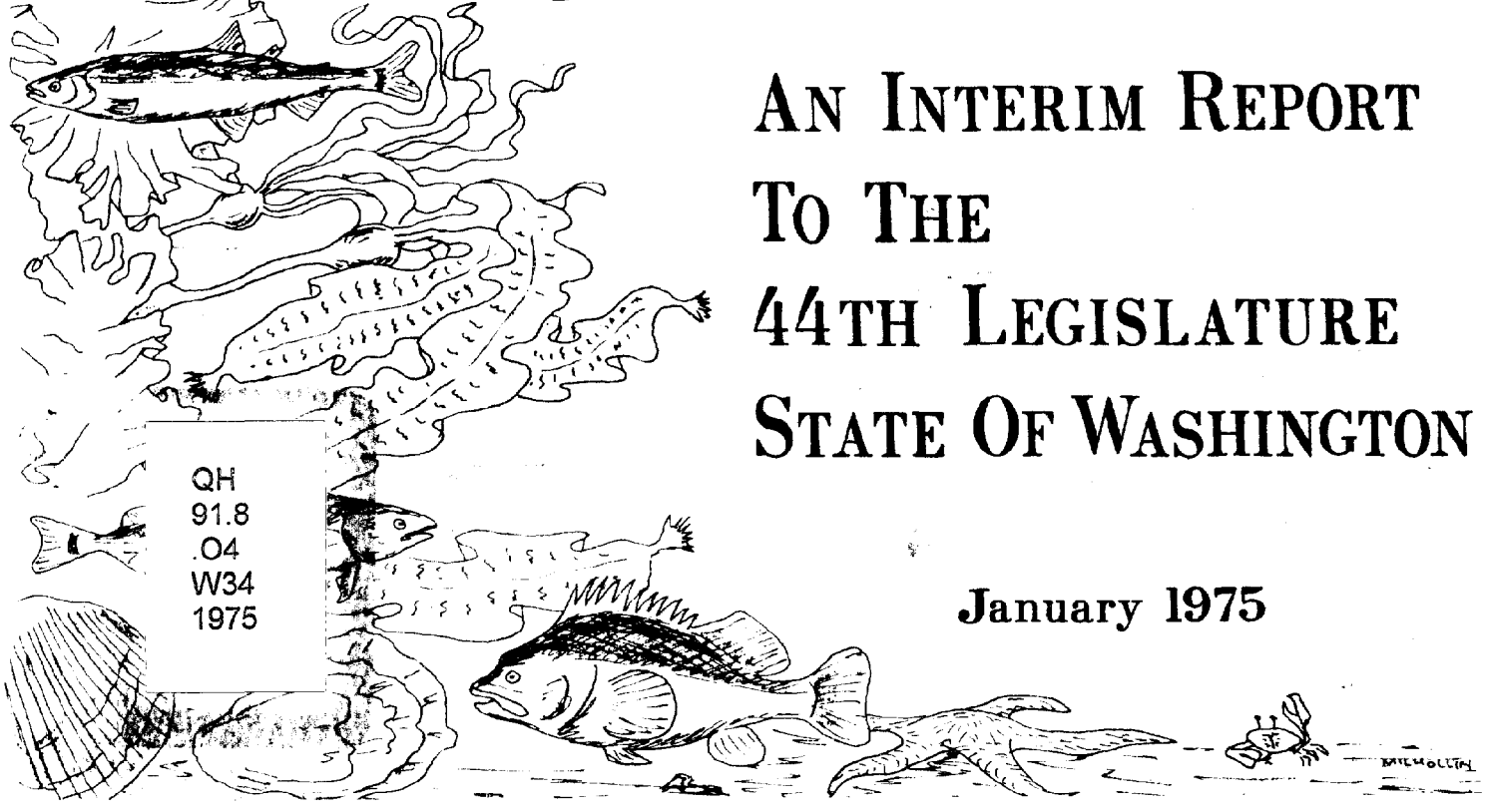
State of Washington
Department of Ecology

BASELINE STUDY PROGRAM
NORTH PUGET SOUND



AN INTERIM REPORT TO THE 44TH LEGISLATURE STATE OF WASHINGTON

January 1975



State of Washington
Department of Ecology

Governor Daniel J. Evans and
Members of the 44th Legislative Session

I am pleased to submit this interim report of the Oil Baseline Study authorized under RCW 43.21A.405-420. This report summarizes our work to January 1, 1975. The final report will be published approximately June 30, 1975.

The program, as mandated by the Legislature, is very comprehensive and is providing valuable information at the very onset. Of special note is the study covering the economic value of our marine resources. While the material enclosed are preliminary in nature, I am sure you will be amazed--as I have been--on the dollar values brought out by this study.

Our initial efforts during this first year of operation have been to:

1. Develop economic information on the commercial species of Washington. Initiate economic studies on sport species and human structures and activities.

2. Establish a project design and management system.

3. Review the existing literature on the biology of selected marine animals and plants found in Northern Puget Sound.

4. Review the literature on the impact of oil upon those organisms in Northern Puget Sound and their associated habitats.

5. Map the marine habitat types of Northern Puget Sound.

6. Establish field survey teams and stations and begin year-long field inventories of the marine habitats of Northern Puget Sound.

This study represents the first major step in providing sound scientific information for use not only in oil impact related decisions, but also for the evaluation of other manmade and natural situations in our state's coastal zone.

Sincerely,

John A. Biggs
Director

JAB:vh
Enclosure

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SUMMARY

AUTHORIZATION AND PURPOSE

This study is the result of RCW 43.21A.405-420 (Senate Bill 2978) in which the Department of Ecology was requested to establish ". . . a continuing, comprehensive program of systematic baseline studies for the waters of the state . . . ." that would aid in the maintenance of water quality standards, as well as address the specific problems associated with oil contamination of the marine ecosystem.

APPROACH

The Legislature had directed emphasis be given to: "Those waters (1) in which the greatest risk of damage from oil spills exists; (2) which contain marine and freshwater life that is particularly sensitive to toxins contained in crude oil, oil products and oil wastes; and which are used or may be used for the harvest, gathering or production of food or food products." Therefore, the first study area chosen was the North Puget Sound area where there are existing petroleum refineries, crude and refined product transfer points, and tanker routes to the refineries. North Puget Sound is defined as the marine waters and submerged lands of Skagit, Whatcom and San Juan counties.

Within this area, systematic inventories of the "Significant Biological Resources" are being conducted on the basis of their occurrence in selected habitat types which will lead to an evaluation of the impact of oil pollution on their well-being. An economic assessment is being made of the value of these inventories

as well as to human structures and activities that might be damaged by an oil spill.

FINDINGS

The economic worth of the North Puget Sound is unfolding as the inventories are made and values are determined for the land, the harvestable natural resources and from marine-related recreational experiences.

The present water quality of this area supports a commercial fishing and tourist industry of considerable magnitude. These industries in turn provide expenditure streams which support other state commerce. Regional input/output analysis permits the estimation of commerce dependent upon these industries. The following table reports results of such an analysis and is based on the processed value of harvested fish of $109,000,000 and a recreation tourist industry of $130,000,000.

INDUSTRY DEPENDENT ON PUGET SOUND FISHERIES AND TOURISM

	FISHERIES	OUT OF STATE TOURISTS
AGRICULTURE	$ 13,800,000	$ 28,900,000
MANUFACTURING	$ 27,400,000	$ 20,600,000
CONSTRUCTION	$ 6,300,000	$ 6,800,000
SERVICES	$ 27,200,000	$ 70,300,000
COMMUNICATION/UTILITIES	$ 8,400,000	$ 11,000,000
TRADES	$ 31,800,000	$ 65,400,000
FINANCE/INSURANCE/REAL ESTATE	$ 9,900,000	$ 11,400,000
HOUSEHOLD INCOMES	$121,000,000	$119,000,000
STATE & LOCAL GOVERNMENT REVENUE	$ 18,900,000	$ 19,700,000

FISHERIES

Nature fluctuates in its productivity and species composition between seasons as well as years. Therefore, a program of this type will always encounter problems in quantification relative to time and place. The amount of damage to commercial fisheries by an accidental oil spill would depend on the season and the place where the spill would occur.

If the spill occurred during a fishing season, it is unlikely that either fishermen or those involved in fish processing could switch their efforts to alternate fish sites or production and a direct economic result could be realized.

In addition, an oil spill in specific places could directly endanger individuals of sensitive species. The commercial fishing effort in North Puget Sound could be directly damaged in terms of adult loss, or more likely, in terms of either loss of young fish or food items of both young and adults.

The damage would be greater to young members of a species and their food items due to their sensitivity to oil toxicity and their utilization of the tidal and subtidal habitats so that losses of their food items, or losses of substantial numbers of young, would lead to a reduction in the potential adult population which would reduce the gross value of the fishery. Losses to the young members of the species would not be fully realized for several years in the future.

The total gross values (1973) of commercial catch of fish which may depend upon Puget Sound habitats is shown in the following table.

COMMERCIAL FIN FISH (INCLUDING CANADIAN)	$141,100,890
MOLLUSC AND SHELLFISH	$ 3,218,039
SALMON EGGS FROM CATCH	$ 283,690
TOTAL	$144,602,619

It is not possible to predetermine the value of a temporary ecological impact such as an accidental oil spill because of not knowing the time and place where this would happen. Such spills may be costly and can reduce the productivity of the affected area.

There is usually a recovery of the ecosystem after varying lengths of time in the case of an accidental petroleum spill. However, the indirect permanent changes of chronic pollution of hazardous material, including petroleum, are subtle and broad in nature and will cause the greatest damage in the long run.

In the case of the accidental petroleum spill, the salmon fisheries would be reduced and most of the shellfish in the contaminated area would be damaged or killed, whereas, a situation of chronic pollution could eventually eliminate the total fisheries of the area.

An analysis of just the salmon fishery has been made of the North Puget Sound area. The table on the following page indicates the area in which the salmon were caught, the catching method, and the species of the salmon.

RECREATIONAL EXPERIENCES

Sport fishing and hunting are evaluated through use of field studies in which sportsmen were asked to indicate the value they placed on their hunting and fishing experiences. The physical

VALUE OF COMMERCIAL SALMON AT 1973 PRICES IN
THE NORTH PUGET SOUND AREA, 1973 CATCH, SPECIES AND VALUE

AREA AND METHOD OF CATCH	COHO	PINK	CHUM	CHINOOK	SOCKEYE	COMMERCIAL SALMON TOTAL VALUE
POINT ROBERTS:						$ 9,910,549
Gill Net	576,074	264,521	---	94,682	1,559,198	
Indian Set Net	7,299	1,935,056	3,124	1,103	48,405	
Purse Seine	503,220	4,271	538,083	486,166	3,887,193	
Reef Net	83	569	---	68	1,434	
NOOKSAK RIVER:						1,122,119
Gill Net	4,199	86,294	279	500,163	7,257	
Indian Set Net	160,705	2,866	78,886	280,400	1,070	
BELLINGHAM BAY:						24,562
Purse Seine	599	949	30	22,776	208	
STUART ISLAND:						872,850
Gill Net	1,680	743	2,206	10	168	
Purse Seine	196,460	380,316	126,167	14,564	69,582	
Reef Net	14,937	42,571	2,430	2,147	18,869	
SALMON BANKS:						10,635,114
Gill Net	467,401	386,415	377,965	44,030	2,958,213	
Indian Set Net	482	1,360	---	206	60,985	
Purse Seine	650,387	1,893,406	399,711	136,453	3,249,142	
Reef Net	1,232	3,586	640	1,370	2,130	
SAN JUAN CHANNEL:						219,383
Gill Net	611	540	240	21	287	
Indian Set Net	---	---	---	---	---	
Purse Seine	11,381	45,000	6,138	2,984	671	
Reef Net	13,881	65,301	3,831	2,742	65,755	
ROSARIO STRAITS:						1,278,876
Gill Net	112,639	76,025	84,648	39,337	---	
Indian Set Net	1,070	2,702	21	461	---	
Purse Seine	187,522	272,168	147,074	122,151	---	
Reef Net	44,478	145,831	19,357	23,392	---	
SKAGIT BAY:						451,820
Indian Drag Seine	7,259	53,156	15	28,732	247	
Gill Net	41,895	47,551	788	102,083	634	
Indian Set Net	19,521	30,431	13,823	74,431	460	
Purse Seine	364	6,989	63	---	---	
Reef Net	---	---	---	---	---	
Indian Trap	8,153	5	643	10,634	3,943	
WEST BEACH:						453,434
Gill Net	36,035	23,001	6,061	38,776	68,173	
Purse Seine	35,119	171,197	2,110	19,942	53,020	
Indian Set Net	---	---	---	---	---	
SAMISH BAY						150,637
Gill Net	158	247	---	146,196	91	
Indian Set Net	27	112	698	3,039	69	
NORTH SOUND						$25,119,344

evidence of the value of hunting or fishing is the "meat worth" of the duck or fish. The following table summarizes the value of sport harvested species in North Puget Sound for 1973.

SPECIES AND CATEGORY	MEAT VALUE	NET BENEFITS
Marine Caught Salmon	$1,000,000 to $1,600,000	$11,800,000 to $14,600,000
Freshwater Salmon	$ 54,000 to $1,980,000	$ 574,000 to $ 2,039,000
Shellfish	$ 206,000	$ 719,000
Steelhead	$ 27,000 to $ 29,000	$ 56,000 to $ 117,000
Ducks and Geese	No commercial values for wild fowl	$ 711,000 to $ 791,000
TOTAL	$1,287,000 to $3,815,000	$13,860,000 to $18,266,000

There are other recreational experiences which are evaluated in terms of a utilization day or other values, although not necessarily based upon detailed field studies, appear to be reasonable. For example, it is difficult to assign a single set value which would describe what each individual would be willing to pay for the privilege of observing the nonhunted birds. A range of values could be somewhere between $2.50 and $20 per watching day. Considering the organized chapters of the Audubon Society, of which there are 7,000 members; the hikers and other individuals; a conservative number of recreation days would be in the order of 30,000 per year. This would give a value range of between $75,000 and $600,000.

Another recreational experience is SCUBA diving, where the North Puget Sound is the preferred diving area. The 25,000 divers generate

approximately 750,000 "diving days" which has been valued at $10,250,000.

The North Puget Sound offers one of the most attractive areas in the world for boating. Boating activities during 1972 cost $125,477,000 which includes purchase of boats, engines, trailers, accessories, parts, storage, docking, and fuel. In addition, the average boat owner, of the 144,400 boats, consumed 28 "boating days" a year for a total of 4,043,200 activity days. At an average of $32 per activity day, this is valued at $125,000,000.

The public parks and beaches account for 177 miles of shoreline of Puget Sound. They were visited by 22,890,000 persons during 1970, which has been valued at $1 per person, per day. Including fees charged, a lower value for total public park recreation use is $24,899,000.

PROPERTY VALUES

Waterfront property was evaluated through a survey of recent real estate transactions. In order to simplify value estimates, only unimproved lands with shoreline access were considered. Within the North Puget Sound region, there are 782 miles of shorelines. The average depth was taken as 560 feet from mean high tide and the premium value per square foot was determined to be 33.8¢. The capitalized premium would be about $781,529,500.

Because access to unspoiled waterfront is a characteristic for which people are willing to pay a premium, any action which reduces the value of such property available implies a sacrifice by society of some of the desirable commodities; namely the amenities, or expected future amenities, which were the reasons

of the premium in the first place. Pollution and threat of pollution of hazardous materials, including accidental and chronic petroleum spills, will lower this premium value.

A recapitulation of the annual range of values for the North Puget Sound area are listed in the following table.

	LOW	HIGH
SPORT HARVESTED FISH AND BIRDS (NET BENEFIT)	$ 1,287,000	$ 3,815,000
NONHUNTED BIRDS (RECREATIONAL VALUE)	$ 75,000	$ 600,000
RECREATION		
SCUBA DIVING DAYS	$ 5,125,000	$ 10,250,000
BOATING ACTIVITY DAYS	$ 62,738,500	$ 125,477,000
PARKS RECREATIONAL USE	$ 12,449,500	$ 24,899,000
PROPERTY VALUE (1973)	$781,529,500	$ 781,529,500
COMMERCIAL SALMON FISHERIES (1973)	$ 25,119,344	$ 25,119,344
TOTAL	$888,323,844	$ 971,688,844

The previous table included only the salmon fishery and the price the fisherman receives at the dockside for his fish. The following table is processed value of the 1973 commercial fishery harvest and the expenditures of out-of-state tourist visiting Puget Sound region for recreational purposes and their respective incomes to households in the state, as well as revenues for state and local governments.

1973 EXPENDITURE STREAM

	VALUE	INCOME	REVENUE
COMMERCIAL FISHERY HARVEST	$109,000,000	$121,000,000	$18,900,000
OUT-OF-STATE TOURISTS VISITING PUGET SOUND	$130,000,000	$119,000,000	$19,700,000
TOTAL	$239,000,000	$240,000,000	$38,600,000

GOALS

To date, the value assessment of the North Puget Sound area has not included an in-depth assessment of the marine biota. One of the goals of the Baseline Program is to inventory systematically the "Significant Biological Resources" based on their occurrence in selected general habitat types. This also includes an appreciation of the ecology of the habitat as well as the "food web" analysis to relate between the amount and type of food available to feed each specie.

Once the ecological relationship and food web is established, the economist can then place values on these lesser plants and animals which may suffer the greatest damage during either an accidental or chronic petroleum spill.

The data and information collected by the biological effort in the field is one of the essential parts of the Baseline Program. It is by necessity laborious and time consuming. Nature fluctuates in its productivity and species composition between seasons as well as years. There must be sufficient repetitive biological inventories to establish averages. Also, these multiple inventories are necessary to establish a more reliable ecological connection within the food web.

Field surveys have produced a preliminary map of the distribution and data on relative abundance of general habitat types of North Puget Sound. Detailed, on-the-ground biological surveys at 21 locations are continuing in order to provide data on seasonal occurrence.

A literature survey is almost complete and is being done by a number of groups who are dealing with either specialized topics, such as, Birds (Department of Game); Fishes (University of Washington, Fisheries Research Institute); Oil Spills (Allen); or generalized reviews, such as, Historical Data (Beak Consultants, Inc.); Current Research (Oceanographic Institute of Washington).

An innovative literature review has produced a set of species fact sheets on the biology of North Puget Sound, oil impact fact sheets, and an analysis of the impact of oil upon the resources and habitat types represented in the North Puget Sound.

RECOMMENDATIONS

In view of the great value of the North Puget Sound area in natural resources, recreational opportunities and land values, it is recommended that:

1. Minimize the risk of either an accidental petroleum spill or of other hazardous material.
2. Maintain the marine water quality guarding against chronic pollution by petroleum or other hazardous material

INTRODUCTION

As a result of RCW 43.21A.405-420 (Senate Bill 2978), the Legislature requested that the Department of Ecology establish " . . . a continuing, comprehensive program of systematic baseline studies for the waters of the state . . . ." that would aid in the maintenance of water quality standards, as well as address the specific problems associated with oil contamination of the marine ecosystem.

The law was approved by the Governor on September 22, 1973 and became effective on December 15, 1973. The Department of Ecology held the first organizational meeting on October 4, 1973 where it was agreed to form an Ad Hoc Advisory Committee. This Advisory Committee consisted of representatives from the State Departments of Ecology, Fisheries, and Natural Resources; the University of Washington; Western Washington State College; METRO: Sea Grant; and the Federal National Oceanic and Atmospheric Administration.

The role of this Advisory Committee was to review and analyze the methods and concepts necessary to answer the legislative intent of the law and to recommend a framework for a baseline study. In view of the time constraints and the magnitude of the program, the Advisory Committee recommended that the above be accomplished by consultants who could devote full time to the project.

Consultants from the Oceanographic Institute and the University of Washington were hired in December when authorization to expend funds were received. A final document was prepared by the consultants in February 1974. This report contained both a broad prospective and a comprehensive program to obtain baseline information.

The staff for the Baseline Program was hired in March by the Department of Ecology and consisted of Dr. David Jamison to supervise the program with one professional assistant and one clerk-typist.

A program plan was developed and initiated by April 15, 1974 using the consultants' reports as a reference. The effort was defined as:

1. A systematic inventory of the "Significant Biological Resources" of Northern Puget Sound based on their occurrence in selected general habitat types.
2. An evaluation of the impact of oil pollution on their well-being.
3. An economic assessment of their value, as well as to human structures and activities that might be damaged by an oil spill.

The Legislature directed emphasis be given to: "Those waters (1) in which the greatest risk of damage from oil spills exists; (2) which contain marine and freshwater life that is particularly sensitive to toxins contained in crude oil, oil products and oil wastes; and which are used or may be used for the harvest, gathering or production of food or food products." Therefore, the first study area chosen was the North Puget Sound area where there are existing petroleum refineries, crude and refined product transfer points, and tanker routes to the refineries. North Puget Sound is defined as the marine waters and submerged lands of Skagit, Whatcom and San Juan counties.

In May 1974, thirty-seven separate groups were sent a request for proposal to perform work on the Baseline Program. There were twelve

responses of which seven were awarded contracts with work commencing in July 1974.

Although weekly and monthly contacts are maintained with each contractor, there was a formal interim progress report made for the period of July through October 1974. Selected reports on the literature review and economics were received at the end of December. Second interim reports are due the end of February.

Appendices to this report are:

1. The October interim reports
2. The December Economic report
3. The literature review final report

Because of the volume of these reports, they are being made available upon request only through the Department of Ecology Library.

PLAN PHILOSOPHY

A relatively novel approach to baseline studies was adopted to allow for an analysis of oil impacts, as well as other impacts as directed by the Legislature. This approach relies upon a basic principle of science called "energy" as a means of describing the different areas where marine organisms live and assigning dollar values to other organisms besides commercial species.

Pushed by the moon's gravitation and the heat of the sun, tides, and winds translate their energy into currents and waves. This liquid energy has, over the past several thousand years, churned the glacial deposits and bed rock of the Puget Sound Basin to produce beaches and bay bottoms with a variety of materials, from mud through sand and gravel to rock. Each of these materials in turn support

different kinds and amounts of plants and animals. Generalized from these energy produced differences, nine different general habitat types common to Puget Sound were chosen for study. (Attachment A)

Data on the distribution and abundance of selected organisms from each of the representative habitats now being studied in the field will be used to (1) characterize the particular under study area and (2) characterize similar but unstudied areas close by or in other parts of Puget Sound. The field data will also be used to refine the habitat type designations in the context of criteria contained in "Vertical Zonation and Substrate Characteristics of the Marine and Estuarine Lands and Waters of Washington." (Attachment B)

In order to place a direct economic value on damaged resources, some basis for that value must be established. The economist can find either a value or values for commercial organisms because they are sold in the market each day, and with some research, the economist can even place a value or values on the adult forms of recreationally important animals, such as, rockfish and Lingcod.

However, those animals may not be directly damaged by an oil spill. One or more of their food items might be harmed instead. Since there is a link between the amount of food available to feed each species and the amount of that species, there is an opportunity to attach dollar values to organisms other than commercial and recreational species by following the linkages in the food web.

The same argument also is true for the predators of commercial and recreational species.

Based on this concept, a list of the "Significant Biological Resources" has been prepared. (Attachment C) Besides commercial and

recreational species, known food items, competitors, and predators have been included. Field studies, the literature review, and the economic analysis are following this list as a means of prioritizing the research effort.

GENERAL UTILITY

The use of habitat types and the food web will permit use of the information in other areas of Puget Sound, as well as for other impacts. For example, the effect of any marina construction upon sensitive marine resources could be predicted from this information. The limitation to this approach lies in both the present scarcity of information on specific impacts and recognition of regional differences in animal and plant composition of the representative habitat types. Such regional differences must be studied in the future to provide a firmer basis for data extrapolation.

STANDARDIZATION OF TECHNIQUES

In addition to care in selecting the basic concepts of the plan, time was spent during plan development in evaluation of field sampling techniques. However, because such techniques are not yet standardized, work has continued on both refining acceptable methods and standardization within the program.

OBJECTIVES

The Baseline Program relating to oil impact is composed of nine basic objectives, all of which are related to the legislative directive and as developed from the scientific analysis of the problems through the Ad Hoc Advisory Committee, the report from the consultants, and the development of the program by the Department of

Ecology's staff (as explained in the previous section).

These objectives are to determine for the marine and estuarine waters of Washington:

1. The present and potential oil contamination.
2. The economic value of man-made structures and man's activities that would be damaged by oil pollution.
3. The significant biological resources.
4. The economic value of significant biological resources that would be affected by oil pollution.
5. The types, distribution and abundance of major habitats.
6. The distribution and abundance of biological resources in major habitats.
7. The impact of oil pollution upon the significant biological resources.
8. Predict the movement of spilled oil.
9. The populations of significant biological resources that serve as major sources of recruitment for adjacent areas.

The preceding objectives have been further broken down into tasks. These are listed in Attachment D.

The relationship of one objective to another is shown by Figure 1.

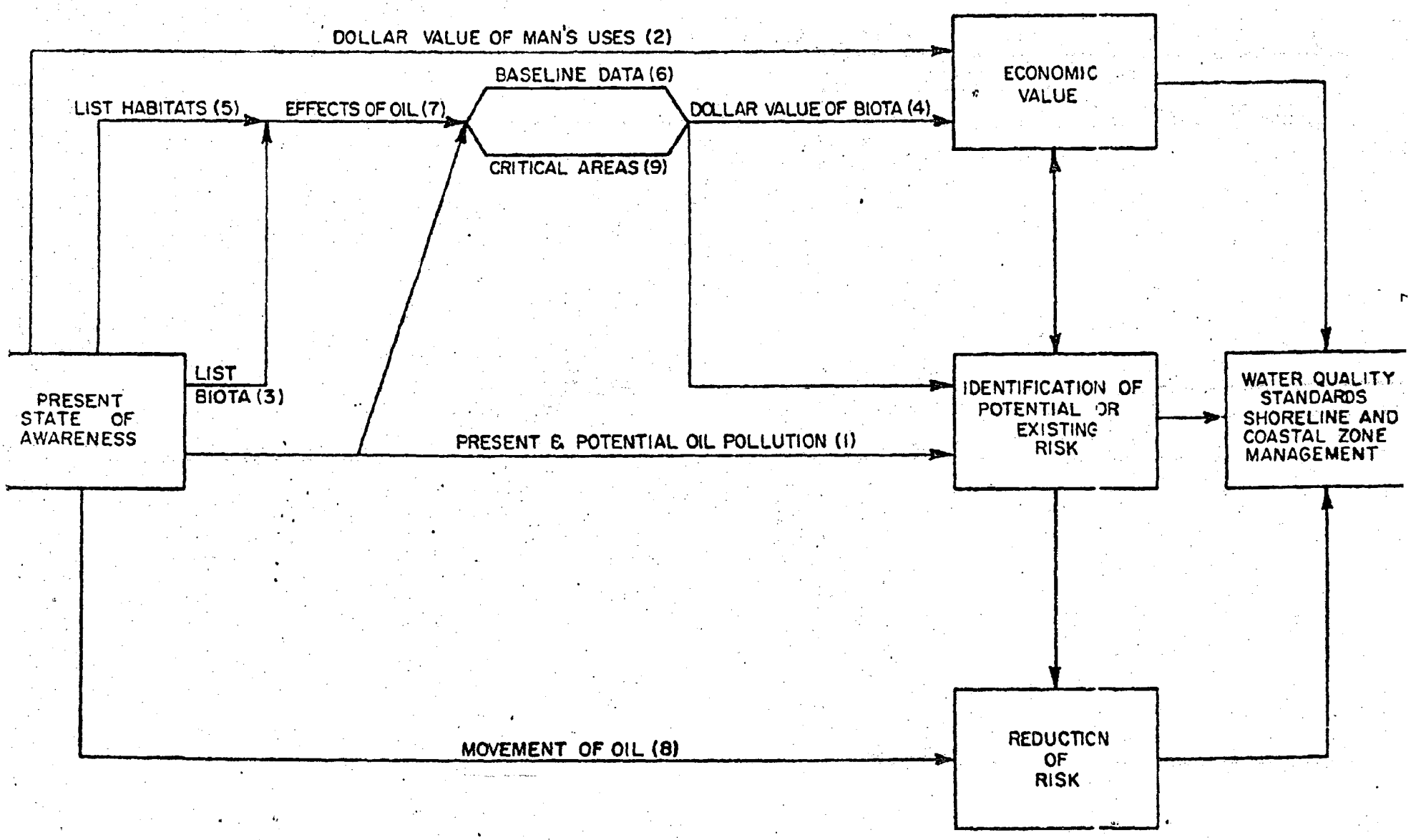
IMPLEMENTATION OF PLAN

The objectives and tasks can be grouped into the following categories: Field Survey, Literature Review, and Economic Evaluation.

The Field Survey portion involves five groups working out of the University of Washington, Western Washington State College and the Department of Ecology.

FIGURE 1

RELATIONSHIP OF OBJECTIVES



The Literature Review is being done by a number of groups who are dealing with either specialized topics, such as, the Department of Game (Birds); University of Washington, Fisheries Research Institute, (Fishes); Allen (Oil Spills): or generalized reviews, such as, Beak Consultants, Inc., (Historical Information), and Oceanographic Institute of Washington, (Current Research).

The Economic Evaluation is being done by the University of Washington.

Table 1 lists the objectives and tasks, together with the contractor and a completion date. Also shown is the type of work which categorizes the expertise of the respective contractor.

Table 2 is a recapitulation of monies spent to date relative to type of work and contractor and the remaining monies left for their respective contracts.

Because of limited funds and work by other agencies, Objectives 8 and 9, as well as parts of other objectives, are not funded at this time.

COORDINATION

The Baseline Program has been carefully coordinated with all interested activities, agencies and departments of the local, state and federal governments, as well as the academic communities and industry. This coordination began with an organizational meeting in October 1973 of an ad hoc advisory committee, which provided recommendations for a baseline program. In September 1974, a Marine Analysis Program Advisory Committee was formed to advise the Department on all aspects of the Baseline Program, as well as other programs of the Land and Marine Analysis Section. The membership

TABLE 1

OBJECTIVE	TASK	CONTRACTOR	COMPLETION DATE	TYPE OF WORK
1	A	William Allen	9/30/74	Literature Review
	B	"	"	"
	C	"	"	"
2	A	DOE Staff	8/15/74	Literature Review
	B	"	"	"
	C	"	"	"
	D	"	"	"
	E	U of W, Crutchfield	12/30/74 and	Economic
	F	"	6/15/75	"
	G	"	"	"
3	A	DOE Staff	8/15/74	Literature Review
	B	"	"	"
	C	U of W, Miller	6/15/75 (Part)	Field Survey
	D	"	" "	"
	E	DOE Staff	8/15/74	Literature Review
	F	DOE Staff	"	"
4	A	U of W, Crutchfield	12/30/74 and	Economic
	B	"	6/15/75	"
	C	"	"	"
	D	"	"	"
	E	Not funded		"
	F	"		"
	G	"		"
	H	U of W, Crutchfield	12/30/74	"
	I	U of W, Crutchfield	6/15/75	"
	J	U of W, Crutchfield	"	"

TABLE 1 (Continued)

OBJECTIVE	TASK	CONTRACTOR	COMPLETION DATE	TYPE OF WORK
	K	U of W, Crutchfield	6/15/75	Economic
	L	"	"	"
5	A	DOE Staff	8/1/74	Field Survey
	B	"	9/30/74	"
	C	Not funded		"
	D	DOE Staff	12/30/74	"
6	A	Beak Consultants, Inc.;	1/17/75	Literature Review
		Game, Dept. of	6/15/75	"
		Miller, U of W	10/30/74	"
		Oceanographic Inst	3/31/75	"
	B	English, U of W Oceanography;	6/15/75	Field Survey
		Miller, U of W Fisheries Research Institute;	6/15/75	"
		Nyblade, U of W Zoology;	6/15/75	"
		Webber, W.W.S.C. Huxley;	6/15/75	"
	C	Beak Consultants, Inc.;	1/17/75	Literature Review
		Game, Dept. of	6/15/75	"
	D	Not funded		"
	E	"		"
	F	"		"
7	A	Beak Consultants, Inc.	1/17/75	Literature Review
	B	"	"	"
	C	NOAA (Federal funds)	----	Laboratory Study
	D	"		"
	E	"		"
	F	"		"
	G	"		"
	H	WWSC	6/15/74	Field Survey

TABLE 1 (Continued)

OBJECTIVE	TASK	CONTRACTOR	COMPLETION DATE	TYPE OF WORK
	I	Not funded		Laboratory Study
	J	DOE Staff		Oil Spill Response Team
	K	Not funded		Analysis
8		Not funded		
9		Not funded		

TABLE 2

The following table indicates the type of work, the contractor, what monies have been spent as of January 1, 1975, and what remains to be spent for completion of contract.

TYPE OF WORK AND CONTRACTOR	BILLING AS OF JANUARY 1, 1975	REMAINING
Literature Review		
Miller	$ 5,400.00	-0-
Beak Consultants, Inc.	42,834.69	$ 16,990.31
Oceanographic Institute of Washington	3,500.00	3,500.00
Department of Game	-0-	5,000.00
Allen	2,195.00	-0-
Economic Evaluation		
Crutchfield	15,652.52	44,347.48
Field Survey		
English	19,354.75	55,645.25
Nyblade	4,293.54	32,706.46
Miller	16,324.91	37,675.09
Webber	10,147.72	58,552.28
DOE--MLM-73/74	7,593.98	-0-
DOE--Boese	1,800.00	-0-
Advisory Consultants		
Bauer	10,216.30	24,783.70
Planning Consultants		
University of Washington	9,924.91	-0-
Oceanographic Commission of Washington	4,333.46	-0-

TABLE 2 (Continued)

TYPE OF WORK AND CONTRACTOR	BILLING AS OF JANUARY 1, 1975	REMAINING
Administration		
Salaries, etc.	$ 40,000.00	$ 24,000.00
Field Orders	2,189.46	878.19
Flights	160.00	
TOTAL	$195,921.24	$303,200.57
	TOTAL	$500,000.00

of this Committee is shown in Attachment E and includes representatives from resource managers of state government, representatives from local and federal government and specialists from the academic communities.

The plan of the Baseline Program provides a framework whereby agencies and activities can both satisfy their requirements, as well as add to the Baseline Program.

The responding federal agencies include the National Oceanic and Atmospheric Administration (NOAA), with their Sea Grant and Marine Ecosystem Analysis (MESA) programs, as well as the U. S. Army Corps of Engineers' dredge spoils study program. METRO and their marine survey program is an example of local government participation. There are also programs of other departments of state government, such as, Fisheries, Game, and Natural Resources, which are contributions to the Baseline Program.

RESULTS

LITERATURE REVIEW

Beak Consultants, Inc., was retained to conduct a general review and analysis of the available literature on the ecology of the "Significant Biological Resources" of Puget Sound and on the possible effects of spilled oils and petrochemical products on these biota. As part of the study, biological and oil impact fact sheets were to be prepared on each species along with an annotated bibliography and a written report on potential impacts by oil on the affected organisms.

In addition to composited information, each fact sheet includes information on area distribution for each species, habitat ecology

life history, economic value, predators, prey, and comments on the article made by the reviewer.

Using qualified biologists reading within their field, data-type information for written materials was abstracted and stored in an integrated retrievable data-base. This was organized to maximize the retrieval of information in such categories as organism groups, species, area of distribution, life stage, habitat, petrochemical type and impact.

A total of nine general habitat types have been considered in this study and the 250 species designated for the literature search have been assigned to thirteen broad organism groupings. By identifying these habitat types and gathering data for input on selected species groups within these habitats, the number of impacts addressed were greatly reduced. An example of Beak's results is shown in Attachment F.

Other workers were retained to examine the unpublished literature on the distribution of marine fish (Dr. Miller, Fisheries Research Institute, University of Washington); the distribution and abundance of marine birds. (Department of Game); and to document the current marine research activities (Oceanographic Institute of Washington).

That portion of the literature review dealing with the natural history of the "Significant Biological Resources" will be updated and refined by the ongoing field surveys.

The complete data base now synthesized from this literature will be utilized along with the field data in the final report to define the seasonal composition of the different habitats and to provide a basis for assigning economic values.

FIELD SURVEY

The data collected by the biological effort in the field and its subsequent analysis are essential parts of the Baseline Program. Only from an on the ground accurate survey can a reasonable idea of the species composition and abundance by habitat type be developed. Such data is necessary to confirm and extend information obtained through the literature review, provide up-to-date information on existing habitat biology, and refine the definition of habitat types and Significant Biological Resources.

Field studies will not be completed until June 1975 because of the need to gather at least a year's worth of data. Even then we may have been looking at an unusual year when the air or water was colder or warmer than normal with resultant high natural mortalities or conversely high natural survival. The environment is constantly changing seasonally and between years. The concept of a baseline must recognize this variation. When these changes are averaged and compared over a three- to five-year period, only then can we more effectively view these changes in relationship to man's impingement on the environment. So at a minimum, data must be gathered during one full year to provide information on seasonal changes.

The biology of representative habitats within three vertical zones are being studied in the field survey.

1. The intertidal zone is being studied by Western Washington State College (Huxley College) and the University of Washington (Department of Zoology). Comparable samples are obtained by the field crews from beaches ranging from mud to rock and comprising most of the habitat types. Obtaining six samples throughout the period of July 1974 through May 1975, the

contractors will be able to document seasonal differences between areas and habitat types.

2. The shallow subtidal area from a extreme lower low water to a minus five meters is being studied by Western Washington State College and the University of Washington (Fisheries Research Institute and Zoology). They are using SCUBA diving as well as beach seines and bottom grabs. Examining similar habitat types as in the intertidal zone, and adding kelp and eelgrass beds, a seasonal picture of the represented habitat types will emerge.

3. The subtidal area below a minus five meters to a minus twenty meters is being inventoried by the University of Washington (Department of Oceanography and the Fisheries Research Institute). The Department of Oceanography is using a bottom grabs, beam trawl, and plankton net to directly sample the living resources found in this area. Water samples are taken to look for nutrients and document temperature and salinity changes. The Fisheries Research Institute is sampling along roughly the minus five meter contour to gain information about the herring, smelt, and young salmon that inhabit the area.

The sample locations for all field surveys are listed in Table 3. Because of funding and the relatively low probability of oil spill damage at depth, the Department of Oceanography effort has been restricted to only three stations.

Unfortunately the data are insufficient as yet to develop conclusions as to the abundance and distribution of Significant Biological Resources by habitat type. Preliminary data are available in the first interim

TABLE 3

SAMPLE LOCATIONS, HABITAT TYPES, AND VERTICAL ZONES
BEING STUDIED BY OIL BASELINE STUDY CONTRACTORS
IN NORTH PUGET SOUND

SAMPLE LOCATION	VERTICAL ZONE	HABITAT TYPE	INVESTIGATOR
Allen Island	Subtidal	Kelp	U.W. Miller
Barnes Island	Subtidal	Kelp	U.W. Miller
Birch Bay	Subtidal	Sand	W.W.S.C.
Birch Bay	Intertidal	Sand	W.W.S.C.
Birch Bay	Subtidal	Sand	U.W. Miller
Cantilever Pier	Intertidal	Rock	U.W. Nyblade
Cherry Point	Intertidal	Mixed-Coarse	W.W.S.C.
Cherry Point	Subtidal	Eelgrass	W.W.S.C.
Cherry Point	Subtidal	Mixed Fine	U.W. English
Cherry Point	Subtidal	Mixed Fine	U.W. Miller
Cherry Point	Subtidal	Open water	U.W. English
Deadmans Bay	Intertidal	Mixed-Coarse	U.W. Nyblade
Deadmans Bay	Subtidal	Mixed-Coarse	U.W. Miller
Drayton Harbor	Intertidal	Mud	W.W.S.C.
Eagle Cove	Intertidal	Sand	U.W. Nyblade
Eagle Cove	Subtidal	Eelgrass	U.W. Miller
East Sound	Subtidal	Mud	U.W. English
East Sound	Subtidal	Open water	U.W. English
Fidalgo Bay	Intertidal	Mud	W.W.S.C.
Fidalgo Bay	Subtidal	Mud	W.W.S.C.
Fidalgo Head	Intertidal	Rock	W.W.S.C.
Fidalgo Head	Subtidal	Sand	W.W.S.C.
Guemes Channel	Subtidal	Sand	U.W. English
Guemes Channel	Subtidal	Open water	U.W. English
Guemes Ils. E.	Subtidal	Sand	W.W.S.C.
Guemes Ils. E.	Intertidal	Sand	W.W.S.C.
Guemes Ils. S.	Intertidal	Mixed-Fine	W.W.S.C.
Guemes Ils. S.	Subtidal	Eelgrass	W.W.S.C.
Legoe Bay	Intertidal	Mixed-Coarse	W.W.S.C.
Legoe Bay	Subtidal	Eelgrass	W.W.S.C.
Padilla Bay	Intertidal	Mud	W.W.S.C.
Padilla Bay	Subtidal	Eelgrass	W.W.S.C.
Point George	Subtidal	Kelp	U.W. Miller
Point George	Subtidal	Rock	U.W. Nyblade
Point Migley	Intertidal	Rock	W.W.S.C.
Shannon Point	Intertidal	Mixed-Coarse	W.W.S.C.
Shannon Point	Subtidal	Sand	W.W.S.C.
South Beach	Intertidal	Mixed-Coarse	U.W. Nyblade
Webb Camp	Intertidal	Mixed-Fine	U.W. Nyblade
Westcott Bay	Intertidal	Mud	U.W. Nyblade
Westcott Bay	Subtidal	Eelgrass	U.W. Miller

reports dated October 30, 1974.

The distribution of general habitat types has been inventoried for the intertidal zone of Northern Puget Sound using aerial photography (see pages 20, 21 and 22). Area specific correlation with existing Shoreline Management Inventories and field checks will begin this spring. Based on a gross evaluation of line miles along beaches and around mud flats and salt marshes, the abundance of the different habitat types other than open water are listed in Table 4 (see page 23). These data are crude and subject to revision based on further analysis this spring.

ECONOMIC ASSESSMENT

INTRODUCTION

Dr. James Crutchfield and his staff from the Institute of Marine Studies of the University of Washington were retained to conduct the economic studies of the North Puget Sound Baseline Program.

The economic analysis center around species of fish, shellfish and birds which are commercially important. The marine biologist is determining the important food items of these species and the ecological relationship in order that the economist can more precisely assign values for the marine natural resources of the area, as well as the value for recreation and land of the area.

The economic worth of an area consists of many factors. There are the values of: harvestable natural resources, such as commercial fisheries; the sport harvested fish and the wild fowl which has a "meat value" but also a much greater value in terms of what people are willing to pay to catch a fish or shoot a duck; the nonhunted birds who are observed by amateur naturalists and hikers; of recreation activities, such as scuba diving, boating, shore side parks

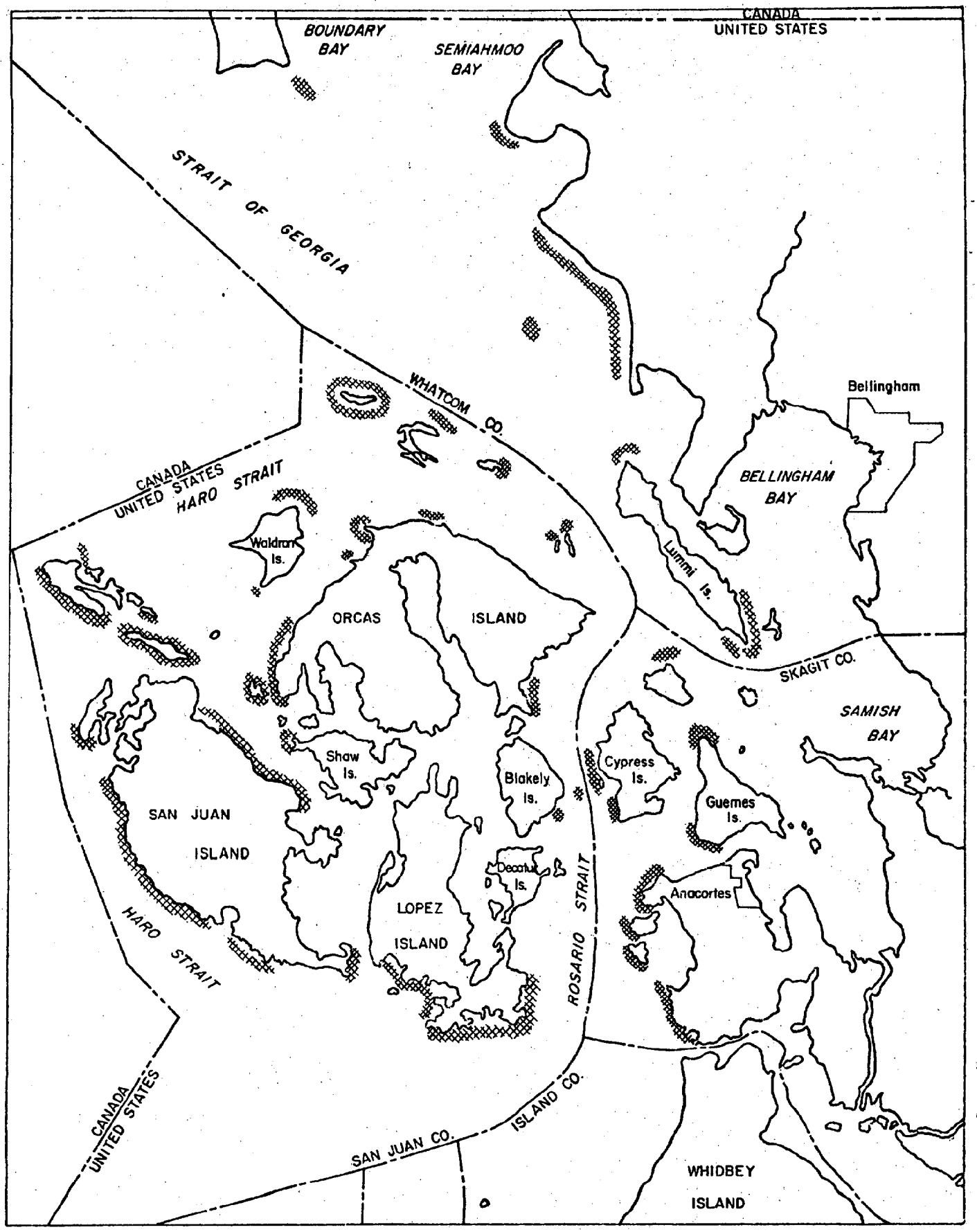


Figure 2 : DISTRIBUTION OF GENERAL HABITAT TYPES IN NORTHERN PUGET SOUND - KELP.

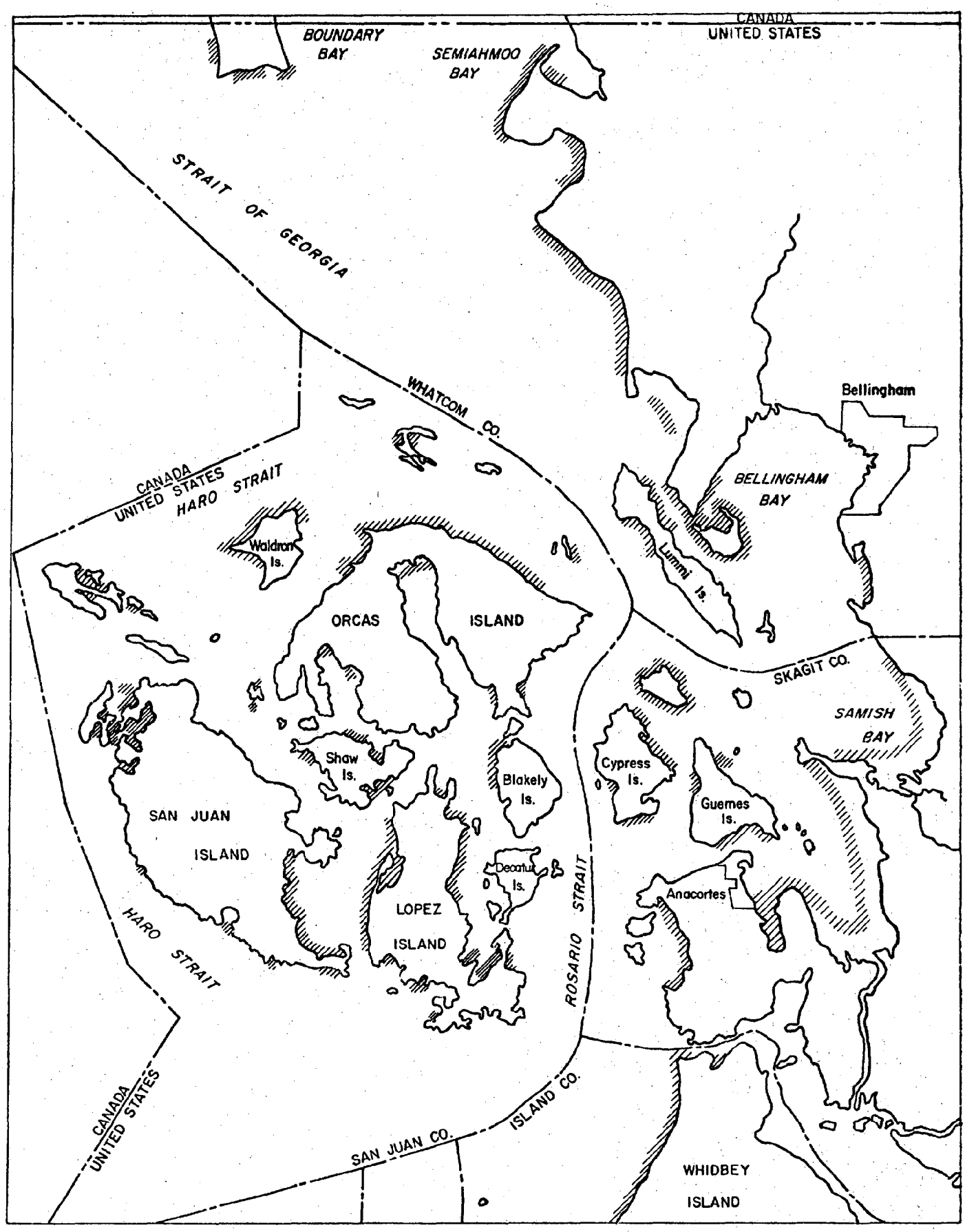


Figure 3: DISTRIBUTION OF GENERAL HABITAT TYPES IN NORTHERN PUGET SOUND - EELGRASS.

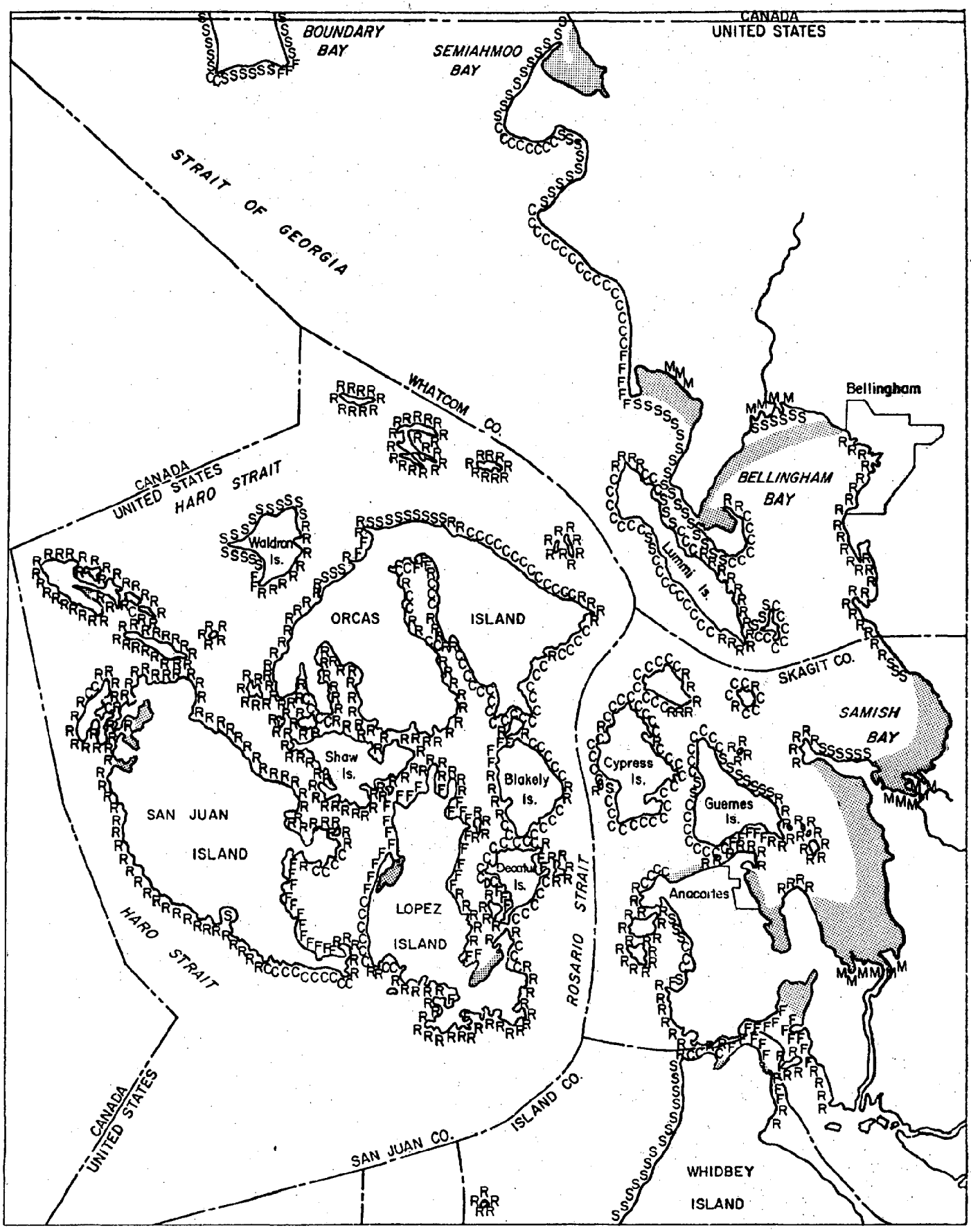


Figure 4 : DISTRIBUTION OF GENERAL HABITAT TYPES IN NORTHERN PUGET SOUND — ▒-MUD, S-SAND, F-MIXED FINE, C-MIXED COURSE, M-SALT MARSH, R-ROCK, OTHER AREAS ARE OPEN WATER.

TABLE 4

ESTIMATED RELATIVE ABUNDANCE OF GENERAL NONLIVING HABITAT TYPES IN NORTHERN PUGET SOUND

HABITAT TYPES	PERCENTAGE OF BEACHES
Nonliving	
Rock	45
Mixed Course	20
Mud	15
Sand	11
Mixed Fine	9
TOTAL	100
Living	
Kelp	20
Eelgrass	31
Salt Marsh	4
TOTAL	55

and recreation areas; and the real estate property value of the area.

The economic costs of an oil spill are not measured simply by totaling the dollars spent on clean up and restoration. The costs must also be measured in terms of opportunities which are eliminated by decreases in usefulness resulting from damage as well as direct and indirect losses of harvestable natural resources.

COMMERCIAL FISHERIES

Nature fluctuates in its productivity and species composition between seasons as well as years. Therefore, a program of this type will always encounter problems of quantification relative to both time and place. The amount of damage to commercial fisheries by an accidental oil spill would depend on the season and the place where the spill would occur.

If a spill occurred during a fishing season, it is unlikely that either fishermen or those involved in fish processing could switch their efforts to alternate fishing sites or production, therefore, a direct economic loss might be realized.

In addition, an oil spill in specific places could directly endanger individuals of sensitive species. For example, the commercial fishery effort in the North Puget Sound area and adjacent waters could be directly damaged in terms of adult loss or more likely in terms of either loss of young salmon or food items of young or adults.

The damage would be greater to young members of a species and their food items due to their sensitivity to oil toxicity and their utilization of the tidal and subtidal habitats so that losses of their food items, or losses of substantial numbers of young, would lead to a reduction in the potential adult population which would

reduce the gross value of the fishery. Losses to the young members of the species would not be fully realized for several years in the future.

The total gross value (1973) of the commercial fisheries catch of species which may depend upon Puget Sound is $144,602,619, as shown in the following table:

COMMERCIAL FIN FISH (INCLUDING CANADIAN)	$141,100,890
MOLLUSC AND SHELLFISH	$ 3,218,039
SALMON EGGS FROM CATCH	$ 283,690
TOTAL	$144,602,619

It is not possible to predetermine the value of a temporary ecological impact such as an accidental oil spill because of not knowing the time and place where this would happen. Such spills may be costly and can reduce the productivity of the affected area.

There is usually a recovery of the ecosystem after varying lengths of time in the case of an accidental petroleum spill. However, the indirect permanent changes of chronic pollution of hazardous material, including petroleum, are subtle and broad in nature and will cause the greatest damage in the long run.

In the case of the accidental petroleum spill, the salmon fisheries would be reduced and most of the shellfish in the contaminated area would be damaged or killed, whereas, a situation of chronic pollution could eventually eliminate the total fisheries of the area.

The North Puget Sound area salmon fishery had a gross annual value of $25,119,344, as shown by Table 5. This table indicates the area in which the salmon were caught, the method used in catching the fish, and the species of the salmon.

TABLE 5
VALUE OF COMMERCIAL SALMON AT 1973 PRICES IN
THE NORTH PUGET SOUND AREA, 1973 CATCH, SPECIES AND VALUE

AREA AND METHOD OF CATCH	COHO	PINK	CHUM	CHINOOK	SOCKEYE	COMMERCIAL SALMON TOTAL VALUE
POINT ROBERTS:						$ 9,910,549
Gill Net	576,074	264,521	---	94,682	1,559,198	
Indian Set Net	7,299	1,935,056	3,124	1,103	48,405	
Purse Seine	503,220	4,271	538,083	486,166	3,887,193	
Reef Net	83	569	---	68	1,434	
NOOKSAK RIVER:						1,122,119
Gill Net	4,199	86,294	279	500,163	7,257	
Indian Set Net	160,705	2,866	78,886	280,400	1,070	
BELLINGHAM BAY:						24,562
Purse Seine	599	949	30	22,776	208	
STUART ISLAND:						872,850
Gill Net	1,680	743	2,206	10	168	
Purse Seine	196,460	380,316	126,167	14,564	69,582	
Reef Net	14,937	42,571	2,430	2,147	18,869	
SALMON BANKS:						10,635,114
Gill Net	467,401	386,415	377,965	44,030	2,958,213	
Indian Set Net	482	1,360	---	206	60,985	
Purse Seine	650,387	1,893,406	399,711	136,453	3,249,142	
Reef Net	1,232	3,586	640	1,370	2,130	
SAN JUAN CHANNEL:						219,383
Gill Net	611	540	240	21	287	
Indian Set Net	---	---	---	---	---	
Purse Seine	11,381	45,000	6,138	2,984	671	
Reef Net	13,881	65,301	3,831	2,742	65,755	
ROSARIO STRAITS:						1,278,876
Gill Net	112,639	76,025	84,648	39,337	---	
Indian Set Net	1,070	2,702	21	461	---	
Purse Seine	187,522	272,168	147,074	122,151	---	
Reef Net	44,478	145,831	19,357	23,392	---	
SKAGIT BAY:						451,820
Indian Drag Seine	7,259	53,156	15	28,732	247	
Gill Net	41,895	47,551	788	102,083	634	
Indian Set Net	19,521	30,431	13,823	74,431	460	
Purse Seine	364	6,989	63	---	---	
Reef Net	---	---	---	---	---	
Indian Trap	8,153	5	643	10,634	3,943	
WEST BEACH:						453,434
Gill Net	36,035	23,001	6,061	38,776	68,173	
Purse Seine	35,119	171,197	2,110	19,942	53,020	
Indian Set Net	---	---	---	---	---	
SAMISH BAY						150,637
Gill Net	158	247	---	146,196	91	
Indian Set Net	27	112	698	3,039	69	
NORTH SOUND						$25,119,344

Out of the price they receive at the dock, the commercial fishermen pay their costs of catch. This will reduce the values received from commercial harvest to a net benefit basis. There are certain fixed costs but the variable cost of component of the total cost changes with changes in productivity of the fishing effort.

Thus, if the cost of fishing becomes greater than realized from the sale of fish, it is obvious that commercial fishing will eventually halt. This can be directly related to loss of productivity in the fishing areas.

SPORT HARVESTED FISH AND BIRDS

Sport harvested species in North Puget Sound area which generally depend upon the environment afforded them are the anadromous, pelagic, and bottom-dwelling finfishes, shellfishes and game birds.

The physical evidence of the value of hunting or fishing is the "meat worth" of the duck or salmon. Also, there is a value for the recreational experience over and above the meat value. This is an amount people are willing to pay to shoot ducks or catch salmon.

The summary of these annual approximations, based on 1973 prices, for the highest and lowest figures for the last three years for North Puget Sound are from $1,287,000 to $3,815,000 for "meat worth" and from $13,860,000 to $18,266,000 for net benefit value, which is the recreational benefit plus the "meat worth."

The following table gives a comparison of "meat values" to "net benefits" for North Puget Sound for the species and categories indicated. The system of arriving at these values has been developed in the economic appendix.

SPECIES AND CATEGORY	MEAT VALUE	NET BENEFITS
MARINE CAUGHT SALMON	$1,000,000 to $1,600,000	$11,800,000 to $14,600,000
FRESHWATER SALMON	$ 54,000 to $1,980,000	$ 574,000 to $ 2,039,000
SHELLFISH	$ 206,000	$ 719,000
STEELHEAD	$ 27,000 to $ 29,000	$ 56,000 to $ 117,000
DUCKS AND GEESE	No commercial values for wild fowl	$ 711,000 to $ 791,000
TOTAL	$1,287,000 to $3,815,000	$13,860,000 to $18,266,000

NONHUNTED BIRDS

There are at least two ways of establishing values for nonhunted birds. One way would be to consider the recreational value that is afforded to amateur naturalists and hikers in the area for water-related birds.

It is difficult to assign a single set value which would describe what each individual would be willing to pay for the privilege of observing the nonhunted birds. A range of values could be somewhere between $2.50 and $20 per watching day as shown in the appendix on economics. Considering organized chapters of Audubon Society, of which there are over 7,000 members, hikers and other individuals, a conservative number of recreation days would be in the order of 30,000 per year which would give a range of values from $75,000 to $600,000.

The recreation days per year for all those belonging to organized amateur naturalist groups or as an individual hiker who enjoys the sight of water-related nonhunted birds is considerable.

Another way to consider the value of nonhunted birds is to evaluate the cost of protecting or salvaging the bird on the theory that if pollution takes place, resources will be spent for their restoration. Even if the expenditures occur, there is no guarantee that the birds hit by oil spills will survive.

From data developed in the Guemes Island 1971 spill and the Manchester Beach spill, the cost of treatment per bird was relatively high and averaged about $3,00 per bird. There is an additional cost of post cleaning care and feeding which will add to basic cost. There is no guarantee that 100 percent survival can be achieved and this factor would also increase the cost per bird. At a ten percent survival, the cost is estimated to be $30.00 per bird.

Past experience in the North Puget Sound area has documented that nonhunted birds will be involved in oil spills. There will be a loss in numbers of these birds and there will be many dollars spent in their clean-up. If chronic pollution is involved, the water-oriented nonhunted birds may be affected in that their source of food may diminish and they would no longer locate in the area. In both cases of pollution, there is risk of reducing the numbers as well as diversity of birds which will result in reduction in the value of the area.

A list of species which would be affected and their numbers as reported by the Christmas bird counts of the local Audubon chapters are shown in Table 6 (see page 30). This indicates the extent of the potentially endangered population in the areas counted. In addition, because rare birds are valued highly, those which are less common in these counts may be especially valuable and worth protecting.

TABLE 6

WATER-RELATED BIRD POPULATIONS FOR SELECTED PUGET SOUND AREAS, 1973, CHRISTMAS BIRD COUNT, AUDUBON SOCIETY

SPECIES GROUP	BELLINGHAM, WASH. AREA	PADILLA BAY-GUEMES ISL.-DECEPTION PASS	SAN JUAN ISLAND-B. C. (BOAT)
LOONS	275	238	125
GREBES	8,051	4,083	383
CORMORANTS	231	667	345
EGRETS AND HERONS	55	104	6
SWANS	30	1	0
GEESE AND BRANTS	226	8,700	0
DUCKS	10,494	7,898	772
EAGLES	9	16	8
OSPREYS, HAWKS, AND FALCONS	14	12	1
RAILS, COOTS, OYSTER CATCHERS	913	123	0
PLOVERS, SURFBIRDS, TURNSTONES	145	179	40
YELLOWLEGS, SNIPES, SANDPIPERS	5,790	11,487	0
GULLS AND TERNS	4,650	3,270	1,625
MURRES	244	640	1,259
GUILLAMOTS	6	66	77
MURRELETS	27	145	28
AUKLETS	0	0	9
(SNOWY) OWLS	32	79	0
KINGFISHERS	17	0	2
RAVENS AND CROWS	0	0	12
BLACKBIRDS AND COWBIRDS	1,694	1,750	4
CROSSBILLS AND SONG SPARROWS	717	750	0
TOTAL	33,620	40,208	4,696

OTHER RECREATION

SCUBA DIVING

SCUBA diving in Puget Sound has been increasing. Diver certification has increased an average of 30 percent per year since 1968. The 25,000 divers in the Puget Sound area generate approximately 750,000 "diving days" which has been valued at $10,250,000. The preferred diving areas are in the San Juan Islands.

Accidental oil spills would curtail this activity until it was cleaned up and safe to dive again. However, if a chronic condition caused a reduction in productivity of the biology, the use of the area would dwindle to the point where the area would not be preferred or utilized.

BOATING

The North Puget Sound offers one of the most attractive areas in the world for boating. Eliminating rowboats, canoes, rubberrafts, etc., there are 144,400 boats in Puget Sound.

Boating activity during 1972 cost $125,477,000 which includes purchase of boats, engines, trailers, accessories, parts, storage, docking, and fuel.

The average boat-owner consumed 28 "boating days" a year with a total of 4,043,200 activity days, at a cost of $32 per day, which would be valued at over $125 million. Half of this could be accounted for in North Puget Sound area.

PARKS ON PUGET SOUND

There are at least 206 public recreation sites on Puget Sound which contain 177 miles of shoreline. These are sites administered by all levels of government, and were visited by 22,899,000 persons during 1970, which has been valued at $1 per person, per day. In addition, camping and moorage fees at these parks were

over $2,000,000. A lower value for total public park recreational use of Puget Sound is $24,899,000.

Since many of the park sites are located in the North Puget Sound area and are frequented on the basis of their shorelines, if these shorelines were damaged by pollution, there would be a percentage reduction depending on the usefulness of the area.

PROPERTY VALUES

Land values are determined by a multitude of characteristics. In order to simplify value estimates, only unimproved land with shoreline access were considered. There are approximately 1,746 miles of shoreline in Puget Sound that are unimproved. The average foot frontage per parcel in the sample is 325 feet. The average parcel size was 18,953.32 square feet, or slightly over four acres, and the average depth was 560 feet from mean high tide.

The premium value per square foot of land was determined to be 33.8¢, therefore, the capitalized premium would be about $1,744,949,600, and at an annual rate of 5 percent rate of interest, this is equivalent to an annual rental premium of $87,247,480.

Within the North Puget Sound region, there are 782 miles of shorelines, which would account for a capitalized premium of $781,529,500, or an annual rental premium of $39,076,475.

Because access to unspoiled waterfront is a characteristic for which people are willing to pay a premium, any action which reduces the value of such property available implies a sacrifice by society of some of the desirable commodity; namely the amenities, or expected future amenities, which were the reasons of the premium in the first place. Pollution and threat of pollution of hazardous materials, including accidental and chronic petroleum spills, will reduce the

value of the associated property. Considering the calculated values to be a conservative estimate since improved properties were not considered, and would run higher, the percentage degradation may be very small but will represent a very substantial sum in terms of reduction of the premium value and resultant rental worth.

SUMMARY OF THE ECONOMIC ASSESSMENTS

As the biological inventories in the North Puget Sound area are more complete and the relationship of the food web and general ecology are better understood, economic values can be refined and additional values developed. The economist can then relate more precise values for each area and species.

Much of the economic worth of the Puget Sound is found in the value derived from marine-related recreational experience.

Sport fishing and hunting are evaluated through use of field studies in which sportsmen were asked to indicate the value they placed on their hunting and fishing experience. Waterfront property is evaluated through a survey of recent real estate transactions. Other recreational experiences are evaluated in terms of utilization day or other values which although not necessarily based on detailed field studies appear reasonable to the authors. The present water quality of Puget Sound supports a commercial fishing and tourist industry of considerable magnitude. These industries in turn provide expenditure streams which support other state commerce. Regional input/output analysis permits the estimation of commerce dependent upon these industries. The following table reports results of such an analysis:

	FISHERIES	OUT-OF-STATE TOURISTS
AGRICULTURE	$ 13,800,000	$ 28,900,000
MANUFACTURING	$ 27,400,000	$ 20,600,000
CONSTRUCTION	$ 6,300,000	$ 6,800,000
SERVICES	$ 27,200,000	$ 70,300,000
COMMUNICATIONS/UTILITIES	$ 8,400,000	$ 11,000,000
TRADES	$ 31,800,000	$ 65,400,000
FINANCE/INSURANCE/REAL ESTATE	$ 9,900,000	$ 11,400,000
HOUSEHOLD INCOMES	$121,000,000	$119,000,000
STATE & LOCAL GOVERNMENT REVENUE	$ 18,900,000	$ 19,700,000

The processed value of the Puget Sound commercial fisheries harvest was $109 million in 1973. This industry and those dependent on its expenditures in the Washington economy provided incomes of $121 million to Washington households and $18.9 million to state and local government. Expenditures by out-of-state tourists visiting the Puget Sound region for recreational purposes were $130 million in 1973. This expenditure stream and the commerce it supported provided incomes of $119 million to Washington households and $19.7 million in state and local government revenues.

The North Puget Sound area value is conservatively estimated to be between $888 and $972 million as shown in the following table:

	LOW	HIGH
SPORT HARVESTED FISH AND BIRDS (NET BENEFIT)	$ 1,287,000	$ 3,815,000
NONHUNTED BIRDS (RECREATIONAL VALUE)	$ 75,000	$ 600,000
RECREATION		
SCUBA DIVING DAYS	$ 5,125,000	$ 10,250,000
BOATING ACTIVITY DAYS	$ 62,738,500	$125,477,000
PARKS RECREATIONAL USE	$ 12,449,500	$ 24,899,000
PROPERTY VALUE (1973)	$781,529,500	$781,529,500
COMMERCIAL SALMON FISHERIES (1973)	$ 25,119,344	$ 25,119,344
TOTAL	$888,323,844	$971,688,844

This represents only a part of the unprocessed marine resources, a conservative estimate of the land values, and recreational value of the area. If these values were reduced by only 10 percent by accidental or chronic pollution, the first year's depreciation would amount to between $88.8 and $97.1 million.

RECOMMENDATIONS

In view of the great value of the North Puget Sound area in natural resources, recreational opportunities and land values, it is recommended that:

1. Minimize the risk of either an accidental petroleum spill or of other hazardous material.
2. Maintain the marine water quality guarding against chronic pollution by petroleum or other hazardous material.

THE MARINE AND ESTUARINE HABITATS OF WASHINGTON

Baseline Studies Program
Department of Ecology

August 1974

ATTACHMENT A

INTRODUCTION

The marine and estuarine lands and waters of Washington contain a diverse assemblage of habitats. These habitats are composed of a variety of substrate types, occur at various depths, and are bathed by waters of varying physical and chemical make up. Because of this habitat diversity, the biological components of Washington's marine and estuarine environment are also diverse. Certain organisms are found exclusively within one habitat type, while others can live in several habitats either as an adult or sequentially during their life history. However, habitat types are not infinite in variety, rather they can be defined on the basis of a few general types and their associated organisms likewise identified.

As a general rule then, to study a representative number of specific areas containing common habitat types would provide data useful in describing all such habitat types.

Therefore, because of time, money, and environmental damage, prohibit sampling of every beach and subtidal area in Washington, we can use the habitat concept in meeting the survey needs of the Baseline Study Program. This means that at the outset of the study we chose several representative habitat types that seemed, from past experience, to be common. We then chose specific areas that appeared to be representative of each type. Each area will then be sampled in enough detail that a statistical statement can be made about that beach as (1) a separate ecological unit on its own, and (2) a representative of like habitat types in other comparable areas around the sound. This method will work to a limited degree based on a literature review and this year's field data; but to put statistical bounds upon the variation between areas, more spatially diverse data is needed than a one year study can generate. We then hope to inventory these habitats that are in the intertidal zone throughout the study area and the State using aerial photography. Subtidal areas must await the development and employment of an underwater camera system for rapidly acquiring bottom data over large areas.

The result of this activity would be a series of maps and text on the distribution and abundance of habitat types and discussion of the species composition, of abundance, seasonal use, etc., of each habitat type.

HABITAT TYPES

The following general habitat types, based mainly on substrate characteristics, has been adopted by the Baseline Studies Program.

Rock
Sand
Mud
Mixed Coarse
  Boulder, gravel, sand
Mixed Fine
  Gravel, sand, mud
Eelgrass bed
Kelp bed
Salt Marsh
Open water

The vertical zonation and specific substrate characteristics associated with each habitat are detailed in the Baseline Studies Program publication entitled, "Vertical Zonation and Substrate Characteristics of the Marine and Estuarine Lands and Waters of Washington."

ROCK

The rock habitat consists of a solid substrate that can occur at any water depth, have any slope, or occur under any hydrological energy conditions. Large boulders usually can be considered representative of the same habitat. The habitat surface is stable. This habitat is abundant in North Puget Sound and occurs with low frequency elsewhere.

SAND

This habitat occurs from moderate to high energy situations. The surface can be essentially flat in small patches or where it is more extensive, the surface is not stable. The slopes are always shallow. San can occur at any depth. This habitat occurs in a number of areas either as large expanses of sand or as small patches.

MUD

Mud occurs in low energy situations, at any water depth and has a shallow slope. Clay, representative of a very fine consolidated mud, occurs rarely. Generally mud is characteristic of protected bays and deeper water with low currents. This habitat is common.

MIXED COARSE: (BOULDER, GRAVEL AND SAND)

This complex habitat is found in high to moderate energy situations, medium to shallow depths, and has a medium to shallow slope. The large boulders represent a sand habitat. The size fractions in between contain a variety of surfaces for organisms to attach to, crawl under, or hide behind or in. Such a habitat is often diverse in its faunal and floral components. This habitat is of common occurrence.

MIXED FINE: (GRAVEL, SAND, AND MUD)

This is another complex habitat which seems to have a characteristic and diverse biota. This habitat occurs in moderate to low energy situations, moderate to shallow slopes, and probably at all depths. This habitat is of moderate occurrence in North Puget Sound. It is common in other areas of Puget Sound and is characteristic of the good little neck clam beds of Washington.

EELGRASS BED

This habitat is characterized by a biological substrate rather than a physical substrate. Zostera marina and Zostera nana occur either in strips or in wide beds from three to four feet above mean lower low water (M.L.L.W.) to eight to twelve feet below M.L.L.W. They occur in moderate to low energy situations and from medium to shallow slope. The physical substrate in which the plants are rooted ranges from sand to mud, but usually a sandy mud. This habitat is common in most of the marine waters of Washington.

KELP BED

Kelp attaches to rocky substrates whether gravel or solid rock. Therefore, this biological habitat occurs in association with either a rocky or mixed coarse habitat. The energy conditions range from high to low. The depth ranges from approximately thirty to fifty feet below M.L.L.W. to two feet above M.L.L.W. This habitat is common. Slopes range from shallow to steep.

SALT MARSH

Another biological habitat, salt marshes, occur mainly above mean high water and are composed of a number of plants. The physical substrate ranges from mud to mixed fine. Energy conditions are low and slope is shallow. This habitat is rare.

OPEN WATER

This habitat is physically characterized by a lack of a solid substrate. The organisms are adapted for constant swimming or floating and rarely spend much time in other habitats except to feed or as they change to another stage in their life history. This habitat occurs in all of the marine and estuarine waters of Washington.

VERTICAL ZONATION AND SUBSTRATE CHARACTERISTICS OF THE MARINE AND ESTUARINE LANDS AND WATERS OF WASHINGTON

Baseline Studies Program
Department of Ecology
August 1974

ATTACHMENT B

INTRODUCTION

A division of the marine and estuarine lands and waters of Washington into general habitat types has been made by the Baseline Studies Program (BSP) of the Department of Ecology. This classification is as crude as the data upon which it was based, but sufficient to direct the field study portion of BSP to specific areas needing attention.

However, in order that future field surveys be undertaken with more efficiency and an increase in scientific productivity, a refined classification system has been developed. All data being gathered by BSP scientists is being analyzed on the basis of this system. The result will be a more accurate description of the habitat types of Washington.

Field data gathered by scientists, educators, and interested laymen could be of value to BSP. However, in order to permit rapid and accurate incorporation of the data into the BSP data files, the exact tidal height (or water depth) (relative to M.L.L.W) and substrate characteristics, as shown in table two, should be provided, where possible, for each sample.

TABLE 1

VERTICAL ZONATION OF THE MARINE AND ESTUARINE LANDS OF WASHINGTON*

Uppermost Horizon	Extreme high water to mean high water
High Intertidal	Mean high water to mean sea level
Middle Intertidal	Mean sea level to mean lower low water
Low Intertidal	Mean lower low water to extreme low water
Subtidal Photosynthetic	Extreme low water to lower limit of photosynthetic zone (approximately -15 meters at M.L.L.W.)
Subtidal - Non photosynthetic	Lower limit of photosynthetic zone to bed of marine waters

*Modified from Ricketts, Calvin, and Hedgpeth. Between Pacific tides. Fourth Edition. 1968

TABLE 2

SUBSTRATE CLASSIFICATION OF THE MARINE AND ESTUARINE LANDS OF WASHINGTON*

TYPE	CHARACTERISTICS
Inorganic	
Solid Rock	Continous or repeated strata
Boulder	Greater than 256mm in diameter
Cobble	64 to 256mm
Pebble-Gravel	4 to 64mm
Sand	
Very coarse	1 to 4mm
Coarse	0.5mm to 1mm
Medium	0.25mm to 0.5mm Gritty in texture
Fine	0.12mm to 0.25mm
Very fine	0.06mm to 0.12mm
Silt	0.06mm to 0.004mm
Clay	Less than 0.004mm - smooth and slick
Organic	
Shell fragments	Calcium carbonate; often contains fragments of mollusc shells.
Detritus	Accumulated wood, sticks, and other undecayed coarse plant materials.
Fibrous peat	Partially decomposed plant remains; parts of plants readily distinguishable.
Pulpy peat	Very finely divided plan remains; parts of plants not distinguishable; varies in color from green to brown; varies greatly in consistence, often being semi-fluid.
Muck	Black, finely divided organic matter; completely decomposed
Eelgrass	
Kelp	

NOTE: Data on beach geology and wave hydrodynamics indicates that beach slope and substrate characteristics are generally related to wave and/or current action. Therefore, in most cases (except for rocky areas) characterization of beaches and subtidal areas by substrate type will be providing information on the beach slope and wave and/or current energy history.

*As modified by Langer and Roelufs, 1944 and the Wentworth scale as modified by Udden.

TABLE 3

ZONATION OF THE MARINE AND ESTUARINE WATERS OF WASHINGTON

Surface	Surface to -1.0 meters
Midwater-photosynthetic	-1.0m to lower limit of photosynthetic zone (approximately -15m from M.L.L.W).
Midwater-nonphotosynthetic	Lower limit of photosynthetic zone (approximately -15m from M.L.L.W.) to within 1.0 of the bottom.
Bottom	Within 1.0m of the bottom

SIGNIFICANT BIOLOGICAL RESOURCES

OF

WASHINGTON

REVISION

Land and Marine Analysis Program
Department of Ecology
January 1975

ATTACHMENT C

INTRODUCTION

In accordance with Objective three of the Department of Ecology's Oil Baseline Study Plan of April 1974, the following species of marine oriented animals and plants have been placed on the Significant Biological Resources list on the basis of one or more of the following criteria.

1. Commercially obtained for food or for industrial products.

2. Recreationally important.

3. A known important food item of a commercial or recreational species.

4. A known important predator or competator on a commercial or recreational species.

Additional species will be added to the list as future research adds to our knowledge of the food webs of the marine environment and as the geographic coverage of the Baseline Study is expanded.

MAMMALS

Scientific Name	Common Name
Lutra canadensis	River otter
Eumetopias jubata	Northern sea lion (steller)
Phoca vitulina	Harbor seal
Callorhinus ursinus	North Pacific fur seal
Orcinus orca	Pacific killer whale
Globicephala scammonii	Pacific blackfish
Phocoena phocoena	Pacific harbor porpoise

BIRDS: Offshore Feeders

Scientific Name	Common Name
Gavia immer	Common Loon
Gavia arctica pacifica	Pacific Arctic Loon
Gavia stellata	Red-Throated Loon
Podiceps grisegena holbollii	Holboel Red-Necked Grebe
Podiceps auritus cornutus	Horned Grebe
Podiceps nigricollis californicus	American Eared Grebe
Aechmorphus occidentalis	Western Grebe
Phalacrocorax auritus cincinatus	White-Crested Cormorant
Phalacrocorax auritus albociliatus	Northwestern Double-Crested Cormorant
Phalacrocorax auritus	Double-Crested Cormorant
Phalacrocorax penicillatus	Brant's Cormorant
Phalacrocorax pelagicus resplendens	Baird Pelagic Cormorant
Olor columbianus	Whistling Swan*
Branta canadensis occidentalis	Western Canada Goose*
Branta nigricans	Black Brant*
Anser albifrons frontalis	Pacific White-Fronted Goose*
Chen caerulescens caerulescens	Lesser Snow Goose*
Anas platyrhynchos platyrhynchos	Mallard*
Anas acuta	Pintail
Anas crecca coralinensis	Green Winged Teal
Anas americana	American Wigeon
Anas clypeata	Northern Shoveler
Aythya valisineria	Canvasback
Aythya marila nearctica	Greater Scaup
Aythya affinis	Lesser Scaup
Bucephala clangula americana	Common Goldeneye
Bucephala islandica	Barrow's Goldeneye
Bucephala albeola	Bufflehead
Clangula hyemalis	Oldsquaw
Histrionicus histrionicus	Harlequin Duck
Melanitta deglandi dixoni	Western White-Winged Scoter
Melanitta perspicillata	Surf Scoter
Melanitta nigra	Black Scoter
Mergus merganser americanus	Common Merganser
Mergus serrator	Red Breasted Merganser
Fulica americana americana	American Coot*
Stercorarisus parasiticus	Parasitic Jaeger
Larus galucescens	Glaucous-Winged Gull*
Larus occidentalis occidentalis	Western Gull*
Larus argentatus	Herring Gull*
Larus californicus	California Gull*
Larus delawarensis	Ring-Billed Gull*
Larus canus	Mew Gull*
Larus philadelphia	Bonaparte's Gull
Larus heermanni	Heermann's Gull*
Larus thayeri	Thayer's Gull*
Sterna hirundo hirundo	Common Tern
Uria aalge californica	Common Murre
Cepphus columba	Pigeon Guillemot
Brachyramphus marmoratus marmoratus	Marbled Murrelet

BIRDS: Offshore Feeders (Continued)

Scientific Name	Common Name
Ptychoramphus aleutica	Cassin's Auklet
Cerorhinca monocerata	Rhinoceros Auklet
Lunda cirrhata	Tufted Puffin
Steganopus tricolor	Wilsons Phalorope
Lobipes lobatus	Northern Phalorope

*also found on shore

BIRDS: Shorebirds

Scientific Name	Common Name
Ardea herodias fannini	Northwestern Great Blue Heron
Numenius phaeopus	Whimbrel
Actitis macularia	Spotted Sandpiper
Heteroscelus incanum	Wandering Tattler
Tringa melanoleucus	Greater Yellowlegs
Tringa flavipes	Lesser Yellowlegs
Calidris canutus rufa	American Knot
Calidris melanotos	Pectoral Sandpiper
Calidris minutilla	Least Sandpiper
Calidris alpina	Dunlin
Limnodromus griseus caurinus	Short-Billed Dowitcher
Limnodromus scolopaceus	Long-Billed Dowitcher
Calidris mauri	Western Sandpiper
Calidris alba	Sanderling
Heamatopus bachmani	Black Oystercatcher
Charadrius semipalmatus	Semipalmated Plover
Charadrius vociferus vociferus	Killdeer
Pluvialis squatarola	Black-Bellied Plover
Aphriza virgata	Surfbird
Arenaria interpres	Ruddy Turnstone
Arenaria melanocephala	Black Turnstone

BIRDS: Casual Marine Feeders

Scientific Name	Common Name
Megaceryle alcyon	Belted Kingfisher
Corvus caurinus	Northwestern Crow
Haliaeetus leucocephalus	Bald Eagle
Pandion haliaetus	Osprey

FISHES: Demersal-epibenthic

Scientific Name	Common Name
Anoplopoma fimbria	Black cod
Ophiodon elongatus	Lingcod
Citharichthys sordidus	Pacific sand dab
Atheresthes stomias	Turbot
Eopsetta jordani	Petrale sole
Glyptocephalus zachirus	Rex sole
Hippoglossus stenolepis	Pacific halibut
Isopsetta isolepis	Butter sole
Lepidopsetta bilineata	Rock sole
Microstomus pacificus	Dover sole
Parophrys vetulus	English sole
Platichthys stellatus	Starry flounder
Pleuronichthys coenosus	C-O sole
Pleuronichthys decurrens	Curlfin sole
Psettichthys melanosticus	Sand sole
Hippoglossoides elassodon	Flathead sole
Lyopsetta exilis	Slender sole
Porichthys notatus	Plain fin midshipman
Gadus macrocephalus	Pacific cod
Merluccius productus	Pacific hake
Microgadus proximus	Pacific tom cod
Theragra chalcogrammus	Walleye pollock
Anarrhichthys ocellatus	Wolf eel
Sebastes alutus	Pacific Ocean perch
Sebastes brevispinis	Short spine rockfish
Sebastes caurinus	Copper rockfish
Sebastes emphaeus	Puget Sound rockfish
Sebastes flavidus	Yellowtail rockfish
Sebastes malanops	Black rockfish
Sebastes paucispinis	Bocaccio
Sebastes ruberrimus	Red snapper
Sebastes pinninger	Orange rockfish
Sebastes goodei	Chili pepper rockfish
Sebastes babcocki	Flag (red banded) rockfish
Sebastes aleutianus	Rough eye
Sebastes diploproa	Split nose
Sebastes elongatus	Greenstriped rockfish
Sebastes auriculatus	Brown rockfish
Sebastes proriger	Redstripe rockfish
Raja binoculata	Big skate
Raja rhina	Long nose skate
Hydrolagus colliei	Rat fish
Acipenser transmontanus	White sturgeon
Acipenser medirostris	Green sturgeon

FISHES: Shoreline

Scientific Name	Common Name
Salmo clarki clarki	Sea run cut throat trout
Hexagrammos decagrammus	Kelp greenling
Hexagrammos lagocephalus	Rock greenling
Hexagrammos stelleri	White spotted greenling
Enophrys bison	Buffalo sculpin
Hemilepidotus hemilepidotus	Red irish lord
Leptocottus armatus	Pacific staghorn sculpin
Oligocottus maculosus	Tide pool sculpin
Scorpaenichthys marmoratus	Cabezon
Amphistichus rhodoterus	Redtail surf perch
Brachyistius frenatus	Kelp perch
Cymatogaster aggregata	Shiner perch
Embiotoca lateralis	Striped sea perch
Hyperprosopon argenteum	Walleye surf perch
Rhacochilus vacca	Pile perch
Phanderodon furcatus	White sea perch
Apodichthys flavidus	Penpoint gunnel
Pholis ornata	Saddleback gunnel
Pholis laeta	Crescent gunnel
Sebastes maliger	Qillback rockfish

FISHES: Open Water

Scientific Name	Common Name
Alosa sapidissima	American shad
Clupea harengus pallasi	Clupea pallasii
Engraulis mordax mordax	Northern anchovy
Oncorhynchus tshawytscha	Chinook salmon
Oncorhynchus kisutch	Coho salmon
Oncorhynchus gorbuscha	Pink salmon
Oncorhynchus nerka	Sockeye salmon
Oncorhynchus keta	Chum salmon
Oncorhynchus masu	Masu salmon
Salmo gairdneri	Steelhead
Hypomesus pretiosus pretiosus	Surf smelt
Spirinchus thaleichthys	Longfin smelt
Thaleichthys pacificus	Eulachon
Mallotus villosus	Capelin
Cynoscion nobilis	White sea bass
Ammodytes hexapterus	Pacific sand lance
Squalus acanthias	Spiny dogfish

ECHINODERMS

Scientific Name	Common Name
Parastichopus californicus	Sea cucumber
Strongylocentrotus droebachiensis	Green urchin
Strongylocentrotus franciscanus	Red urchin
Strongylocentrotus purpuratus	Purple sea urchin
Pisaster orchraceus	Purple starfish
Pycnopodia helianthoides	Sunflower starfish

CRUSTACEANS

Scientific Name	Common Names
Pandalus jordani	Ocean pink shrimp
Pandalus borealis	Pink shrimp
Pandalopsis dispar	Sidestripe shrimp
Pandalus platyceros	Spot shrimp
Pandalus danae	Dock shrimp
Pandalus goniurus	Coonstripe shrimp
Pandalus hypsinotus	Coonstripe shrimp
Lopholithodes formaminatus	Box crab
Cancer magister	Dungeness crab
Cancer productus	Red rock crab
Lopholithodes mandtii	Puget Sound king crab
Orchestia traskiana	Sand flea
Idothae resecata	Beach isopod
Euphausia pacifica	Euphausid
Idothae wosnesenskii	Beach isopod

ANNELIDS

Scientific Name	Common Name
Nereis vexillosa	Pile worm

MOLLUSCS

Scientific Name	Common Name
Crassostrea virginica	Eastern oyster
Ostrea lurida	Olympia oyster
Crassostrea gigas	Japanese oyster
Crassostrea gigas kumamoto	Kumamoto oyster
Mytilus edulis	Blue mussel
Mytilus californianus	California mussel
Haliotis rufesceans	Red abalone
Haliotis kamtschatkana	Northern abalone
Saxidomus giganteus	Butter clam
Clinocardium nuttalli	Common cockle
Panope generosa	Geoduck
Tresus nuttalli	Horse clam
Tresus capax	Big neck
Mya arenaria	Soft shell clam
Venerupis japonica	Japanese little neck
Zirfaea pilsbryi	Piddock
Siliqua patula	Razor clam
Protothaca staminea	Rock or native little neck
Chlamys hastata hericia	Pacific pink shrimp
Pecten caurinus	Sea scallop
Hinnites multirugosus	Rock scallop
Chlamys hindsi	Hinds' scallop
Polinices lewisii	Moon snail
Thais lamellosa	Wrinkles purple snail
Cryptochiton stelleri	Giant gunboat chiton
Mopalia lignosa	Chiton
Urosalpinx cinerea	Native drill
Ocinebra japonica	Japanese oyster drill
Loligo opalescens	Pacific Coast squid
Octopus hongkongensis	Octopus
Octopus dofleini	Octopus

SEAWEEDS

Scientific Name	Common Name
Gigartina papillata	Red algae
Gigartina exasperata	Red algae
Iridaea cordata	Red algae
Nereocystis Luetkeana	Brown algae, bullwhip kelp
Macrocystis pyrifera	Kelp
Porphyra perforata patens	Red algae, nori
Porphyra perforata perforata	Red algae, nori
Porphyra miniata	Red algae, nori
Porphyra san jaunensis	Red algae, nori
Prophyra abbottae	Red algae, nori
Prophyra porphyra nereocystis	Red algae, nori

GRASSES

Scientific Name	Common Name
Zostera marina	Eelgrass
Phyllospadix scouleri	Surf grass

OIL BASELINE PROGRAM

OBJECTIVES AND TASKS

The objective and their respective tasks are listed below:

1. Determine the magnitude and location of recent and potential oil contamination of the marine waters of Washington.
   - A. Determine location of oil contamination
   - B. Determine type of oil.
   - C. Determine quality of oil
2. Determine the economic value of man-made structures and man's activities that would be damaged by oil pollution in the marine and estuarine waters of Washington.
   - A. List types of structures located in/on marine and estuarine waters that would be affected by oil pollution.
   - B. Determine which activities in or adjacent to marine and estuarine waters might be affected by oil pollution.
   - C. Map location of structures.
   - D. Map location of water dependent activities.
   - E. Determine the individual and collective economic value of the structures and activities for an appropriate base year that would be affected by oil pollution.
   - F. Develop a method for assessing damages against an oil polluter for negatively affecting human uses and structures of the marine environment.
   - G. Determine potential impact of oil pollution upon man's activities in the marine and estuarine waters of Washington in appropriate future years.

3. Determine and list the significant biological resources of the marine and estuarine waters of Washington.
   A. Determine the commercial organisms.
   B. Determine the recreational organisms.
   C. Determine food items of commercial organisms.
   D. Determine food items of recreational organisms.
   E. Determine organisms that otherwise directly effect commercial and recreational organisms.
   F. Determine marine oriented birds and mammals other than above that may be damaged by oil pollution.
4. Determine the economic value of significant biological researches that would be affected by oil pollution in the marine and estuarine waters of Washington.
   A. Determine economic value of commercial organisms for an appropriate base year.
   B. Determine economic value of recreational organisms for an appropriate base year.
   C. Determine economic value of food items for commercial organism.
   D. Determine economic value of food items for recreational organisms.
   E. Determine the economic value of eelgrass beds as habitats.
   F. Determine the economic value of seaweed beds as habitats.
   G. Determine economic value of organisms that otherwise directly affect commercial and recreational organisms.
   H. Determine economic value of marine oriented birds and mammals other than above that may be affected by oil pollution.
   I. Develop a method for adjusting the economic values obtained above for inflation and other variables that may vary from year to year.

J. Determine method for assessing damages against oil polluter for negatively affecting the commercial and recreational biological resources.

K. Determine method of assessing the damages against an oil polluter for negatively affecting the food items of commercial and recreational resources.

L. Determine method of assessing damages against oil polluter for negatively affecting all other significant biological resources.

5. Determine the types, distribution and abundance of major habitats in the marine and estuarine waters of Washington.

A. Prepare a list of habitats in the marine and estuarine waters of Washington.

B. Map habitat distribution in North Puget Sound.

C. Map habitat distribution in rest of marine and estuarine waters of Washington.

D. Calculate habitat abundance by region.

6. Document the distribution and abundance of biological resources and relevant oceanographic parameter in itertidal and shallow subtidal habitats.

A. Review available information on North Puget Sound.

B. Inventory these resources during all seasons in the North Puget Sound area for one year.

C. Review available information on other areas of Washington.

D. Extend inventory.

E. Monitor yearly variation in resources and parameters above in North Puget Sound area.

F. Monitor yearly variation in all marine and estuarine waters of Washington.

7. Determine how and the degree to which the significant biological resources would be affected by oil pollution.

   A. Review data on: oil spills, bioassays, and other sources as needed.

   B. Review available data on biology of significant biological resources and estimate probability of effect by oil pollution.

   C. As needed, conduct appropriate bioassays on selected biological marine organisms for various life history stages measuring uptake, retention and release by type and amount of oil.

   D. As needed, conduct appropriate bioassays on selected marine organisms for various life history stages measuring toxicity.

   E. As needed, conduct appropriate bioassays on selected marine organisms for various life history stages measuring sublethal effects.

   F. As needed, conduct appropriate bioassays on selected marine organisms for various life history stages measuring toxicity upon consumers of contaminated organisms.

   G. As needed, conduct appropriate bioassays on selected marine organisms for various life history stages measuring sublethal effects upon consumers of contaminated organism.

   H. Document the existing background level of oil in selected marine organisms during various life stages, seasons and areas as well as in marine and estuarine watersand sediments.

   I. Determine the movement and biological effects of oil entrained in deeper water and/or in sediments after oil spill.

   J. Develop oil spill biological response team to analyze short term effects from an actual oil spill.

   K. Using data from tasks A-G, and I, predict those significant biological resources that might be damaged.

8. Develop the capability of predicting the movement of oil discharged upon the water surface.
9. Determine the distribution and abundance of intertidal and shallow subtidal populations of significant biological resources that serve as major sources of recruitment for adjacent areas.

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Bureau of Sport Fisheries and Wildlife
National Oceanic and Atmospheric Administration
METRO
Sea Grant

ATTACHMENT E

OIL POLLUTION AND THE SIGNIFICANT BIOLOGICAL RESOURCES OF PUGET SOUND:

A REVIEW AND ANALYSIS OF AVAILABLE INFORMATION

PREPARED FOR

STATE OF WASHINGTON DEPARTMENT OF ECOLOGY

PREPARED BY

BEAK CONSULTANTS INCORPORATED
1336 S. W. Second Avenue
Portland, Oregon 97201

Project D2089

January 17, 1975

ATTACHMENT F

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I. INTRODUCTION

Beak Consultants Incorporated was retained by the Washington State Department of Ecology to conduct a review and analysis of the available literature on the ecology of the "Significant Biological Resources" of Puget Sound, and on possible effects of spilled oils and petrochemical products on these biota. As part of the study, fact sheets incorporating information on distribution, aspects of habitat, ecology and life history, and susceptibility to oil and petrochemical pollution were prepared for each resource species. In addition, an annotated bibliography and a written report outlining potential effects of oil pollution were supplied. In order to provide a useful finished product incorporating a large volume of material, BEAK independently devised a general computerized information sorting and retrieval system. This system, as it was used for this project, has produced composite species fact sheets and an annotated bibliography which fulfill Objective 6, Task A of Washington State's Marine Analysis Program. Objective 7, Task A and part of Objective 7, Task B have been fulfilled by computerized composite oil impact fact sheets. The remainder of Objective 7, Task B has been fulfilled by the text section of this report. Magnetic tapes including all raw information have also been provided. The organization of biological information in BEAK's part of the Marine Analysis Program has followed guidelines established by the Washington Department of Ecology. The species and habitats to be considered were also defined by the Department.

Traditional literature searches, including computerized programs, have attempted to manage information by incorporating abstracted written materials, developing annotated bibliographies, and preparing key word indices. These services are essentially the same as cross-referenced card index systems, but allow for the management of more information and faster searches of stored

sources. The search for material is shortened considerably, but the user must eventually return to the original source for specific information.

BEAK's system of computerizing data on a more detailed level was utilized here because of the unique goals of the project. Information was gathered by qualified biologists reading within their fields. Data-type information from written materials was abstracted and stored in an integrated retrievable database. The data were organized to maximize the retrieval of information in such categories as organism group, species, area of distribution, life stage, habitat, petrochemical type, and impact. The computer output from the system consists of an annotated bibliography and fact sheets which display information on distribution, habitat, and oil impact for each species in composite format. In addition to composited information, each fact sheet includes information for each species on life history, economic value, predators, prey, and comments on the article made by the reviewer. The methods section will describe methodologies employed by the computerized system in more detail.

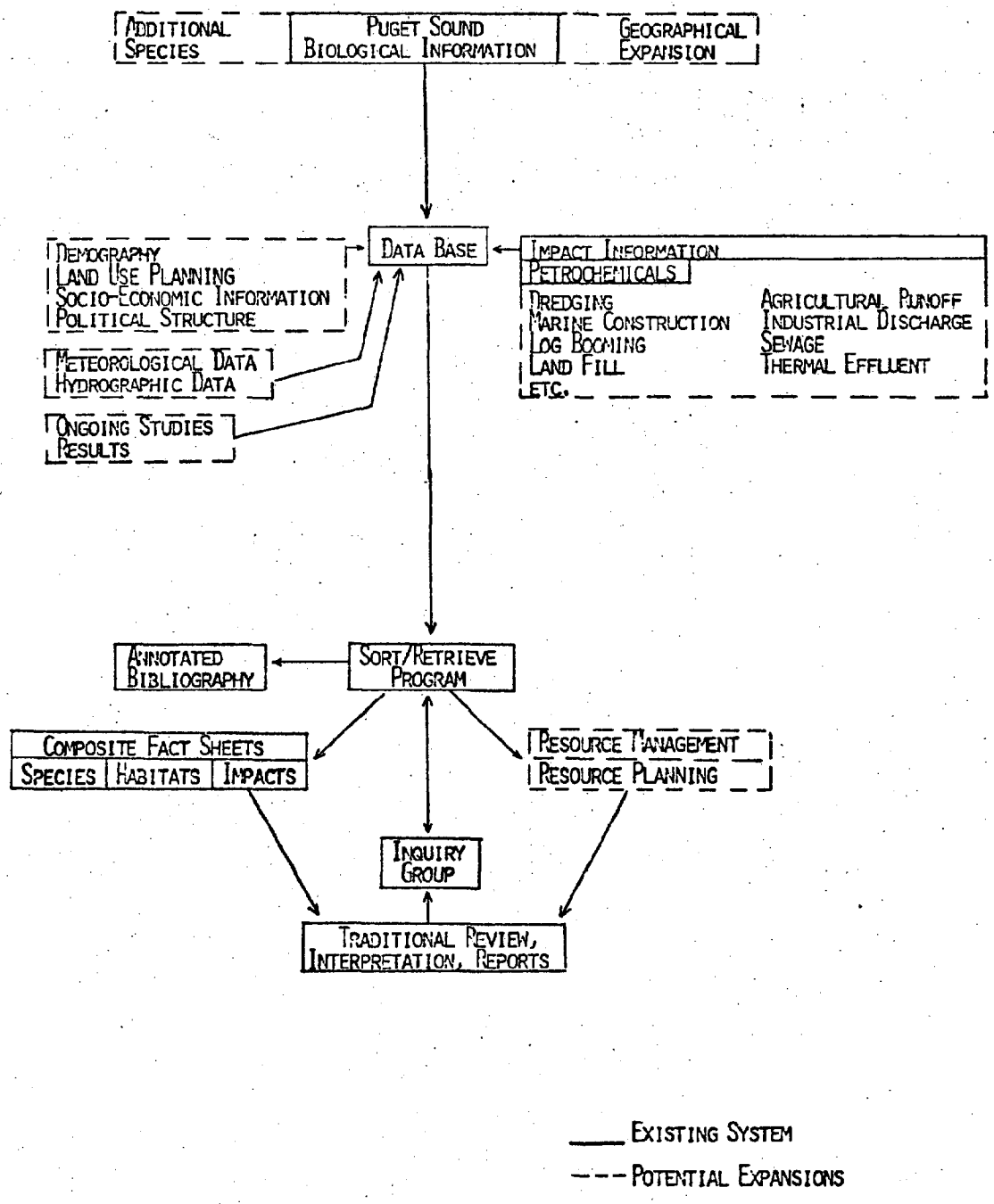
For probable oil pollution impact assessment, a total of nine general habitat types, encompasing over 150 combinations of habitat characteristics, have been considered in this study. The 250 species designated for the literature search have been assigned to thirteen broad organism groupings. By identifying these habitat types and gathering data for input on species groups, the number of organism-habitat combinations was reduced to a manageable size and it became possible to estimate impacts for each of these combinations.

A block diagram of BEAK's system as it exists (and as it can be expanded) is presented in Figure 1. All inputs have involved: (1) the reading and abstracting of articles, (2) coding and keypunching of selected materials, (3) several editorial steps, and (4) storage of the information. Information

in the output will be useful to planners and legislators concerned with projected petrochemical pollution in the Puget Sound area. Further, the output will be useful to scientists interested in examing background data on the biota of Puget Sound and, of course, the impacts of oils upon them.

If BEAK's system is expanded (as indicated in Figure 1), its application to local and regional planning, siting studies, the projection of natural resource management needs, and the assessment of actual and potential impacts of a wide variety of human activities should be apparent.

FIGURE 1


ADDITIONAL SPECIES
PUGET SOUND BIOLOGICAL INFORMATION
GEOGRAPHICAL EXPANSION
DATA BASE
DEMOGRAPHY
LAND USE PLANNING
SOCIO-ECONOMIC INFORMATION
POLITICAL STRUCTURE
METEOROLOGICAL DATA
HYDROGRAPHIC DATA
ONGOING STUDIES RESULTS
IMPACT INFORMATION
PETROCHEMICALS
DREDGING
MARINE CONSTRUCTION
LOG BOOMING
LAND FILL
ETC.
AGRICULTURAL RUNOFF
INDUSTRIAL DISCHARGE
SEWAGE
THERMAL EFFLUENT
ANNOTATED BIBLIOGRAPHY
SORT/RETRIEVE PROGRAM
COMPOSITE FACT SHEETS
SPECIES
HABITATS
IMPACTS
RESOURCE MANAGEMENT
RESOURCE PLANNING
INQUIRY GROUP
TRADITIONAL REVIEW, INTERPRETATION, REPORTS
EXISTING SYSTEM
POTENTIAL EXPANSIONS

II. METHODS

The methods used by BEAK to accomplish the purposes of this project have been briefly mentioned in the Introduction. Essentially these involved the use of a computerized sorting and retrieval system to rearrange information from the available literature into comprehensive fact sheets on distribution and habitat associations. To facilitate the review of all material entered into the system and to allow a reader to locate the original data source, an annotated bibliography, listed alphabetically by author, was also compiled by computer. The textual portion of this report serves interpretive and predictive functions.

In order to build the data-base from which composite fact sheets were derived, information was extracted from the literature and entered onto species and oil impact information sheets. The data were subsequently keypunched from these sheets directly into the data-base. The species information sheets contained the following categories for data entry:

Species
Life Stage
Area
Location
Month
Habitat
Physical-Chemical
Abundance
Predators
Food
Life History
Value
Comments

In addition to these categories, oil impact information sheets contained the following categories:

Petrochemical Studied
Impact Parameter
Impact Criterion
Dose
Result

Nine major habitat types (described below) were accessed by species, life stage, area, and time of occurrence. The habitat composite sheets are organized as follows:

Habitat Type
Vertical Zonation
Species
Life Stage
Area

Jan. Feb. Mar.

* (star indicates occurrence)

Each piece of information occurring on these fact sheets is accompanied by its reference number and the value rating that had been assigned to it.

Approximately 250 species of plants and animals were considered in this study (See Appendix B). For most of these species, the system recognizes five life stages (Tables 1 and 2), covering development from eggs or gametes to reproducing adults. "Area" refers to one of the following areas:

Open Coast	Hood Canal
Strait of Juan De Fuca	Southern Puget Sound
San Juan Archipelago	Straits of Georgia
North Puget Sound	Discovery Passage
Whidbey Basin	Greater Puget Sound
Admiralty Inlet	General (specified)
Puget Sound Basin	

"Location" is defined as closely as possible within the "Area," using latitude and longitude whenever appropriate. When available, the month during which the study was conducted is indicated. The habitat is specified as closely as possible. Definitions of terms used in habitat description are given in Table 3. The habitat designations which appear on the composite species fact sheets combine appropriate description words for each of five groups of habitat characteristics (Table 4). For example, "Demersal-benthic/Subtidal-photosynthetic/Inorganic/Mixed/Very coarse" might appear. By combining descriptors in this way, over 150 combinations of habitat characteristics can be applied to actual habitats observed in the field.

Physical-chemical data include such parameters as temperature, salinity, light, dissolved oxygen, turbidity, etc. Abundance data assume a wide variety of forms depending upon the information source. Predators and food organisms are indicated to the narrowest taxon. Life history information is entered in

paragraph form and includes such information as migration and spawning habitats, fecundity, growth patterns, etc. "Value" is a qualitative category and reflects the commercial, recreational, predator, competitor or prey status of the organism.

The petrochemical referred to in an oil impact fact sheet can be any one of the 35 crude oils and petrochemical products given in Table 5. Impact parameters have been divided into direct and indirect impacts as follows:

Direct	Indirect
Mortality	Food supply
Reproduction	Predators
Predation	Environment (specified)
Tainting	
Avoidance	
Growth	
Physiology (specified)	
Mobility	
Density (specified)	

The impact "criterion" given on oil impact fact sheets depends on the information source, and may include such entries as LD_{50}, TLM, % mortality, etc. "Dose" refers to oil exposure or treatment. The outcome of a set of experimental or observational conditions is given as the "result."

After designing the data input system described above, the literature search was begun by using commercial search services to provide an idea of the availability of pertinent information and help define the direction in which to proceed. Commercial search services were neither detailed nor comprehensive enough in their coverage to be used alone, however. Large areas of pertinent information were defined, and these were then searched in more detail.

After having been read, articles were rated regarding their usefulness to the project, not merely for their scientific excellence or validity, on a scale of 1 (excellent) to 5 (poor). Information of questionable validity is of

questionable usefulness, but information of high veracity may also be of only marginal usefulness, and may therefore receive a low rating. The suitability of the data for inclusion into the system was the major consideration behind the rating.

The storage-retrieval system conceived by BEAK uses Data Management Language (DML), a computer language provided by Computer Sciences Corporation (CSC). The program was run on a Univac 1108 computer in both timesharing and batch modes. The use of a time-sharing system has the advantage that users in several locations can simultaneously access the data-base.

To reduce the amount of computer storage space required, and to facilitate the cross-referencing of the information, codes were created for the major data input components of the program. Habitats were given a five-digit code, each digit representing one of the five classes of habitat descriptors given in Table 4. In this way, habitat zones could be combined with a large variety of substrate types and textures allowing much detailed information to be stored in limited computer space.

Other input data were coded to reflect either general ecological or oil impact information using the first digit of a two-digit code. The second digit represented parameters such as month, life stage, etc.

After the data were abstracted and coded, they were edited and then keypunched for entry into the data-base. The data-base was edited once in its "raw" state and again after the compositing process.

The output contained in the species and oil fact sheets was used as part of the basis for writing the projected impact section of this report.

Using the composited species and oil impact fact sheets, the text was

prepared to follow the logical sequence of the program's development. General impacts of oils (crudes, light products, and heavy products) on each of nine generalized habitats is discussed. Under each habitat type, each of thirteen organism groups were discussed relative to their occurrence in that habitat. The nine habitats are given in Table 6. Habitat types referred to in the text are independent of depth, and, with the exception of "open water," primarily represent substrate types. The five "mixed" habitats used in the composite fact sheets have been condensed into two in the text. "Mixed - Coarse" in the text combines "mixed/very coarse" and "mixed/coarse" from the composite sheets. "Mixed - Fine" in the text combines "mixed/medium," "mixed/fine," and "mixed/very fine" from the composite sheets. Other habitat types should be self-explanatory. Under each habitat type, each of thirteen organism groups were discussed relative to their occurrence in that habitat and their susceptibility to oil impacts in those habitats.

Each subsection of the "Expected Impact" portion of the text is followed by an indication of the reliability of the material presented in that subsection. Criteria used for assigning reliabilities are as follows:

****: Very reliable: The information presented is well documented in the literature and is supported by generally accepted biological and physical principles.

***: Reasonably reliable: The information presented is supported by generally accepted biological and physical principles and is partially supported in the literature.

**: Deductive: The information presented is supported by generally accepted biological and physical principles and is circumstantially supported in the literature.

*: Speculative: The information presented is consistent with generally

accepted biological and physical principles, and is suggested by information in the literature.

III. RESULTS - COMPUTER OUTPUT

A. Annotated Bibliography

The annotated bibliography has been organized as described in the preceding "Methods" section. Cross reference numbers relating data to the articles from which they were abstracted are listed on the composite fact sheets. At the end of each fact sheet, the author and date of publication of each article cited are listed according to reference number. An article can then be located by the author's last name in the annotated bibliography and a comparison of reference numbers will assure selection of the correct abstract.

B. Composite Species Fact Sheets

The composite species fact sheets were organized as described in the preceding "Methods" section. Information was taken from raw data sheets and compiled by the computer into a format which presents information on each species.

C. Composite Oil Impact Fact Sheets

The composite oil impact fact sheets were organized as described in the preceding "Methods" section. Information was taken from raw data sheets and compiled by the computer into a format which presents information on each oil impact.

D. Composite Habitat Fact Sheets

The composite habitat fact sheets were organized as described in the preceding "Methods" section. Habitat types were chosen to accomodate as many habitats occurring in Puget Sound as possible. The system has been constructed to allow access to data according to general habitat type for any species. Over 150 possible combinations of habitat characteristics have been condensed

into nine basic habitat types. The basic habitats correspond to combinations of descriptors given in Table 7.

TABLE 1

FORMAT EXAMPLE — SPECIES FACT SHEET

		SPP.	REF.NO	RATING
SPECIES	MACROCYSTIS PYRIFERA			
	KELP			
DISTRIBUTION				
STAGE:	SPOROPHYTE(DIPLOID)			
AREA:				
	HABITAT: LABORATORY		90	3
	PHYS-CHEM: TEMPERATURE: 17. C (OPTIMUM)		90	3
	COMMENT REFERENCE NO. 90			
AREA:	OPEN OCEAN			
	MONTH: ALL	S	24	2
	HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-NONPHOTOSYNTHETIC/INORGANIC/SOLID	S	24	2
	PELAGIC/SURFACE			
	QUANITY: 90000 METRIC TONS ANNUAL HARVEST	S	24	2
AREA:	STRAIT OF JUAN DE FUCA			
	MONTH: ALL (1911, 1912)		81	3
	HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		81	3
	COMMENT REFERENCE NO. 81			
LOCATION	: NEAH BAY		89	2
	HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		89	2
	COMMENT REFERENCE NO. 89			
AREA:	SAN JUAN ARCHIPELAGO			
	COMMENT REFERENCE NO. 78			
AREA:	GENERAL			
LOCATION	: CALIFORNIA		75	3
	MONTH: ALL		75	3
	HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		75	3
	PHYS-CHEM: TEMPERATURE: 0.-18. C (OPTIMUM)		75	3
	SALINITY: 26. 0/00 (OPTIMUM)			
	LIGHT: 48-1600 FT-CANDLES AT 15. C			
LOCATION	: CALIFORNIA		75	3
	MONTH: MAR.APR.MAY.JUN.JUL.AUG		75	3
	HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		75	3
STAGE:	MITOSPORES.MEIOSPORES			
AREA:	GENERAL			
LOCATION	: CALIFORNIA		75	3
	MONTH: ALL		75	3
	HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		75	3
	PHYS-CHEM: TEMPERATURE: 0.-18. C (OPTIMUM)		75	3
	SALINITY: 26. 0/00 (OPTIMUM)			
	LIGHT: 48-1600 FT-CANDLES AT 15. C			
STAGE:	GAMETOPHYTES(HAPLOID)			
AREA:	GENERAL			
LOCATION	: CALIFORNIA		75	3

TABLE 1 (cont.)

MONTH: ALL			75	3
HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER			75	3
PHYS-CHEM: TEMPERATURE: 0.-18. C (OPTIMUM)			75	3
SALINITY: 24. 0/00 (OPTIMUM)				
LIGHT: 48-1600 FT-CANDLES AT 15. C				
VALUE				
COMMERCIAL: DOLLARS (1958 ANNUAL HARVEST VALUE ONE MILLION DOLLARS)		S	24	2
COMMERCIAL			75	3
COMMERCIAL			81	3
LIFE HISTORY				
PHOTOSYNTHESIS: NOT PERMANENTLY AFFECTED BY SALINITIES OF 25.0 0/00 GREATER THAN OR LESS THAN THAT OF NATURAL SEAWATER IN 18-HR. EXPOSURE. LONGER EXPOSURES (5-DAY) AT 20. C IN SEAWATER DILUTED 10% TO 25% WITH DISTILLED WATER RESULTED IN LOWER PHOTOSYNTHETIC CAPACITY. GROWTH PROBABLY INCREASES ABOUT 2-FOLD FOR EVERY 10.0 C TEMP RISE. TEMPS ABOVE 18.0 C MAY POSSIBLY HAVE ADVERSE EFFECTS. GROWTH LAB EXPERIMENT: 90 DAYS. 15 METERS. 15-18 C; PHOTOSYNTHETICALLY ACTIVE IN LIGHT OF 5% SURFACE INTENSITY -- DOUBLED AREA EVERY 21 DAYS; LENGTH EVERY 24 DAYS.		S	24	2
GROWTH RATES: 7.1-50 CM/DAY FROND ELONGATION. 7.5-8.9% INCREASE/DAY IN STIPE LENGTH. DISTRIBUTIONS IN NORTH AMERICA. FROM 27 DEG. NORTH LAT. TO THE MONTEREY PENINSULA.			75	3
GROWTH RATES: 7.1-50 CM/DAY FROND ELONGATION. 7.5-8.9%. "MACROCYSTIS" HAS A DEPTH DISTRIBUTION OF 3-37.5 METERS. ITS INNER LIMITS ARE DETERMINED BY WAVE SHOCK. ITS OUTER LIMITS ARE FREQUENTLY SET BY WATER CLARITY.			75	3
SPORES ARE PRODUCED ALL YEAR LONG. WITH THE MAXIMUM PRODUCTION OF ZOOSPORES IN LATE SPRING. MINIMUM IN JANUARY. THE RELEASE OF SPORES SEEMS TO BE RELATED TO THE AMOUNT OF SUNLIGHT. AVERAGE LIBERATION RATE OF SPORES IS 3900 SPORES/4IN/SQ.CM. OF SPOROPHYLL SURFACE. THE SPOROPHYTE GENERATION BLOOMS IN SPRING. DEPENDING ON LIGHT INTENSITY. NO GROWTH OCCURS UNDER VERY DENSE CANOPIES.				
THIS KELP WHICH IS A PRIMARY PRODUCER OF PLANKTONIC MATERIAL IS PERENNIAL. HOLDFASTS CONSTANTLY REPLACE SENILE FRONDS WITH NEW ONES. MAXIMUM AGE OF INDIVIDUAL FRONDS UNDER FAVORABLE CONDITIONS IN 20 METERS OF WATER IS ABOUT SIX MONTHS.				
THE GAMETOPHYTE PRODUCED FROM THE MEIOSPORES MAY TAKE UP TO 80 DAYS TO DEVELOP AND MATURE IN THE SUMMER AS				

TABLE 1 (cont.)

COMPARED TO 130 DAYS IN WINTER.
THE GAMETOPHYTE PLANTS CAN SURVIVE FOR MORE THAN A YEAR UNDER CONDITIONS UNFAVORABLE TO YOUNG SPOROPHYTES.
YOUNG SPOROPHYTES ARE SCARCE IN WINTER. REPRODUCTIVE MATURITY OF A PLANT IS REACHED AT AGE 9-12 MONTHS.
MINIMUM TIME FOR COMPLETION OF A LIFE HISTORY CYCLE IS 12-14 MONTHS.

KELP BEDS PROVIDE SHELTER, REFUGE, AND FOOD FOR LARVAL, JUVENILE, AND ADULT STAGES OF MANY FISH.
PHOTOSYNTHESIS IS DEPENDENT ON THE PRESENCE OF DISSOLVED CALCIUM, AND IT WILL CEASE IN ONE HOUR IN ITS ABSENCE.

FOOD

PREDATORS

HALIOTUS FULGENS (ABALONE), ASTRAEA UNDOSA (WAVY TOP), NORRISIA NORRISII (TURBAN), GIRELLA NIGRICANS (OPALEYE), CRUSTACEANS, GASTROPODS, ECHINOIDS, STRONGYLOCENTROTUS FRANCISCANUS, STRONGYLOCENTROTUS PURPURATUS — S — 24 — 2

"STRONGYLOCENTROTUS SP." -- FEED ON BASE OF STIPE.
"DIDOTEA RESECATA" -- GRAZES NEAR PNEUMATOCYSTS CAUSING SLOUGHING OF HEALTHY BLADES. — 75 — 3

COMMENTS

24 — MACROCYSTIS SPP. — S — 24

78 — "MACROCYSTIS" WAS NOT FOUND ATTACHED AROUND THE ISLAND, BUT WAS WASHED ASHORE. — 78

81 — IT GROWS NEAR "NEREOCYSTIS LUETKEANA" ON THE SHORE SIDE OF THESE BEDS. — 81

89 — PROBABLY MISIDENTIFIED. THE ALGA OBSERVED WAS MOST LIKELY MACROCYSTIS INTEGRIFOLIA.

90 — THE TIME OF THE MOST RAPID TRANSLOCATION (65-78 CM/HR) OF ORGANIC PRODUCTS THROUGH THE SIEVE TUBES WAS IN MARCH. THE PEAK GROWING SEASON FOR KELP. — 90

RATINGS

```
1         2         3         4         5
*********************************************
          24  S     75                  89
                    78
                    81
                    90
```

TABLE 1 (cont.)

OIL IMPACT FACT SHEET

		SPP.	REF.NO	RATING
SPECIES	MACROCYSTIS PYRIFERA KELP			
OIL	DIESEL #2			
DIRECT IMPACTS				
STAGE	SPOROPHYTE(DIPLOID)			
PARAMETER:	PHYSIOLOGY: PHOTOSYNTHESIS		42	3
HABITAT:	LABORATORY		42	3
CRITERIA:	TEM		42	3
PHYS-CHEM:	DOSE: 0.02 MM FILM + 1% EMULSION (SHORT TERM EXPOSURE)			
RESULT:	<7 DAYS		42	3
	COMMENT REFERENCE NO. 42			
PHYS-CHEM:	DOSE: 0.02 MM FILM + 0.1% EMULSION (SHORT TERM EXPOSURE)			
RESULT:	<7 DAYS		42	3
	COMMENT REFERENCE NO. 42			
PHYS-CHEM:	DOSE: 0.02 MM FILM + 0.01% EMULSION (SHORT TERM EXPOSURE)			
RESULT:	<7 DAYS		42	3
	COMMENT REFERENCE NO. 42			
PHYS-CHEM:	DOSE: 0.02 MM FILM + 1% EMULSION (CHRONIC EXPOSURE)		42	3
RESULT:	<6 HOURS		42	3
	COMMENT REFERENCE NO. 42			
PHYS-CHEM:	DOSE: 0.02 MM FILM + 0.1% EMULSION (CHRONIC EXPOSURE)		42	3
RESULT:	<6 HOURS		42	3
	COMMENT REFERENCE NO. 42			
PHYS-CHEM:	DOSE: 0.02 MM FILM + 0.01% EMULSION (CHRONIC EXPOSURE)		42	3
RESULT:	<6 HOURS		42	3
	COMMENT REFERENCE NO. 42			
PARAMETER:	PHYSIOLOGY: PHOTOSYNTHESIS (BOTTOM BLADES)		69	2
HABITAT:	LABORATORY		69	2
CRITERIA:	1-DAY % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM:	DOSE: 0.01% OIL-SEAWATER EMULSION		69	2
RESULT:	-20%		69	2
	COMMENT REFERENCE NO. 69			
PHYS-CHEM:	DOSE: 0.1% OIL-SEAWATER EMULSION		69	2
RESULT:	-10%		69	2
	COMMENT REFERENCE NO. 69			
PHYS-CHEM:	DOSE: 1.0% OIL-SEAWATER EMULSION		69	2
RESULT:	5%		69	2
	COMMENT REFERENCE NO. 69			

TABLE 1 (cont.)

CRITERIA: 3-DAY % REDUCTION IN PHOTO. CAPACITY	69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION	69	2
RESULT: 62%	69	2
COMMENT REFERENCE NO. 69		
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION	69	2
RESULT: 95%	69	2
COMMENT REFERENCE NO. 69		
PHYS-CHEM: DOSE: 1.0% OIL-SEAWATER EMULSION	69	2
RESULT: 100%	69	2
COMMENT REFERENCE NO. 69		
PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS (SURFACE BLADES)	69	2
HABITAT: LABORATORY	69	2
CRITERIA: 3-DAY % REDUCTION IN PHOTO. CAPACITY	69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION	69	2
RESULT: 20%	69	2
COMMENT REFERENCE NO. 69		
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION	69	2
RESULT: 80%	69	2
COMMENT REFERENCE NO. 69		
PHYS-CHEM: DOSE: 1.0% OIL-SEAWATER EMULSION	69	2
RESULT: 100%	69	2
COMMENT REFERENCE NO. 69		
PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS (HALF-GROWN BOTTOM BLADES)	69	2
HABITAT: LABORATORY	69	2
CRITERIA: 2-HR % REDUCTION IN PHOTO. CAPACITY	69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION	69	2
RESULT: 5%	69	2
COMMENT REFERENCE NO. 69		
CRITERIA: 3-HR % REDUCTION IN PHOTO. CAPACITY	69	2
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION	69	2
RESULT: -5%	69	2
COMMENT REFERENCE NO. 69		
CRITERIA: 7-HR % REDUCTION IN PHOTO. CAPACITY	69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION	69	2
RESULT: 10%	69	2
COMMENT REFERENCE NO. 69		
CRITERIA: 14-HR % REDUCTION IN PHOTO. CAPACITY	69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION	69	2
RESULT: 20%	69	2
COMMENT REFERENCE NO. 69		
CRITERIA: 24-HR % REDUCTION IN PHOTO. CAPACITY	69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION	69	2
RESULT: 32%	69	2

TABLE 1 (cont.

	COMMENT REFERENCE NO. 69		
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION		69	2
RESULT: 75%		69	2
COMMENT REFERENCE NO. 69			
CRITERIA: 48-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION		69	2
RESULT: 60%		69	2
COMMENT REFERENCE NO. 69			
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION		69	2
RESULT: 100%		69	2
COMMENT REFERENCE NO. 69			
OIL FUEL OIL: NAVY			
DIRECT IMPACTS			
STAGE SPOROPHYTE(DIPLOID)			
PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS (YOUNG BLADES)		69	2
HABITAT: LABORATORY		69	2
CRITERIA: 4-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION		69	2
RESULT: 25%		69	2
COMMENT REFERENCE NO. 69			
CRITERIA: 8-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION		69	2
RESULT: 42%		69	2
COMMENT REFERENCE NO. 69			
CRITERIA: 12-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.1% OIL-SEAWATER EMULSION		69	2
RESULT: 100%		69	2
COMMENT REFERENCE NO. 69			
PARAMETER: MORTALITY		77	3
GROWTH:			
HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		77	3
CRITERIA: COMPARISON OF TOXICITY OF FUEL OIL AND DIESEL #2		77	3
RESULT: FUEL OIL IS MORE TOXIC (CLENDENNING AND NORTH, 1960)		77	3
COMMENT REFERENCE NO. 77			
PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS		77	3
HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		77	3
CRITERIA: DECREASED EVOLUTION OF OXYGEN OR PIGMENT LEACHING		77	3
RESULT: DECREASED PHOTOSYNTHESIS		77	3
COMMENT REFERENCE NO. 77			
OIL DIESEL, TRUCK			
DIRECT IMPACTS			

TABLE 1 (cont.)

STAGE: SPOROPHYTE(DIPLOID)			
PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS		77	3
HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		77	3
CRITERIA: DECREASED EVOLUTION OF OXYGEN OR PIGMENT LEACHING		77	3
RESULT: DECREASED PHOTOSYNTHESIS		77	3
COMMENT REFERENCE NO. 77			
OIL: FUEL OIL			
DIRECT IMPACTS			
STAGE: SPOROPHYTE(DIPLOID)			
PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS		42	3
HABITAT: LABORATORY		42	3
CRITERIA: FT-SIGNIFICANT (LOSS OF PHOTOSYNTHETIC CAPACITY)		42	3
PHYS-CHEM: DOSE: 1% EMULSION BOILER FUEL IN SEA WATER.		42	3
RESULT: 3 HRS.		42	3
COMMENT REFERENCE NO. 42			
PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS (YOUNG BLADES)		69	2
HABITAT: LABORATORY		69	2
CRITERIA: 8-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.05% OIL-SEAWATER EMULSION		69	2
RESULT: -10%		69	2
COMMENT REFERENCE NO. 69			
CRITERIA: 16-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.05% OIL-SEAWATER EMULSION		69	2
RESULT: +23%		69	2
COMMENT REFERENCE NO. 69			
CRITERIA: 24-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.05% OIL-SEAWATER EMULSION		69	2
RESULT: +64%		69	2
COMMENT REFERENCE NO. 69			
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION		69	2
RESULT: -14%		69	2
COMMENT REFERENCE NO. 69			
CRITERIA: 28-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.05% OIL-SEAWATER EMULSION		69	2
RESULT: 100%		69	2
COMMENT REFERENCE NO. 69			
CRITERIA: 48-HR % REDUCTION IN PHOTO. CAPACITY		69	2
PHYS-CHEM: DOSE: 0.01% OIL-SEAWATER EMULSION		69	2
RESULT: 24%		69	2
COMMENT REFERENCE NO. 69			
PARAMETER: MORTALITY		77	3
GROWTH:			
HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER		77	3

TABLE 1 (cont.)

CRITERIA: COMPARISON OF TOXICITY OF FUEL OIL AND DIESEL #2	77	3
RESULT: FUEL OIL IS MORE TOXIC (CLENDENNING AND NORTH, 1960)	77	3
COMMENT REFERENCE NO. 77		

OIL OTHER: CRESOLS

DIRECT IMPACTS

STAGE SPOROPHYTE(DIPLOID)

PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS	77	3
HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER	77	3
CRITERIA: DECREASED EVOLUTION OF OXYGEN OR PIGMENT LEACHING	77	3
RESULT: DECREASED PHOTOSYNTHESIS	77	3
COMMENT REFERENCE NO. 77		

OIL OTHER: PHENOLS

DIRECT IMPACTS

STAGE SPOROPHYTE(DIPLOID)

PARAMETER: PHYSIOLOGY: PHOTOSYNTHESIS	77	3
HABITAT: BENTHIC-DEMERSAL/SUBTIDAL-PHOTOSYNTHETIC/INORGANIC/BOULDER	77	3
CRITERIA: DECREASED EVOLUTION OF OXYGEN OR PIGMENT LEACHING	77	3
RESULT: DECREASED PHOTOSYNTHESIS	77	3
COMMENT REFERENCE NO. 77		

COMMENTS

42

LAG TIME FOR EFFECT IS 4-6 DAYS. ET-SIGNIFICANT IS THE SIGNIFICANT EXPOSURE TIME REQUIRED TO PRODUCE A NOTED LONG TERM EFFECT. TEM IS THE MEDIAN EXPOSURE TIME REQUIRED TO PRODUCE AN EFFECT. — 42

42

THE EXACT METABOLIC PATHWAYS INVOLVED IN THIS OIL TOXICITY TO PLANTS ARE NOT KNOWN. HOWEVER IT IS NOT BY REDUCTION OF OXYGEN AVAILABILITY. IT IS AN ACTION ON CYTOPLASMIC MEMBRANES AS NOTED BY LOSS OF TURGOR PRESSURE OF FRONDS RESULTING IN FLACCID APPEARANCE. — 42

69

NEGATIVE REDUCTIONS IN PHOTOSYNTHETIC CAPACITIES REPRESENT INCREASED CAPACITY. THESE DATA FOR HALF-GROWN BOTTOM BLADES CONFLICT WITH THOSE ON THE EFFECTS OF DIESEL FUEL ON MATURE BOTTOM AND SURFACE BLADES. EFFECTS ON YOUNG BLADES WERE MUCH MORE SEVERE, REFLECTING HIGHER VULNERABILITY. YOUNG KELP FRONDS CAN BE EXPOSED TO EMULSIFIED DIESEL OIL FOR ONLY 6-12 HOURS WITHOUT IRREVERSABLE DAMAGE. A LAG TIME OF ABOUT TWO DAYS WAS NOTED FOR THE APPEARANCE OF VISIBLE INJURY DUE TO OIL. — 69

77

NO INVESTIGATION SPECIFICS GIVEN. — 77

TABLE 1 (cont.)

RATINGS

1	2	3	4	5
	69	42		
		42		
		77		

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DATE DUE

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