10-26-90
SIMPSON BLDG,
ANCHORAGE

FISH/SHELLFISH RESTORATION MEETING

NAME	REPRESENTING	PHONE	FAX
BRIAN ROSS	EPA - RPWG, ANCH.	271-2461	271-2467
Charles H Peterson	UNC - Chapel Hill (reviewer)	(919) - 726-6841	(919) - 726-2426
RITA A. MIRAGLIA	SUBSISTENCE ADF+G	267-2358	
DAVE G. ELLIS	Forest Service	586-8784	586-8781
JOHN STRAND	NOAA/NMFS	789-~~6627~~ 6605	789-6608
BOB SPIES	AMS / WESTNET	(415) 373-7142	(415) 373-7834
Will Barber	University of Alaska Fairbanks	(907) 474-7177	
Alex Wertheimer	NOAA/NMFS	789-6040	789-6096
Mark Brodersen	ADEC	465-2610	
Mark Kuwada	ADF+G	267-2277	349-1723
Kent Roth	ADF&G	267-2153	
Kelly Hepler	ADF&G	267-2195	
Sam Shaw	ADF+G	424-3212	
Tom Kron	ADF&G	267-2166	
Jeff Hartman	ADF+G	~~4~~65-4160	465-4165
Chuck Meacham	ADFG	344-0541	
David Carlton	ADFG	789-6601	789-6604
David Cross	ADF&G	772-2853	
Jim Bodkin	USFWS	786-3451	
Susan Cormier	USEPA	271-2461	271-2467
MARTHA FOX	EPA - SEATTLE 206	442-1497	
Stephen Burbee	EPA - Anchorage	278-8012	

also Tom Dean (ADN)

Evelyn Fagg	ADFG	424-3213	424-3235

10/25

Coastal Habitat

Name	Affiliation	Phone	FAX # (if known)
Sandy Rabinowitch	Dept. of the Interior	257-2563	257-2510
MARTHA FOX	EPA - SEATTLE	(206) 442-1497	
Stephen Bughee	EPA - Anch.	278-8012	276-7178
Malin Babcock	NOAA Auke Bay Lab	789-6018	789-6094
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Charles H Peterson	Univ. of North Carolina	(919)-726-6841	(919)-726-2426
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Lt John F. Karinen	NOAA/NMFS/AKBL	(907) 789-6054	
Linda Conner	USEPA	(907) 271-2461	271-2467
Richard Meganck	Corvallis EPA Lab	503 757 4600	757-4799
Jim Bodkin	USFWS, AFWRC	907 786-3451	
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Kim Sundberg	ADF&G	267-2374	
Mike Mitchell	Preston Thorgrimson	276-1969	276-1365
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David Cantilon	NOAA/NMFS	907-789-6601	907-789-6601
Mark Broderson	ADEC	465-2610	
JOHN STROUD	NOAA/NMFS	907-789-6605	907-789-6608

From Sam Shaw

10-26-90
Fish/Shellfish

Salmon Restoration Studies

I. Escapement Enumeration - Stock-specific
   A. Aerial Survey Program
      1. More surveys of current index sites #, and precision
      2. Added index sites in oiled areas
   B. Ground Survey Program (Both ground + aerial needed)
      1. Continuation + expansion of at current sites
      2. Added index sites in oiled areas
   C. Weirs of oiled systems
   D. Stream life studies (residence time in streams)

II Stock Identification (needed to alter mgmt strategies in-season)
   A. Coded wire Tagging studies (recovery monitoring?)
      1. Tagging
         a. Hatcheries - all species
         b. oiled wild stocks - pinks + sockeye
      2. Recovery
         a. Port Sampling
         b. Brood Stock Sampling
         c. Wild Stock escapement Sampling (Weirs)
   B. Otolith marking Studies (for Feas. Study category)
      1. Tagging - (Hatcheries)
      2. Recovery
         a. Port Sampling
         b. Hatchery Brood stock
         c. Selected wild stocks
   C. Adult Tagging

for longer-term mgmt for restn.

Necessary to do in concert w/ CWT program (CWT are the test of the technique).

III Run Reconstruction

A. Historic data summarization

B. Computer modeling + analysis

↳ to synthesize avail. info,
incl run timing, tagging, catch info,
to predict which stocks being exploited
(to help exploit in optimum way - i.e., away
from stressed/oiled pops.)

Stan Senner
from C Meacham

To: Stan Senner
Restoration Program Manager
OSIAR Division

From: Wayne Donaldson
Shellfish Biologist
Commercial Fisheries
Cordova

September 25, 1990

Project ideas for restoration studies.

1) Two species of intertidal clams were affected by spilled oil and cleanup activities. The littleneck clam (Protothaca staminea) and butter clam (Saxidomus giganteus) are native to the spill area and are utilized by subsistence, personal use and sport fishermen. Various marine mammals, such as sea otters also utilize clams. Recovery of the intertidal clam resource can be enhanced by stocking intertidal areas with seed from indigenous clams. This study would obtain adult clams from the spill area and send them to a hatchery for spawning. The resultant seed would be stocked into the spill area to enhance the natural recovery process.

2) There is insufficient knowledge about the habitat requirements of juvenile spot shrimp (Pandalus platyceros) in Prince William Sound. The literature suggests that juvenile spot shrimp rear in shallow water. Most of the impact associated with the spill has occurred in shallow water areas. Identification of the habitat(s) of juvenile spot shrimp will help enhance the shrimp stock. Both state and federal resource agencies will be able to assess impacts of current cleanup activities. Habitat characteristics will greatly aid the evaluation of future clean up operations and future development in shallow water areas of the Sound.

3) Continuation of resource abundance surveys for spot shrimp will improve the management of this species for commercial, subsistence, personal use and sport fishing uses. A very limited data base of annual abundance should be continued to provide resource managers information on juvenile, male and female stock segments upon which to base future harvest rates.

cc: Meacham
Hilsinger
Ackley
Trowbridge

MEMORANDUM STATE OF ALASKA

TO: Charles P. Meacham
Fishery Program Manager
OSIAR
Anchorage

DATE: October 3, 1990

FROM: Kent Roth Kent
Fishery Biologist
Sport Fish Division
Anchorage

SUBJECT: Restoration Ideas

Sport Fish/Osiar staff have prepared the following preliminary list of restoration feasibility/research studies for consideration:

1) Access - Public Lands
   a) Determination and mapping of land ownership in PWS
      1) site specific recommendations for land acquisitions for access or fisheries protection/development would be made after review of the land ownership status
   b) Development of access for sport anglers
      1) Expansion of Cordova road system boat launches, trails, parking and camping areas
      2) Road to Whittier and expansion of Whittier area roads, boat launches, trails, parking and camping areas
      3) Expansion of Valdez road system boat launches, trails, parking and camping areas
   c) Development of recreational and educational brochures and manuals for PWS

2) Rockfish in PWS
   a) Species distribution and relative abundance
      1) Expand data base to prepare for future spills and to compensate for uncertainty of Exxon Valdez spill
   b) Historical and present sport and commercial exploitation (harvest by species)
   c) Monitor future exploitation
      1) Commercial catch monitoring
      2) Sport catch monitoring
         a) Port sampling - cohort analysis
         b) Sport charter logbook program
   d) Production, maintenance, and evaluation of artificial reefs

3) Cutthroat trout/Dolly Varden char data base
   a) Update ADF&G anadromous stream catalog to include sites with populations of anadromous trout and/or char
   b) Stock status and evaluation of cutthroat trout in streams and lakes along the Cordova road system

c) Evaluation of the commercial exploitation of anadromous trout and char
d) Determination of natural mortality rates of trout and char

4) Area fisheries maintenance, development, and/or enhancement
a) construction of fish passes to PWS lakes and upper stream reaches
b) maintenance of existing fish pass structures

cc: Krasnowski
Whitmore
Hepler
Mills
Hoffmann
Hansen
McBride
Delaney
Rutz

DRAFT

1991 Feasibility Studies - Factors to be considered in proposing studies

Proposed projects should reflect the need to determine technical feasibility or environmental benefit of candidate restoration approaches or techniques (i.e., those potential restoration projects specifically related to a damaged resource which, if technically feasible, have the likelihood of being realistically considered/implemented as a restoration measure). Besides technical feasibility, projects may also address information necessary to confirm the benefits or enable the implementation of a potential technique otherwise feasible. For example, one of the 1990 studies provided necessary information to confirm the use of upland forested areas as habitat for marbled murrelets and harlequin ducks. Factors to be considered include:

1) must be restoration of damage resulting from the spill; injury documentation; link to NRDA (including intrinsic values).

2) likelihood of project ultimately being proposed as a full-scale restoration measure.

3) probability of successful study.

4) ecological importance of target resource.

5) ability to evaluate success and document ecological value of project.

6) cost of feasibility study.

DRAFT

1991 Restoration Projects -
Factors to be considered in proposing projects

Agencies have decided to consider appropriate restoration projects for implementation in 1991. This is not contingent on whether any restoration funds become available in the immediate future from the responsible party. Proposed projects will be those that are technically feasible and can be implemented in the 1991 field season. Recovery of an injured resource being the primary goal, projects should also provide, either directly or indirectly, a net environmental benefit. Potential projects will include those that will mitigate known or documented damages and also any actions which will mitigate other sources of environmental disturbance (immediate threats) interfering with the natural recovery of injured resources. Finally, neither the timing nor the magnitude of any potential settlement for damages should be considered when proposing candidate projects. Factors to be considered include:

1) addresses known NRDA damage (including intrinsic values); must be restoration of damage resulting from the spill.

2) known technical feasibility.

3) reasonable to implement considering the expectations for natural recovery.

4) importance of implementing in 1991; examples include:
   - ability to implement project in 1991
   - addresses an existing damage which would likely continue to cause impacts;
   - addresses the threat of additional (cumulative) impacts which, if eliminated, would allow a quicker recovery of an injured resource;
   - should be implemented immediately by the agencies even if funds from the responsible party are not yet available.

5) net environmental benefit expected.

6) benefits ecosystem/multiple species.

7) reasonable duration of project (multi-year o.k.); results you expect from the project and ability to evaluate and submit results in a reasonable period of time.

8) geographic scope (should not be restricted to PWS, unless that is the only area that damage may be effectively addressed at this time).

9) cost of implementation.

10) extent to which something will be done anyway through routine agency management activities (e.g. restoration funds should not go towards maintenance of USCG navigation lights or ADFG normal fisheries management, etc.).

11) any project should not interfere with cleanup activities or NRDA studies/projects.

MEMORANDUM **STATE OF ALASKA**
Department of Fish and Game

TO: Brian Ross
U.S. EPA
Restoration Planning Team Leader
Oil Spill Restoration
Planning Office
Anchorage

DATE: October 25, 1990

FILE NO:

THRU:

TELEPHONE NO: 465-4160

SUBJECT: Restoration Meeting Submission from FRED Division

FROM: Brian J. Allee Ph.D.
Director
Division of FRED

Thank you for inviting staff from the Fisheries Rehabilitation Enhancement and Development Division to the Fish/Shellfish Restoration Work Session. Tom Kron, Regional Program Manager, and Jeff Hartman, Economist, will be attending. To the extent possible, we have responded to your cover letter and provided some restoration concepts as well as feasibility study concepts for you review.

FRED Division has a broad range of Fish stocking and fisheries rehabilitation tools and other fisheries analytical tools that could be applied to restoration. If you need to utilize these tools in the process of restoring fisheries we would be happy to assist you.

Included in this letter is (1) a list of proposed restoration projects and a Brief Project Proposal for selected projects and (2) a list of proposed feasibility studies and brief Project Proposals for selected studies. A few of the feasibility studies also occur in the list of restoration projects, since portions of the work would immediately serve to restore affected fishery resources.

I would like to emphasize that the restoration ideas that we have listed are strictly suggestions to give you some concept of the type of projects that FRED Division would be capable of participating in. Any number of projects identified in this submission could be intertwined with projects proposed by other agencies, and we are willing and interested in becoming cooperators with other agencies.

We are equipped to respond quickly to application of fishery enhancement and rehabilitation technologies should there be a compelling need to do so. The FRED Division's statutes under State of Alaska Title 16 allow us to apply a wide variety of enhancement and rehabilitation activities on virtually on all species of fin fish and shellfish in Alaska waters. No other state agency has this charge. With a number of State owned enhancement facilities in place, the additional costs of projects related to salmonid restoration will be very small compared to starting a new stock rehabilitation program from scratch.

FRED Division also oversees the regulatory process for transport of live fish and eggs, in state waters. Again, no other state agency has this authority, and we would be willing to discuss an expedited process for the restoration activities (that may require re-seeding or stocking of fish and shellfish), within Title 16 constraints. The state's fishery enhancement program includes a

multi-discipline rehabilitation staff consisting of genetics, fish health and pathology, limnology, esturine ecology, engineering and design, fish culture, fish tagging, planning and economics. We have the experience of building the largest ocean ranching program in North America and know how to apply these technologies as quickly or as methodically as you require.

If we may be of further assistance, or if more detail is needed in these projects please contact me at 465-4160, Tom Kron at 267-2158 or Jeff Hartman at 465-4160.

Attachments

cc: Bob Burkett
Jim Cochran
Nick Dudiak
Jeff Hartman
Johnny Holland
Jeff Koenings
Tom Kron
Jerry Madden
Larry Peltz
Keith Pratt
Lonnie White
Jim Hasbrouck

DRAFT
LIST OF FRED DIVISION
PROPOSED RESTORATION PROJECTS

October 25, 1990

The following is a list of proposed projects for restoration of damages from the Exxon Valdez oil spill. It is being submitted to Brian Ross, U.S. EPA Restoration Planning Team Leader, Oil Spill Restoration Planning Office, by Director Brian J. Allee of the Division of Fisheries Rehabilitation, Enhancement and Development (FRED).

This preliminary submission will undergo further revision in the future and is intended to be a working document for formulation of more detailed plans. Project order on this list has not been based on predetermined priorities.

The projects that are listed with an asterisk (*) have more detailed project proposals attached.

1.* Sockeye Rehabilitation through fertilization of lake systems in Prince William Sound and Cook Inlet. ~15-50K/yr per system

Principal Project Coordinator: Dr. Jeff Koenings (FRED Division, Soldotna)

2.* Increasing juvenile salmonid and trout growth using inorganic nutrient additions to rivers.

Principal Project Coordinators: Dr. Jeff Koenings (FRED Division, Soldotna)

3.* Improving environmental yield of salmon and harvests by Evaluation and Modeling of Wild Pink Salmon Stock Population Size in Prince William Sound, Including Potential Interactions with Enhanced Stocks (Note: Same as Feasibiltiy study #3).

Principal Project Coordinators: Larry Peltz (FRED Division, Cordova), Dr. Jim Hasbrouck, (FRED Division Biometrician, Anchorage), Dr. Doug Eggers (Comm Fish Division, Juneau), Hal Geiger (Comm Fish Division, Juneau).

4. Rebuilding of Pink Salmon Populations in Streams and Esturine Areas Impacted by the Exxon Valdez Oil Spill

Principal Project Coordinators: Larry Peltz (FRED Division, Cordova), Nick Dudiak (FRED Division, Cordova), Lonnie White (FRED Division, Kodiak)

5. Improving sustainable yield of coho and sockeye with NEW Eyak Lake Spawning Channel for coho and sockeye salmon

Principal Project Coordinator: Larry Peltz (FRED Division, Cordova)

6.* Marine Fin Fish and Shellfish Development Center Serving Cook Inlet, PWS, Kodiak and Ak. Peninsula.

Principal Project Coordinators: Tom Kron, Keith Pratt, (FRED Division, Anchorage, Dr. Don Kramer, (University of Alaska, Seagrant, Anchorage)

DRAFT
LIST OF FRED DIVISION
PROPOSED RESTORATION FEASIBILITY STUDIES

October 25, 1990

The following is a list of proposed feasibility studies for restoration of damages from the Exxon Valdez oil spill. It was requested by Brian D. Ross with the Oil Spill Impact, Assessment and Restoration Planning Office and it is submitted by Dr. Brian J. Allee, Director of the Division of Fisheries Rehabilitation, Enhancement and Development (FRED).

This preliminary submission will undergo further revision in the future and is intended to be a working document for formulation of more detailed plans. Project order on this list has not been based on predetermined priorities.

Studies are listed in 2 groups. The **NRDA GROUP of Feasibility Studies** consist of projects for fish species that have preliminary study information on damages available or are suspected to show signs of exposure to oil. The **Feasibility studies aimed at Replacement of Services Lost from Damages** refer to projects for which there is no current evidence of damage to the target fish species (known by FRED Division), but the study is aimed at replacing services lost to fishermen from the oil spill.

The studies that are listed with an asterisk (*) have more detailed project proposals attached.

NRDA GROUP of Feasibility Studies

1.* Feasibility of Enriching Near-shore Environments with Either Organic or Inorganic Fertilizer to Optimize Survival of Rearing Salmonids

Principal Investigator: Dr. Jeff Koenings (FRED Division, Soldotna) and University of Alaska-Southeast

2.* Feasibility of Enriching Stream Environments with Organic Fertilizer to Optimize Survival of Rearing Salmonids

Principal Investigator: Dr. Jeff Koenings (FRED Division, Soldotna)

3.* Evaluation and Modeling of Wild Pink Salmon Stock Population Size in Prince William Sound, Including Potential Interactions with Enhanced Stocks

Principal Investigators: Larry Peltz (FRED Division, Cordova), Dr. Jim Hasbrouck (FRED Division Biometrician, Anchorage), Hal Geiger, (Division of Comm Fish, Juneau), Dr. Doug Eggers (Division of Comm Fish, Juneau)

4. Rebuilding of Pink Salmon Populations in Streams and Esturine areas Impacted by the Exxon Valdez Oil Spill

Principal Investigator: Larry Peltz (FRED Division, Cordova), Nick Dudiak (FRED Division, Homer)

5.* Dolly Varden Rehabilitation Feasibility Study

Principal Investigator: Larry Peltz (FRED Division, Cordova), Dave Parks (FRED Division, Clear Hatchery), Staff (Sportfish Division, Anchorage)

6.* Cutthroat Trout Restoration Feasibility Study

Principal Investigator: Larry Peltz (FRED Division, Cordova), Staff (Sportfish Division, Anchorage)

7. Black Cod (Sablefish) Larval Collection Techniques

Principal Investigator: Keith Pratt (FRED Division, Anchorage)

8. Black Cod Culture Techniques

Principal Investigator: Nick Dudiak (FRED Division, Homer)

9.* Rehabilitation/Restoration of Rockfish Feasibility Study

Principal Investigator: Keith Pratt (FRED Division, Homer)

10. Herring Early Life Stage Rehabilitation

Principal Investigator: Nick Dudiak (FRED Division, Homer)

11. Clam and Mussel Collection, Culture, and Seeding Techniques

Principal Investigator: Jim Cochran (FRED Division, Juneau)

Feasibility Studies aimed at Replacement of Services Lost from Damages

1. Evaluation of the Enhancement Potential for Pink and Chum Salmon Populations on Montague Island

   Principal Investigator: Larry Peltz (FRED Division, Cordova)

2.* King Crab Culture Techniques and Feeding Trials

   Principal Investigators: Lonnie White (FRED Division, Kodiak) and Dr. Tom Shirley (University of Alaska-Southeast)

3.* King Crab Rehabilitation: Gulf of Alaska Site Selection

   Principal Investigators: Lonnie White (FRED Division, Kodiak) and Dr. Tom Shirley (University of Alaska-Southeast)

4. King Crab Evaluation of Rehabilitation Success

   Principal Investigators: Lonnie White (FRED Division, Kodiak) and Dr. Tom Shirley (University of Alaska-Southeast)

5. Tanner and Dungeness Crab Rehabilitation Techniques

   Principal Investigator: Jim Cochran (FRED Division, Juneau), Nick Dudiak (FRED Division, Homer)

6. Halibut Egg-Collection Techniques

   Principal Investigator: Keith Pratt (FRED Division, Anchorage)

7. Halibut Culture Techniques

   Principal Investigator: Keith Pratt (FRED Division, Anchorage)

8. Shellfish and Finfish Artificial Habitat Investigation. This feasibility study will explore the application of artificial reef design, site selection, and evaluation for several species of finfish and shellfish.

   Principal Investigator: Keith Pratt (FRED Division, Anchorage)

9. Replacement of Aquatic Plants

   may be might to increasing egg survival for herring (better on diff algae than on others)

   Principal Investigator: Jim Cochran (FRED Division, Juneau)

10. Scallop Enhancement Techniques

    Principal Investigator: Jim Cochran (FRED Division, Juneau)

FRED Restoration Project #1

Sockeye Rehabilitation through fertilization of lake systems in Prince William Sound and Cook Inlet.

Principal Project Coordinators: Dr. Jeff Koenings (FRED Division, Soldotna), Nick Dudiak (FRED Division, Homer)

Injury Documentation;link to NRDA

NRDA Studies are underway to determine if fishery closures following the Exxon Valdez Oil Spill resulted in higher than desired escapement of sockeye salmon into spawning areas. High densities of fish in certain sensitive spawning streams may lead to reduced survival of eggs or fry, and a net loss in outmigration. If these studies reveal reduced population sizes of important stocks of sockeye, restoration may be desired. If studies do not confirm that reductions of sockeye salmon have occurred in the area's studied this study may still be a least cost approach for replacing lost services related to environmental damage that have affected salmon fishermen.

Methods

Restoration in this case would be aimed at replacing lost sockeye production by rehabilitating systems that are nutrient limited, and capable of sustaining greater numbers of spawners. The controlled additions of nitrogen and phosphorous to the surface of sockeye (O. nerka) nursery lakes has substantially enhanced the survival of rearing juveniles, in Alaska. Sixteen lakes throughout the State have received nutrient additions to increase the production of sockeye and coho smolts. The increased numbers of smolts have in-turn increased numbers of adults either for spawning or harvest by the common property fishery.

Several potential sites exist in Prince William Sound and in Cook Inlet where these methods could be applied. Since the technical feasibility of this approach is known this project could begin in 1991, and should be carried out for 3 or more years.

Net environmental benefits expected

Models for estimating the change in the size of each stock of salmon must be applied to specific systems and projects. Typical a typical fertilization project on a single lake system may increase harvest from 10,000 to 100,000 salmon.

Cost of implementation

Costs of nutrient modification projects depend on many variables. Some may include additional stocking. Costs of investigations, and applications for each lake vary between $15,000 and $50,000 annually.

FRED Restoration Project #2

Increasing juvenile salmonid and trout growth using inorganic nutrient additions to rivers.

Principal Project Coordinators: Dr. Jeff Koenings (FRED Division, Soldotna)

Injury Documentation;link to NRDA

While FRED Division is not aware of the existence of oil exposure data on rainbow trout, and other stream rearing trout anglers may have avoided traditional recreational fishing sites for this species through the fear of contamination or through expectation of poorer recreational experience.

Similarly, oil exposure data on coho salmon (O. kisutch) is not available, however, coho are highly amenable to rehabiltiation, and may serve as an excellent species of salmon to rehabilitate for the purpose of replacing lost services related to environmental damage that have affected commercial and sport salmon fishermen.

Methods

Restoration in this case would be aimed at replacing lost trout and salmon production or by improving fishing opportunities through improving of other nearby trout fishing opportunities.

Improved in-river production of forage increases the survival of rearing trout, such as (O. mykiss) and salmon (O. kisutch). The purpose of nutrient additions is to stimulate the natural food chain to increase forage production and thereby enhance fish production. As the size of most fish populations in freshwater are controlled by lack of adequate rearing, increased rearing capacity will lead to an increase in the stocks of stream rearing fishes.

Several potential sites exist in Prince William Sound and in Cook Inlet where these methods could be applied. Since the technical feasibility of this approach is known this project could begin in 1991, and should be carried out for 3 or more years.

Net environmental benefits expected

Literature on improvements in rearing success of salmon and trout are available but not sufficient to project the change in the size of each stock of salmon that would occur from a specific stream system or projects.

Cost of implementation

Costs of nutrient modification projects depend on many variables. Some may include additional stocking. Costs of investigations, and applications for each stream system will be determined by the project coordinator.

FRED Restoration Project #6

Marine Fin Fish and Shellfish Development Center for Cook Inlet, Prince William Sound and Kodiak/Alaska Peninsula.

Principal Project Coordinator: Tom Kron, Keith Pratt, Don Kramer

Injury Documentation;link to NRDA

NRDA study results suggest that several species of marine fin fish and shell fish may have been damaged by the Exxon Valdez oil spill. Some of the finfish species mentioned include rockfish, herring, sablefish, (possibly halibut, pollack, sole, pacific cod). Some of the shellfish species mentioned include spot shrimp, clams, and mussels. As studies progress, other shellfish may show signs of damage to populations from oil contamination.

With so many marine fish species showing signs of exposure or sensitivity oil, it is likely that managers may be forced to respond with conservative management techniques where population sizes are expected to be reduced. Slow growth to sexual maturity in the natural environment may exacerbate these management efforts aimed at increasing populations by reducing or ceasing common property harvests.

There is also a considerable risk that some of these species may not respond to conventional management actions for decades (such as with Red King Crab in the Bering Sea). Many of the species mentioned, however, are highly amenable to culture of one or more lifestages, and there is a large potential for rehabilitating stocks damaged by this event or future events. However, a large marine laboratory sufficient in size to aggressively develop cultural techniques for early life stages does not presently exist in the areas of Alaska affected by the oil spill.

Methods

FRED Division proposes the construction of a Marine Fishes Cultural Development Center to serve South Central Alaska, Kodiak, and Prince William Sound. This facility would house university, state and federal studies for rehabilitation of marine fin fish and shellfish in Alaska waters.

Suggested Site: Seldovia

Net environmental benefits expected

Creation of the methods for culturing and rehabilitating important marine species would significantly reduce the risk of lost fishing income and fishing opportunities associated with losses or dramatic population crashes of stocks of marine fish, and shellfish through catastrophic environmental events, or long term damage from the Exxon Valdez Oil Spill. Application of rehabilitation techniques to specific stocks of fin fish and shellfish, will provide population size and growth information that would be difficult for managers to obtain in conventional surveys.

Cost of implementation

Rough costs for the repair and modification of an existing lab site in Seldovia for conducting small scale work is approximately $500,000. A large scale lab, and cultural center could cost several million dollars.

Brief Proposal #1 for Restoration Feasibility Studies

Feasibility of Enriching Near-shore Environments with Either Organic or Inorganic Fertilizer to Optimize Survival of Rearing Salmonids

Principal Investigator: Dr. Jeff Koenings (FRED Division, Soldotna) and University of Alaska-Southeast.

Injury Documentation;link to NRDA

Pink salmon populations in oil impacted areas of coastal Alaska demonstrate signs of physical exposure to oil, and populations of some small stocks may have been damaged. As such, these natural stocks may respond to rehabilitation. Local esturine rearing conditions may prove to be a limiting factor to pink salmon stock rebuilding efforts through management or intensive rehabilitation, in that food abundance can be ecologically constrained. These constraints in food production may handicap efforts of managers to increase stocks of pink salmon or other near - shore rearing salmonids through allowing for larger escapement.

Estuaries typically receive energy inputs from terrestrial detritus and from phytoplankton which supports production of zooplankton. A lack of terrestrial decomposition in Alaska may limit the amount of detritus exported from watersheds into the near-shore environment. Enrichment of estuaries with a combination of inorganic and organic fertilizers may stimulate the seasonal production of zooplankton (as has been shown for freshwater zooplankton), the principal forage item for juvenile pink and chum salmon.

This study could also be a low cost approach for replacing services lost to fishermen related to environmental damage that have affected other areas of the salmon fishery.

Methods

Restoration in this case would be aimed at replacing lost pink salmon production or production of specific stocks known to rear in the near-shore areas receiving treatment.

This study would compare the effects of both controlled additions of nitrogen and phosphorous inorganic fertilizers, with organic fertilizers to designated nearshore areas.
Tagging studies would be initiated to evaluate the comparative success of the two options.

Several potential areas in Prince William Sound and in Cook Inlet would be investigated to conduct the trials.

Likelihood of project ultimately being proposed as a full scale restoration measure

Probability of successful study.

Ecological importance of target resource.

Ability to evaluate success and document ecological value of project

Cost of feasibility study.

Costs, are yet to be computed.

Brief Proposal #2 for Restoration Feasibility Studies

Feasibility of Enriching Stream Environments with Organic Fertilizer to Optimize Survival of Rearing Salmonids

Principal Investigator: Dr. Jeff Koenings (FRED Division, Soldotna) and University of Alaska-Southeast).

Injury Documentation;link to NRDA

While FRED Division is not aware of the existence of oil exposure data on rainbow trout, and other stream rearing trout anglers may have avoided traditional recreational fishing sites for this species through the fear of contamination or through expectation of poorer recreational experience.

Similarly, oil exposure data on coho salmon (O. kisutch) is not available, however, coho are highly amenable to rehabilitation, and may serve as an excellent species of salmon to rehabilitate for the purpose of replacing lost services related to environmental damage that have affected commercial and sport salmon fishermen.

Fish forage production in nutrient-poor coastal streams is heavily dependent on the amount of detritus entering the system especially under a heavy streamside canopy.

Methods

Restoration in this case would be aimed at replacing lost trout and salmon production or by improving fishing opportunities through improving of other nearby trout fishing opportunities.

The addition of organic fertilizers seeks to stimulate the detrital food chain in order to produce more food items for stream rearing trout (e.g., O. mykiss) and salmon (O. kisutch). An increase in the growth and survival of stream rearing fish will lead to an increase in the survival to adult fish, and increase common property harvests.

Several potential sites exist in Prince William Sound and in Cook Inlet where these methods could be applied.

Likelihood of project ultimately being proposed as a full scale restoration measure

Probability of successful study.

Ecological importance of target resource.

Ability to evaluate success and document ecological value of project

Cost of feasibility study.

Costs, are yet to be computed.

Brief Proposals #3 for Restoration Feasibility Studies

Evaluation and Modeling of Wild Pink salmon Stock Population Size and fishery interactions with enhanced fish in Prince William Sound.

Principal Investigators: Larry Peltz, FRED Division; Dr. Jim Hasbrouck, FRED Division; Karen Crandall, FRED Division; Hal Geiger, Division of Comm Fisheries.

Injury Documentation;link to NRDA

Pink salmon populations in oil impacted areas of coastal Alaska demonstrate signs of physical exposure to oil, and populations of some small stocks may have been damaged. As such, these natural stocks may respond to rehabilitation. Managers propose to restore these stocks population numbers by allowing for increased escapement to respective streams of origin. In the process of reducing exploitation to small stocks of salmon that have been stressed, exploitation may be reduced on larger and unimpacted populations. This could create biological and economic feedbacks. Biological feedbacks could occur, in that stronger stocks may overescape, causing decreased production. Economic feedbacks could occur, in that the harvest of some hatchery stocks may be reduced or restricted to terminal areas with reduced quality and decreased value.

The ability to separate all discrete stock components is important for management of the Pink Salmon fishery and for evaluating the consequences of specific restoration alternatives in Prince William Sound, as well as Lower Cook Inlet and Kodiak.

Methods

Existing studies in the NRDA process intend to gain a better understanding pink salmon fishery interactions. Some of the new studies proposed below could be combined with the tasks that would be continuing under the existing pink salmon damage assessment studies.

The spacial and temporal distribution of enhanced, and wild stocks in oil impacted areas will be determined through coded wire tagging. In addition, otolith marking and scale pattern analysis will be tested as potential alternatives to coded-wire tagging.

1. Coded-wire tagging is assumed to continue at the same locations and levels of tag application as in NRDA study #3. Additional wild stock sites may be added if deemed necessary.

2. Otolith marking will be attempted at one or more hatcheries. Catch contributions will be compared to results obtained from coded-wire tagging. The presence of naturally occurring otolith marks will be investigated at wild stock sites.

3. The use of scale pattern analysis to differentiate wild and hatchery stocks of fish will be investigated. Investigations will concentrate on the same hatcheries and wild stock systems as the coded wire tagging and otolith marking.

4. Modeling of the probable harvest outcomes of various management actions aimed at increasing population size of stocks that are considered to be biologically weak and impacted by the oil spill. The analysts will develop a time series of projected harvests of stocks originating from major production systems of natural and enhanced fish in the Sound. These efforts could be part of, or in addition to the run reconstruction modeling associated with

existing NRDA studies.

Likelihood of project ultimately being proposed as a full scale restoration measure

Application of management actions and rehabilitation actions aimed at restoring damaged pink salmon populations are likely to occur since this is an extremely important fishery in Prince William Sound. Improved tools for evaluating the success of those programs are likely to be useful.

Probability of successful study.

Application of CWT's and associated recovery programs to enhanced and selected wild stocks will, on its own, provide new knowledge of stock composition of harvests. Thus, probability of success is close to 100 %. New quantitative marking tools are promising, and may provide reliable and affordable stock separation techniques. A breakthrough in this area is deemed likely, because of the success with this identification technique in the enhancement of sockeye salmon.

Ecological importance of target resource.

Pink salmon are high in the food chain, and an important resource in the Sound. Hundreds of individual pink salmon stocks exist in Prince William Sound, Lower Cook Inlet and Kodiak. Some stocks, impacted by the spill may be small in population number and dramatically altered or lost without rehabilitation.

Ability to evaluate success and document ecological value of project

Excellent

Cost of feasibility study.

Additional Spinoffs:

This study may aid in the evaluation of alternative forms of restoration of weak stocks through rehabilitation and/or enhancement.

Brief Proposals #5 for Restoration Feasibility Studies

Dolly Varden Restoration Feasibility Study

Injury Documentation;link to NRDA

Populations of Dolly Varden in streams and shorelines have demonstrated signs of exposure to oil. Certain populations in impacted areas may have been reduced by this exposure. Some of the affected Dolly Varden stocks are popular as recreational, subsistence or personal use fishery

Methods

Rehabilitation techniques for Dolly Varden are known and in practice in interior areas of Alaska. Techniques for culture are likely to be transferrable to Prince William Sound. The site selection work for PWS stocks that are culturally optimum for restoration has not been undertaken.

Site selection for potential stocks for restoration would occur with test lots being incubated and reared at Clear Hatchery or another state facility.

Likelihood of project ultimately being proposed as a full scale restoration measure

Probability of successful study.

Excellent, because of proven success with Dolly Varden enhancement in Alaska interior.

Ecological importance of target resource.

Ability to evaluate success and document ecological value of project

Cost of feasibility study.

Costs, between $20,000 and $50,000 annually depending on number of stocks to be rehabilitated.

Investigators:

Larry Peltz, FRED Division; David Parks, FRED Division Clear Hatchery, other investigator, Division of Sportfish.

Brief Proposals #6 for Restoration Feasibility Studies

Cutthroat Trout Restoration Feasibility Study

Injury Documentation;link to NRDA

Populations of Cutthroat Trout in streams and shorelines have demonstrated signs of exposure to oil. Certain populations in impacted areas may have been reduced by this exposure. Some of the affected Cutthroat stocks are popular as recreational, subsistence or personal use fisheries.

Methods

Rehabilitation techniques for Cutthroat are known and have been applied in several western states. While not in practice in Alaska, culture techniques and stock selection methods that have been applied to rainbow trout and dolly varden could be duplicated. Techniques for culture are likely to be transferrable to Prince William Sound. The site selection work for PWS stocks that are culturally optimum for restoration has not been undertaken.

Site selection for potential stocks for restoration would occur with test lots being incubated and reared at Clear Hatchery or another state facility.
Likelihood of project ultimately being proposed as a full scale restoration measure

Probability of successful study.

Excellent because of proven success with cutthroat enhancement in the Western U.S.

Ecological importance of target resource.

Ability to evaluate success and document ecological value of project

Cost of feasibility study.

Costs between $20,000 and $50,000 annually depending on number of stocks to be rehabilitated.

Investigators:

Larry Peltz (FRED Division, Cordova), David Parks (FRED Division Clear Hatchery), Staff (Sportfish Division, Anchorage).

Brief Proposals #9 for Restoration Feasibility Studies

Rehabilitation/Restoration of Rockfish Feasibility Study

Injury Documentation;link to NRDA

Tissue analysis of resident populations of rockfish in reef zones affected by the oil spill demonstrate exposure to hydrocarbons. Populations of rockfish may have been reduced. Recruitment may be dramatically reduced in populations of sexually mature fish and several age classes could experience low fecundity, and low numbers of larval forms. It may take several years before recruitment of rockfish are improved.

Methods

Culture techniques for rockfish are not developed in North America, however, appropriate food organisms, and culture practices that have been applied to marine fishes with very small larval lifestages are expected to be applicable to rockfish. This study would begin with a literature search for rock fish culture experiences from Japan. Techniques for collecting fertilized females from live bearing species would be tested at selected sites impacted by the oil spill.

Trial incubation of fertilized eggs would be tested at a selected State Hatchery in PWS or Kodiak.

Likelihood of project ultimately being proposed as a full scale restoration measure

Probability of successful study.

Ecological importance of target resource.

Ability to evaluate success and document ecological value of project

Cost of feasibility study.

Investigators:

Keith Pratt, FRED Division; .

Brief Proposals #2 for Restoration Feasibility Studies

Red King Crab Rehabilitation Feasibility

I. DESCRIPTION

1. Title: **Red King Crab Rehabilitation Feasibility Study**
2. Goal: Test feasibility of culturing red king crab embryos to their first benthic stage, evaluate settlement of the young crabs in two "seeded" and one control bay, report and make recommendations based on findings.
3. Location: Kodiak
4. Team: Lonnie White, FB III, Leader. Cooperative effort with Commercial Fisheries Division staff.
5. Schedule: Start March 1991; Three-year study.
6. Background: Red king crab populations were at a very low level prior to the Exxon Valdez oil spill. If impacted, some stocks would be at increased risk, and recovery could extend for many years: 50? Culture of crabs could be a tool to accelerate recovery of stocks. Culture of red king crab has been accomplished by the Japanese.

II. JUSTIFICATION

1. Need: Red king crab are a high-value product. Restoring populations to higher numbers would restore earnings to the fishing fleet.
2. Benefits: This feasibility study would provide information needed to evaluate this culture approach with red king crab in Alaska.
3. Criteria

   A. Relationship to NRDA studies and injured natural resources.
   B. Identified public concern: Item E. Mariculture in the fish and shellfish matrix would encompass this approach.
   C. Ability to implement the study in the near future: Study plan has been developed and is ready to implement as soon as funds are available.
   D. Reasonable likelihood of success: Team leader Lonnie White has a proven track record in mariculture and fisheries project accomplishment. Staff are available. Japanese success improves probability of success. It is highly likely that a feasibility study will be completed and needed information produced and reported.
   E. Cost relative to funds available: Yearly cost of $111,330 for each of three years.

III. OBJECTIVES

1. Method: This project will test the feasibility of culturing red king crab from embryos to the first benthic stage. Research will involve culturing of young crabs and evaluation of the success of their settlement in two bays.

A. Culture and Research
B. Evaluation of Settlement
C. Recommendations and Design for Expansion

The project involves cooperative work with the Commercial Fisheries Division.

2. Evaluation: Final evaluation will be based on successful settlement of crabs in the two seeded bays, as compared to the control bay. Enumeration of crabs stocked and crabs settled are an important part of the study. Of the budget, 35% or $39,000 is for the evaluation task.

IV. APPROACH

1. Method: This is a three-year project. The first year will focus on establishing the crab culture facilities and trial runs with proposed methods. The second year is when major production numbers will be collected. The third year will be a replicate of year two.
2. Evaluation: Enumeration of crab stocked and crab settled are key data.

V. BUDGET ESTIMATE

1. By Task: Culture: $72,330; Evaluation: $39,000. Total: $111,330/year.
2. Future Costs: Year Two: $111,330. Year Three: $111,330.

VI. ABSTRACT

To restore red king crab through culture. Test feasibility of culturing red king crab embryos to the first benthic stage, evaluate the settlement of young crabs in two seeded bays and one control bay, and report with recommendations.

MEMORANDUM STATE OF ALASKA

TO: Stan Senner **Date:** September 25, 1990

FROM: Dana Schmidt and Bruce Barrett
Commercial Fisheries Division
Kodiak

SUBJECT: Restoration Program

We offer the following comments in response to your restoration matrix and request for 1991 restoration feasibility/research studies.

We can anticipate a reduced salmon harvest in the Kodiak Management Area (KMA) if the overescapement that occurred from the EXXON Valdez spill in 1989 causes negative impacts. The KMA salmon stocks are managed on escapement goals with harvest opportunity permitted only when there are fish surplus to escapement requirements. Thus we inherently have a restoration mechanism built into our salmon fisheries management plan with the restoration accomplished at the expense of lost harvest opportunity to ensure escapement.

Meeting escapement goals by decreasing fishing time would restore fish available for non-marine wildlife to the same levels as non-impacted systems. Marine species which feed on salmon would be affected but should be recovered in a single generation by meeting escapement goals of returning fish. The above mechanism would not be true only if impacts were of such a magnitude that escapement goals were not met. In that case, multiple years may be necessary to restore runs to pre-spill levels. Standard enhancement practices such as those used by the FRED Division could accelerate the restoration process and mitigate potential future damages to commercial, subsistence, and sport fisheries and wildlife dependent upon salmon.

Within the Kodiak Management Area there are several important salmon producing systems which could be better managed for commercial, subsistence, and sport interests with more precise monitoring of escapements. These include the Karluk, Ayakulik, and Buskin Rivers. Currently the annual salmon escapements into these systems are counted though rigid aluminum weirs which are operated by seasonal employees. These weirs regularly do not withstand flood events and carcass buildups associated with massive pink salmon escapements. Since the salmon runs to these systems are regulated on escapement counts, management precision is compromised each time a weir washout occurs which can often be several times a year. The installation and operation of floating weirs on these systems would likely permit ADF&G to obtain complete escapement counts through flood events and pink salmon carcass buildup periods. In turn this would permit more precise fisheries management for ensuring that escapement requirements are met

and resource users are afforded an ample opportunity to harvest surplus fish. If restoration research funds were made available this year, a floating weir design could be tested on the Karluk, Ayakulik, and Buskin Rivers as early as 1991.

cc: L. Nicholson
C. Meachum

10-26-90

NOAA'S NATURAL RECOVERY MONITORING PROGRAM FOLLOWING THE EXXON VALDEZ OIL SPILL

EXPOSURE OF JUVENILE SALMON TO HYDROCARBON CONTAMINATION IN PRINCE WILLIAM SOUND

P.I.: Alex Wertheimer, NMFS, Auke Bay Laboratory

This project would monitor the exposure of juvenile pink and chum salmon to hydrocarbons in oiled and non-oiled areas of Prince William Sound. The potential impact of the oil spill on juvenile salmon was one of the greatest concerns expressed by both the scientific community and the public commentaries to the NRDA process. NRDA research has identified MFO-induction and hydrocarbon body-burdens in juvenile pink salmon in Prince William Sound in oil year 1. Preliminary analysis indicates that the source of contamination is ingestion rather than or in addition to exposure to water soluble fraction. Contamination of juvenile pink salmon decreased in oil year 2 to the point that hydrocarbon body-burdens were no longer detectable. Analysis of enzyme induction indicating exposure to oil has not yet been completed for 1990 samples of juvenile pink salmon or 1989 and 1990 samples of juvenile chum salmon. The MFO analyses are a more sensitive measure of contamination than actual hydrocarbon body-burden. If these analyses indicate that exposure to hydrocarbons continues in areas polluted by the oil spill, then it is important to determine if such exposure continues following extensive clean-up activity in oiled areas, such as mechanical removal and bioremediation.

This project falls under Restoration Approach V identified in the Matrix of Potential Restoration Approaches: "Conduct long-term research/ monitoring programs on populations and ecology". It is directly related to the outcome of NRDA research, and would be implemented only if contamination of juvenile salmon in 1990 is identified by tests for MFO induction. The feasibility for determining exposure is well-established; the project can be readily implemented for the 1991 field season. Proposed timeframe is for one year, with re-evaluation of the need for continuance prior to oil year 4. The benefits of the project will be to provide managers information for determining the efficacy of on-going restoration efforts to the point at which direct contamination of the most valuable fishery resource in Prince William Sound is no longer detectable.

Estimated Costs: Sample collection: 60 K
MFO Analysis: 25 K
Management/analysis/reporting: 15 K
TOTAL: 100 K

10-26-90

NOAA'S NATURAL RECOVERY MONITORING PROGRAM FOLLOWING THE EXXON VALDEZ OIL SPILL

RECOVERY OF EPIBENTHIC PREY POPULATIONS OF JUVENILE SALMON IN OILED BAYS IN PRINCE WILLIAM SOUND

P.I.: Alex Wertheimer, NMFS, Auke Bay Laboratory

This project would monitor populations of epibenthic crustaceans on heavily oiled and lightly oiled beaches within oiled embayments in Prince William Sound. Epibenthic crustaceans, especially harpacticoid copepods, produced in the intertidal and upper sub-tidal regions of beaches are an important prey item for juvenile pink and chum salmon, as well as other species of fish. Because these organisms live in or near sediments, the contamination of beach sediments by the Exxon Valdez oil spill may directly impact the epibenthic community. Perturbation of harpacticoid copepod populations have been documented in other oil spills; the direction of the perturbation can be either negative or positive. Damage to prey populations of salmon and other fishes has been a concern identified by both the peer reviewers and public commentaries to the NRDA process. NRDA research has been directed at determining if there were acute effects relative to the degree of sediment contamination to harpacticoid copepod taxa that are important prey resources for juvenile salmon. In Oil Year 1, comparisons of the abundance of these animals showed no significant difference between oiled and control sites, with a trend of higher abundance at oiled sites. In Oil Year 2, research was directed at lightly and heavily contaminated beaches within oiled embayments. If analysis of the 1990 data indicate that there are differences in the abundance of these fish prey relative to the degree of oil contamination, then it is important to determine if such perturbation continues following extensive clean-up activity in oiled areas, such as mechanical removal and bioremediation.

This project falls under Restoration Approach V identified in the Matrix of Potential Restoration Approaches: "Conduct long-term research/ monitoring programs on populations and ecology". It is directly related to the outcome of NRDA research, and would be implemented only if a perturbation to the harpacticoid copepod prey suite has been indicated. The feasibility for this type of monitoring is well-established; the project can be readily implemented for the 1991 field season. Proposed timeframe is for one year, with re-evaluation of the need for continuance prior to oil year 4. The benefit of the project will be to track restoration of an important trophic component of near-shore ecosystems, which will provide managers information for determining the efficacy of on-going restoration efforts.

Estimated Costs: Sample collection: 70 K
Sample Processing: 90 K
Management/analysis/reporting: 30 K
TOTAL: 190 K

10-26-90

NOAA'S NATURAL RECOVERY MONITORING PROGRAM
for
SELECT MARINE FISHES

Information collected by NOAA NRDA programs has documented the exposure of several marine fish species to hydrocarbon contamination. Analysis of bile samples from Dolly Varden char, pollock, several species of flatfish and possibly other species has shown elevated levels of hydrocarbon metabolites, even a year after the spill.

NOAA proposes to continue monitoring the presence of fluorescent aromatic compounds (FACs) in the bile of affected fish species until an estimate of the timeframe of the recovery to baseline conditions can be determined.

Liver samples from select species will be collected and analyzed for aryl hydrocarbon hydroxylase (AHH) activity and immunochemically quantitated IA1 type cytochrome P-450, both of which are known to be increased after exposure to a variety of chemical contaminates.

Samples also will be taken and analyzed to measure histopathological changes, reproductive disorders and levels of DNA adducts.

The geographic extent of this sampling and the species that will be targeted will be determined from information currently being analyzed under NOAA NRDA studies.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Alaska Fisheries Science Center
National Marine Mammal Laboratory
7600 Sand Point Way N.E., Bin C15700
Seattle, Washington 98115-0070

(206) 526-4045 FTS: 392-4045

October 2, 1990 F/AKC3:trl

MEMORANDUM FOR: RPWG -- John Strand

FROM: F/AKC3- Tom Loughlin

SUBJECT: Restoration Feasibility Studies

Please find attached the matrices that you sent containing possible restoration projects. My interests are with those pertaining to marine mammals and I have checked the matrices in those projects that I thought were possible and of high priority. I noted in some cases those instances where the proposed study is inappropriate or not possible to achieve.

I have an interest in the long-term monitoring of status and trends of affected marine mammals in Prince William SOund and adjoining waters and support your efforts in that direction. The Long-Trem Ecological Research Site is appropriate for this area and I encourage the establishment of such a site.

Thank you for the opportunity to comment and please let me know if I can be of further assistance.

attach.

Restoration Feasibility Study Number 1: Reestablishment of *Fucus* in Rocky Intertidal Ecosystems

Species of the marine alga *Fucus* are critical structural components of the intertidal ecosystem on rocky shores in the oil spill area. Qualitative evidence indicates that *Fucus* was damaged by both the spilled oil and cleanup efforts. If the natural recovery of *Fucus* can be enhanced through the dispersal of spores or transplants, it will benefit the associated flora and fauna on intertidal rocky shores. This study will involve field tests to develop and demonstrate the feasibility of a *Fucus* restoration project and will document the natural recovery of *Fucus* under various conditions. The U.S. Environmental Protection Agency is the lead agency.

Restoration Feasibility Study Number 2: Reestablishment of Critical Fauna in Rocky Intertidal Ecosystems

Certain faunal species are key components of intertidal rocky ecosystems. Examples include grazers, such as limpets (e.g., *Diodora*), and predators, such as starfish (e.g., *Leptasterias*). Recolonization rates for these organisms, and for the alga *Fucus*, may limit the natural rates of recovery for entire communities. This feasibility study will compare the rates of recovery in communities with and without such species as limpets, and will evaluate techniques for enhancing recolonization rates. The U.S. Forest Service is the lead agency.

Restoration Feasibility Study Number 3: Identification of Potential Sites for Stabilization and Restoration with Beach Wildrye

Beach wildrye (*Elymus mollis*) was affected by both spilled oil and cleanup activities, and is extremely important in the prevention of erosion in the coastal environment. Erosion can lead to the destabilization and degradation of cultural and recreational sites and wildlife habitats. There are well established techniques for restoring rye grasses on coastal dune systems. This study will identify sites at which damage has occurred and restoration activities appear to be feasible. The Alaska Department of Natural Resources is the lead agency.

Restoration Feasibility Study Number 4: Identification of Upland Habitats Used by Wildlife Affected by the Oil Spill

A variety of marine birds, waterfowl and other bird and mammalian species were killed by the spill or injured by contamination of their prey and habitats. Many of these species are dependent on

aquatic or intertidal habitats for such activities as feeding and resting, but they also use upland habitats in forests, along streams or above the tree line. Through the public scoping process and technical consultations, many people have suggested that protection of upland habitats from further degradation may be an important way to help wildlife recover from the effects of the oil spill. This study will explore the linkages between wildlife affected by the oil spill and upland habitats, focusing in 1990 on marbled murrelets (*Brachyramphus marmoratus*) and harlequin ducks (*Histrionicus histrionicus*). The U.S. Fish and Wildlife Service and the Alaska Department of Fish and Game are the lead agencies.

Restoration Feasibility Study Number 5:
Land Status, Uses, and Management Plans in Relation to Natural Resources and Services

Through the scoping process, members of the public have suggested a wide variety of projects to acquire the equivalent of injured resources. Examples are the acquisition of timber or development rights, conservation easements, recreational and cultural sites, inholdings within state and federal areas and buffer strips along streams and coasts. Habitat protection may also be the best means of providing for the long-term restoration of wildlife populations. To begin identifying and evaluating potential restoration projects of this type, this study will summarize existing information about the current status, uses and management plans of both public and private lands. The Alaska Department of Natural Resources is the lead agency.

DATE: September 25, 1990

MEMORANDUM FOR: John Strand

FROM: Alex Wertheimer

SUBJECT: Restoration Feasibility Studies For 1991

I appreciated seeing the list of feasibility studies and the matrix of potential restoration approaches. I have no recommendations for specific restoration feasibility studies, but I had some thoughts on the restoration matrix in relation to salmon which I'll pass on to you.

When the matrix was first created, the magnitude of the pink salmon return to Prince William Sound in 1990 was an unknown. The matrix and prioritization of restoration approaches/feasibility studies must now be viewed in that context. The record returns to the Sound do not by any means preclude actual and documentable damage to the resource. Overall return rates are well within the documented marine survival range for pink salmon. Impacts from the spill could have occurred which reduced the aggregate production to some degree, and particular wild stocks to a considerable extent. The degree of damage may have even been compensated to some extent by other effects of the spill, such as removal of avian predators. The large catch and escapement is, however, clear evidence that there was no catastrophic impact on the total productivity of the Sound for salmon in the marine environment. Aggregate losses, if any, are transient because escapements are, in general, adequate or better. Long-term effects will be localized to particular stream systems or littoral areas that were directly and severely impacted by the spill.

If the preceding logic is valid, the restoration alternatives should be considered in the context of localized impacts rather than general production systems. All of the approaches directed at increased productivity have potential application to restore damaged production systems. For example, Protecting Upland Habitat (l) is certainly a viable method to restore productivity to a damaged system, where additional stress on the system could prevent recovery. Applying the idea throughout Prince William Sound is appealing to those of us concerned with long-term productivity of the fish-producing habitat, but that is a concern that existed prior to the oil spill. Without large-scale, long-term losses to mitigate, it seems difficult to justify as a general approach. Alternatives n and q are examples of attempts to use the restoration process to justify action on management problems that were neither caused not exacerbated by the spill. Again, catastrophic loss of the resource may have justified action on such general issues. Without catastrophic damage, this type of approach would be inappropriate.

Alternative j is at first read simply a bad idea. I may be misinterpreting the intent of the alternative, but I understand it

to mean that depleted natural stocks would be "restored" by transplants from other abundant stocks. This would be counter to the ADFG Genetics Policy. I interpret the alternative in this way because there is a separate alternative referencing preservation of wild gene pools and local populations(h). This latter alternative, if it included transplants from the local population back into the impacted watershed (the "honest thief" technique), would be an excellent approach to "jump start" depleted stocks.

Alternative v is an interesting one. Where does damage assessment end and restoration begin in monitoring populations and conducting long-term ecological research? For many species, including pink salmon, the current damage assessment projects are in a real sense the start point for such research. Which process is responsible? Let me know when you figure it out!

MEMORANDUM STATE OF ALASKA

TO: Stan Senner
Restoration Specialists
Oil Spill Impact Assessment
and Restoration
Anchorage

DATE: October 10, 1990

FROM: Charles P. Meacham
Fishery Program Manager
Oil Spill Impact Assessment
and Restoration
Anchorage

Subject: Restoration--
Fish Ideas

Below are current Damage Assessment projects for salmon, clams, and rockfish that could logically be considered for transition to restoration funding. Of particular value to the expedited restoration process is that these three projects can be implemented immediately with a high probability of success. Approximate costs associated with these projects are detailed in Table 1.

SALMON:

Restoration of salmon stocks affected by oil will be a difficult task since some wild stocks and hatchery stocks were oiled and others were not. From a practical standpoint there will be a commercial salmon fishery within PWS. My feeling is that a complete closure of the commercial fishery is not practical nor would it really benefit the resource as a whole, the State, or Nation. The challenge of restoring oiled salmon stocks in the face of a commercial fishery then becomes one of differentiating between stocks. Broad stock units would include the following:

Oiled wild stocks
Oiled hatchery stocks
Un-oiled wild stocks
Un-oiled wild stocks

Production from hatchery stock groups can be controlled reasonably well by hatchery practices. Production from wild stocks is a function of escapement levels (controlled by the commercial fishery) and environmental factors. Environmental factors are beyond our control. However, one can differentially harvest salmon stocks if able to distinguish between them. The first task of restoration then becomes one of stock identification. Stock identification can be accomplished in a variety of ways, including identifying natural markers (such as through scale pattern analysis, electrophoresis, nuclear DNA analysis) associated with a given stock of fish or by applying marks to juveniles (coded wire tags, otolith mass marking, etc).

I would suggest a two pronged approach; first, use existing technology to implant coded wire tags in juvenile fish in 1991, and second, enter into a small scale feasibility study to more economically mass mark hatchery fish such as through otolith mass marking.

ROCKFISH:

We know that there were lethal effects to rockfish, as shown by the recovery of dead and dying rockfish immediately after the spill; and, that there were sub-lethal effects, based on bile samples taken later in 1989. The results of the 1990 field studies will help in determining the long term persistence of the sub-lethal effects and to what extent the shallow reef habitats and food sources were affected. Restoration efforts for rockfish are dependent on the results of the 1990 study.

If (1) the presence of hydrocarbons is detected in the tissue, food samples, or sediment samples collected in 1990, or (2) the histopathological examination or enzyme activity indicates persistent sub-lethal effects of the oil, then studies similar to Fish/Shellfish Study 17 conducted in 1990 would be warranted under restoration in order to determine the long term persistence of these sub-lethal effects to appropriately design directed restoration efforts.

Current data indicate that stocks of bottom fish, including rockfish, are depressed. Rockfish are long lived fish (with maximum age approaching 100 years) and exhibit relatively slow recruitment making restoration a long term, very difficult process; thus, restoration efforts may need to take the form of compensation for lost or damaged resources. This project should logically transition toward continued evaluation of stocks of rockfish with emphasis on stock status and population dynamics of these fish.

An examination of historical commercial fisheries data coupled with a port sampling program evaluating sport and commercial harvests would provide a database of harvest levels and the basic age and size composition information for these fish providing a basis for assessing sustainable yields of these stocks. In addition, the age structure data would permit cohort analysis to determine if specific age groups are weak. It is also necessary to assess the distribution and abundance of these stocks within the area affected by the spill in order to manage these stocks geographically. A stock inventory program could be initiated to determine the distribution and species composition of these species. This would be accomplished by divers, hook and line or trawl type surveys. Diving techniques are preferred in order to avoid mortality associated with destructive sampling techniques in areas of low stock density. These studies will also serve to expand our database in preparation for future spills and compensate somewhat for the uncertainty from the Exxon Valdez spill.

CLAMS:

Many controlled studies and the results of several oil spills have shown that
spills can have long term effects on clam populations. This is both because clams are sedentary, inhabiting the intertidal regions and sediments which are most susceptible to accumulation of oil, and because clams are unable to metabolize hydrocarbons and tend to bioaccumulate hydrocarbons in tissues. In addition to the effects hydrocarbons may have had on Prince William Sound clam populations, it is hypothesized that both the mechanical and biological cleanup activities in PWS may have especially impacted young-of-the-year clams.

Although the current clam damage assessment project has collected data on clams at scattered sites around Prince William Sound, little is currently known about the actual distribution and density of clams. This clam study should now transition toward an inventory of clam populations across various habitat and identify suitable habitats for clam population enhancements through restorative transplants or seeding projects.

Once suitable enhancement locations have been identified, there are at least two methods of restoring clam populations to a healthy condition. The first restoration project alternative would be to transplant adult clams into the spill area from unaffected locations. A pilot transplant experiment was successfully conducted as part of the current damage assessment study. A second restoration project alternative would be to restore clam populations through a seeding project. Under this alternative, clams would be taken from healthy areas and spawned under controlled laboratory conditions. Clams grown to the juvenile stage under controlled conditions would be introduced into substrate which had been heavily impacted by oil or by cleaning efforts. The advantages of spawning and rearing clams to a juvenile stage in a controlled environment are twofold. First, adult clams can be induced to spawn several times during a growing season, and second, survival of the larval stage is greatly enhanced under protected conditions.

MEMORANDUM State of Alaska

TO: Stan Senner
Restoration Program Mgr.
OSIAR Division
Anchorage

DATE: October 11, 1990

FILE NO: SS10390.txt

TELEPHONE NO: 465-4210

FROM: Ken Parker
Director
Division of Commercial Fisheries
Juneau

SUBJECT: Restoration
Feasibility Studies

I have had an opportunity to review your request for 1991 restoration feasibility studies. I am concerned that the restoration planning effort and feasibility studies conducted to date have not adequately addressed the potential damages to the salmon fishery resources of Prince William Sound, Lower Cook Inlet, and Kodiak Island due to the Exxon Valdez oil spill. This is puzzling to me in view of the emphasis of the NRDA studies on salmon, and the great economic value of these resources to the Prince William Sound, Lower Cook Inlet, and Kodiak Island region, and their importance to the ecosystem.

Damages to the salmon resource may include: 1) long term damage to the habitat, 2) short term losses of production due to increases in mortality rate, and 3) short term reductions in production due to over-escapement. Habitat restoration and direct enhancement (i.e. hatcheries) are potential restoration methods. However, these methods by themselves are not sufficient to restore damaged salmon resources. Because the oil was not uniformly distributed in time and space, these damages are potentially stock specific and restoration must address the effect of continued fishery exploitation on damaged stocks.

Continued utilization of the fishery resources that were not damaged by the oil is certainly in the public interest. In view of the value of the resource, the high dependance of the area economies on fishing, it is certain that the public and industry would not accept a blanket closure of the fisheries to restore damaged fishery resources. Therefore, we must find a way to manage existing fisheries to provide some protection to the damaged stocks.

Certain elements of the NRDA program, (coded wire tagging, run reconstruction, and improved escapement estimation) were designed to provide damage assessment as well as provide the information to manage fisheries for more stock specific harvest. It should be clear that restoration funding to continue this activity in the future is legitimate and in the public interest.

cc: Collinsworth Erickson Larson Eggers
Regional Supervisors

1991 Feasibility - NPS Archeology ideas

↓ match to matrix

g. Implement a "site steward" program that employs local residents to watch over cultural sites. (Archeological or historic and burial sites).

Implement a cooperative program between NPS/State Historic Preservation Office and existing site steward programs such as the Kodiak Area Native Association program. Work with Native and Village corporations to involve local fishermen in a site stewardship program. Concern has been expressed that increased visibility may result in greater visitation, disturbance, collection and possibly digging on sites. In many areas this may be highest during the fishing season, thus Native fishermen would be a very effective candidate for stewards. The National Park Service and/or the State Historic Preservation Office would be the regulatory agency, while the Kodiak Area Native Association and others would be the implementing agency.

h. Improve enforcement of historic preservation laws. (Archeological or historic and burial sites).

Conduct regular patrols of affected sites using the ARPA investigator, archaeologists and park rangers or other law enforcement personnel. The threat of looting and vandalism to cultural resources has increased as a result of greater visibility and knowledge of site locations acquired during cleanup activities. Surveillance of sites may prevent looting or vandalism and may acquaint the public of the penalties if a perpetrator is apprehended. The National Park Service would be the lead agency.

i. Increase public education/improve law enforcement to reduce vandalism and looting of historical, archaeological, and burial sites.

Increase circulation of ARPA brochure and poster to include schools, commercial fishermen, Native corporations, and general public. Create/assemble teaching materials to be distributed to teachers and schools. Develop a small, portable exhibit that can travel to many small rural communities that might not otherwise be acquainted with cultural resource preservation. Promote and expand Archaeology Week and associated activities. Produce public service announcements for radio and television. Public awareness of the repercussions of increased site visitation, and site disturbance and collection as a result of greater site visibility may result in reduced site impact. The National Park Service through its Archeological Assistance Division would be the lead agency.

MEMORANDUM

STATE OF ALASKA
Department of Fish and Game

TO: Stan Senner
Restoration Program Manager
Division of OSIAR
Anchorage

DATE: September 28, 1990

FILE NO:

THRU:

TELEPHONE NO: 465-4160

SUBJECT: Restoration Feasibility Studies

FROM: Brian J. Allee
Director
Division of FRED

Thank you for the opportunity to submit restoration feasibility studies to the Oil Spill Restoration Planning Office. Fisheries enhancement techniques represent an economically viable approach to restoring damaged resources from this event. They also are an efficient tool for restoring services lost from resources that may be difficult to restore to their former population levels. There are also significant spinoffs in improving our knowledge for fishery management and population dynamics information that can be gained from enhancement.

To the extent possible, I am making FRED Division technical staff available to you for the purpose of providing assistance on application of fishery enhancement, rehabilitation, and development techniques to restoration. The contact names for the proposed feasibility projects are attached. Due to the short response time, we have elaborated on only one of the projects in the attached Brief Restoration Feasibility Proposal. Some of the feasibility studies on the list will be developed further by the end of the first week of October.

Formal economic information exists for many of the species so that it may be possible to provide further insights into the costs and benefits of specific enhancement alternatives as they are compared with other restoration options.

Please feel free to contact me if you need further details or have any questions.

Attachments

cc: Brian Allee
Bob Burkett
Jim Cochran
Nick Dudiak
Jeff Hartman
Johnny Holland
Jeff Koenings
Tom Kron
Jerry Madden
Larry Peltz
Keith Pratt
Lonnie White

DRAFT
AGGREGATE LIST OF FRED DIVISION
PROPOSED RESTORATION FEASIBILITY STUDIES

September 27, 1990

The following is a list of proposed feasibility studies for restoration of damages from the Exxon Valdez oil spill. It is being submitted to Stan Senner, ADF&G representative with the Oil Spill Impact, Assessment and Restoration Planning Office by Director Brian J. Allee of the Division of Fisheries Rehabilitation, Enhancement and Development (FRED).

This preliminary submission will undergo further revision in the future and is intended to be a working document for formulation of more detailed plans. Additional brief project proposals are being prepared by FRED Division staff and will be available through the identified project leader. Project order on this list has not been based on predetermined priorities.

1. Feasibility of Enriching Nearshore Environments with Either Organic or Inorganic Fertilizer to Optimize Survival of Rearing Salmonids

   Principal Investigator: Jeff Koenings (FRED Division, Soldotna) and University of Alaska-Southeast

2. Feasibility of Enriching Stream Environments with Either Organic or Inorganic Fertilizer to Optimize Survival of Rearing Salmonids

   Principal Investigator: Jeff Koenings (FRED Division, Soldotna)

3. Evaluation and Modeling of Wild Pink Salmon Stock Population Size in Prince William Sound, Including Potential Interactions with Enhanced Stocks

   Principal Investigators: Larry Peltz (FRED Division, Cordova) and FRED Division Biometrician

4. King Crab Culture Techniques and Feeding Trials

   Principal Investigators: Lonnie White (FRED Division, Kodiak) and Tom Shirley (University of Alaska-Southeast)

5. King Crab Rehabilitation: Gulf of Alaska Site Selection

   Principal Investigators: Lonnie White (FRED Division, Kodiak) and Tom Shirley (University of Alaska-Southeast)

6. King Crab Evaluation of Rehabilitation Success

   Principal Investigators: Lonnie White (FRED Division, Kodiak) and Tom Shirley (University of Alaska-Southeast)

7. Tanner and Dungeness Crab Rehabilitation Techniques

   Principal Investigator: Jim Cochran (FRED Division, Juneau)

8. Halibut Egg-Collection Techniques

   Principal Investigator: Keith Pratt (FRED Division, Anchorage)

9. Halibut Culture Techniques

   Principal Investigator: Keith Pratt (FRED Division, Anchorage)

10. Shellfish and Finfish Artificial Habitat Investigation. This feasibility study will explore the application of artificial reef design, site selection, and evaluation for several species of finfish and shellfish.

    Principal Investigator: Keith Pratt (FRED Division, Anchorage)

11. Replacement of Aquatic Plants

    Principal Investigator: Jim Cochran (FRED Division, Juneau)

12. Scallop Enhancement Techniques

    Principal Investigator: Jim Cochran (FRED Division, Juneau)

13. Black Cod Larval Collection Techniques

    Principal Investigator: Keith Pratt (FRED Division, Anchorage)

14. Black Cod Culture Techniques

    Principal Investigator: Nick Dudiak (FRED Division, Homer)

15. Herring Early Life Stage Rehabilitation

    Principal Investigator: Nick Dudiak (FRED Division, Homer)

16. Clam and Mussel Collection, Culture, and Seeding Techniques

    Principal Investigator: Jim Cochran (FRED Division, Juneau)

17. Dolly Varden Rehabilitation Techniques

    Principal Investigator: Larry Peltz (FRED Division, Cordova)

18. Cutthroat Trout Rehabilitation Techniques

    Principal Investigator: Larry Peltz (FRED Division, Cordova)

19. Evaluation of the Enhancement Potential for Pink and Chum Salmon Populations on Montague Island

    Principal Investigator: Larry Peltz (FRED Division, Cordova)

20. Rebuilding of Pink Salmon Populations in Streams Impacted by the Exxon Valdez Oil Spill

    Principal Investigator: Larry Peltz (FRED Division, Cordova)

Brief Restoration Feasibility Proposal

I. DESCRIPTION

1. Title: **Red King Crab Rehabilitation Feasibility Study**
2. Goal: Test feasibility of culturing red king crab embryos to their first benthic stage, evaluate settlement of the young crabs in two "seeded" and one control bay, report and make recommendations based on findings.
3. Location: Kodiak
4. Team: Lonnie White, FB III, Leader. Cooperative effort with Commercial Fisheries Division staff.
5. Schedule: Start March 1991; Three-year study.
6. Background: Red king crab populations were at a very low level prior to the Exxon Valdez oil spill. If impacted, some stocks would be at increased risk, and recovery could extend for many years: 50? Culture of crabs could be a tool to accelerate recovery of stocks. Culture of red king crab has been accomplished by the Japanese.

II. JUSTIFICATION

1. Need: Red king crab are a high-value product. Restoring populations to higher numbers would allow fisheries to occur.
2. Benefits: This feasibility study would provide information needed to evaluate this culture approach with red king crab in Alaska.
3. Criteria

   A. Relationship to NRDA studies and injured natural resources.
   B. Identified public concern: Item E. Mariculture in the fish and shellfish matrix would encompass this approach.
   C. Ability to implement the study in the near future: Study plan has been developed and is ready to implement as soon as funds are available.
   D. Reasonable likelihood of success: Team leader Lonnie White has a proven track record in mariculture and fisheries project accomplishment. Staff are available. Japanese success improves probability of success. It is highly likely that a feasibility study will be completed and needed information produced and reported.
   E. Cost relative to funds available: Yearly cost of $111,330 for each of three years.

III. OBJECTIVES

1. Method: This project will test the feasibility of culturing red king crab from embryos to the first benthic stage. Research will involve culturing of young crabs and evaluation of the success of their settlement in two bays.

A. Culture and Research
B. Evaluation of Settlement
C. Recommendations and Design for Expansion

The project involves cooperative work with the Commercial Fisheries Division.

2. Evaluation: Final evaluation will be based on successful settlement of crabs in the two seeded bays, as compared to the control bay. Enumeration of crabs stocked and crabs settled are an important part of the study. Of the budget, 35% or $39,000 is for the evaluation task.

IV. APPROACH

1. Method: This is a three-year project. The first year will focus on establishing the crab culture facilities and trial runs with proposed methods. The second year is when major production numbers will be collected. The third year will be a replicate of year two.
2. Evaluation: Enumeration of crab stocked and crab settled are key data.

V. BUDGET ESTIMATE

1. By Task: Culture: $72,330; Evaluation: $39,000. Total: $111,330/year.
2. Future Costs: Year Two: $111,330. Year Three: $111,330.

VI. ABSTRACT

To restore red king crab through culture. Test feasibility of culturing red king crab embryos to the first benthic stage, evaluate the settlement of young crabs in two seeded bays and one control bay, and report with recommendations.

271-246

To Stan Senner
From C Meacham

TO: Stan Senner
Restoration Program Manager
OSIAR Division

9-28-90 DATE: September 28, 1990

TELEPHONE: 465-4210

FROM: David Ackley
Marine Fisheries Biometrician
Division of Commercial Fisheries

SUBJECT: Restoration Suggestions

Stan, below are some suggestions for potential restoration projects. Please contact me if you have any questions.

Distribution and abundance of littleneck clams (Protothaca staminea) and butter clams (Saxidomus giganteus) within Prince William Sound (PWS)

A current NRDA impact assessment project has collected data on clams at specific sites within Prince William Sound and is in the process of investigating the potential effects of the oil spill on clam growth. Although necessary for restoration considerations, little is currently known about the distribution and density of clams within PWS. This study would inventory clam populations across various habitat types within PWS, expand the impact assessment results to clam populations thoughout PWS, and identify suitable habitats for clam population enhancements through restorative transplants. The Alaska Department of Fish and Game is the lead agency.

Transplant of clams from healthy habitats to areas affected by the oil spill or cleaning efforts.

Clam populations within PWS were damaged by the oil spill, by beach cleanup efforts, and by removals due to oil spill impact assessment studies. This study will transplant adult clams into the spill area from unaffected locations to restore populations to healthy levels throughout PWS. A transplant experiment was successfully conducted as part of an NRDA impact assessment study. The Alaska Department of Fish and Game is the lead agency.

Seeding of areas in PWS affected by the oil spill by juvenile clams grown under controlled conditions.

Assuming a demonstrable impact on clam populations within the path of the oil spill, it is possible that affected populations may be restored through a seeding project. Under this study, clams would be taken from healthy areas and spawned under controlled laboratory conditions. Clams grown to the juvenile stage under controlled conditions would be introduced into substrate which had been heavily impacted by oil or by cleaning efforts. The advantages of spawning and rearing clams to a juvenile stage in a controlled environment are twofold. First, adult clams can be induced to spawn several times during a growing season, and second, survival of the larval stage is greatly enhanced under protected conditions. The Alaska Department of Fish and Game is the lead agency.

Investigation of juvenile spot shrimp (Pandalus platyceros) abundance and habitat.

An NRDA impact assessment study has sampled adult spot shrimp habitat in order to determine the possible impacts of the PWS oil spill on the adult spot shrimp population. Although adult spot shrimp inhabit deep waters, it is believed that juvenile shrimp inhabit shallower waters likely to have been impacted by the spill. Little is known about the abundance, nursery areas or vertical distribution of juvenile (under 30 mm) spot shrimp. This study would sample potential nursery areas and depth strata for juvenile shrimp and provide information about areas which should be protected or enhanced to rehabilitate shrimp stocks which are already at low levels due in part to commercial exploitation. The Alaska Department of Fish and Game is the lead agency.

Investigation of reef habitat distribution within PWS and estimation of associated species.

Reef structures comprise an important habitat to many species, including rockfish, and provide a protective area for the juvenile stages of several species. Because this habitat is necessary to many species, it is important to determine whether habitat availability is a limiting factor in species diversity and abundance. This study would determine the extent of reef habitat within PWS, catalog the species present at a representative sample of reef sites, and determine areas of PWS deficient in reef structures. The Alaska Department of Fish and Game is the lead agency.

Colonization of artificial reefs by various species within PWS.

Reef structures comprise an important habitat to many species, including rockfish, and provide a protective area for the juvenile stages of several species. An increase in the availability of this habitat type may lead to a subsequent increase in associated species and further enhance commercial and sport fishing opportunities within PWS. This study would introduce artificial reef structures into selected areas within PWS and monitor colonization rate, species diversity and effectiveness of material use and placement. The Alaska Department of Fish and Game is the lead agency.

cc: Gordon Kruse
Chuck Meacham
John Hilsinger

United States Department of Agriculture | Forest Service | Alaska Region

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Reply to: Oil Spill Meetings | Date: October 18, 1990

Subject: Restoration Planning Meeting 10/25/90

To: Hal Kibby (EPA), Art Weiner (ADNR), Roy Nowlin (ADF&G) Ray Highsmith (UAF), Andy Hootin (UAF), John Karinen (NMFS), Josh Schimel (UAF), Kim Sundberg (ADF&G), Steve Jewett (UAF), Pete Petersen (Peer Reviewer), Bob Spies (Chief Scientist), Jeep Rice (NMFS)

On October 25, 1990, a Coastal Habitat restoration work session is scheduled to be held starting at 8:30 am at the Simpson Building at 645 G. Street in Anchorage, Alaska. The purpose of the meeting is to review the results of the 1990 Fucus and intertidal invertebrate restoration feasibility studies, propose new restoration feasibility and restoration projects for 1991. The detailed agenda includes:

8:30 am Introductions and opening discussion of purpose.....Gibbons

8:45 am Review of Fucus feasibility project.....~~Kibby~~ Stekoll

9:00 am Review of intertidal invertebrate feasibility project..Hootin

9:30 am Feasibility Studies/NRDA Damages.....Gibbons
(See Progress Report for guidelines)

Subtidal.....Jewett

Intertidal.....Hootin
Highsmith
Kim Sundberg Karinen
Weiner
~~Kibby~~ Ross

Supratidal.....Schimel
~~Kibby~~ Ross

12:00 Lunch

1:00 pm Restoration Projects/NRDA Damages.....Gibbons
(See Progress Report for preliminary list of factors)

Subtidal.....Jewett
Intertidal.....Hootin et al
Supratidal.....Schimel et al

4:00 pm Summary and Recommendations.....Gibbons/Group

Dave R. Gibbons, Ph.D
Restoration Planning Work Group

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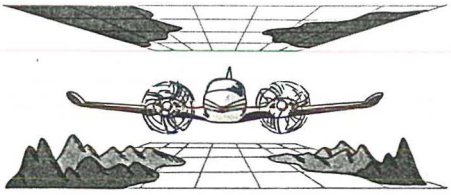


casi

COMPACT AIRBORNE
SPECTROGRAPHIC IMAGER

Technically superior, flexible,with very fine spectral resolution and very high sensitivity at a practical cost, **CASI** is the multispectral imager designed for remote sensing from small aircraft. It is the only device of its kind with user programmable bands, allowing spectral resolution of up to 1.8 nm. Designed with the future in mind, **CASI** is upgradeable and adaptable for your application.

CASI APPLICATIONS:

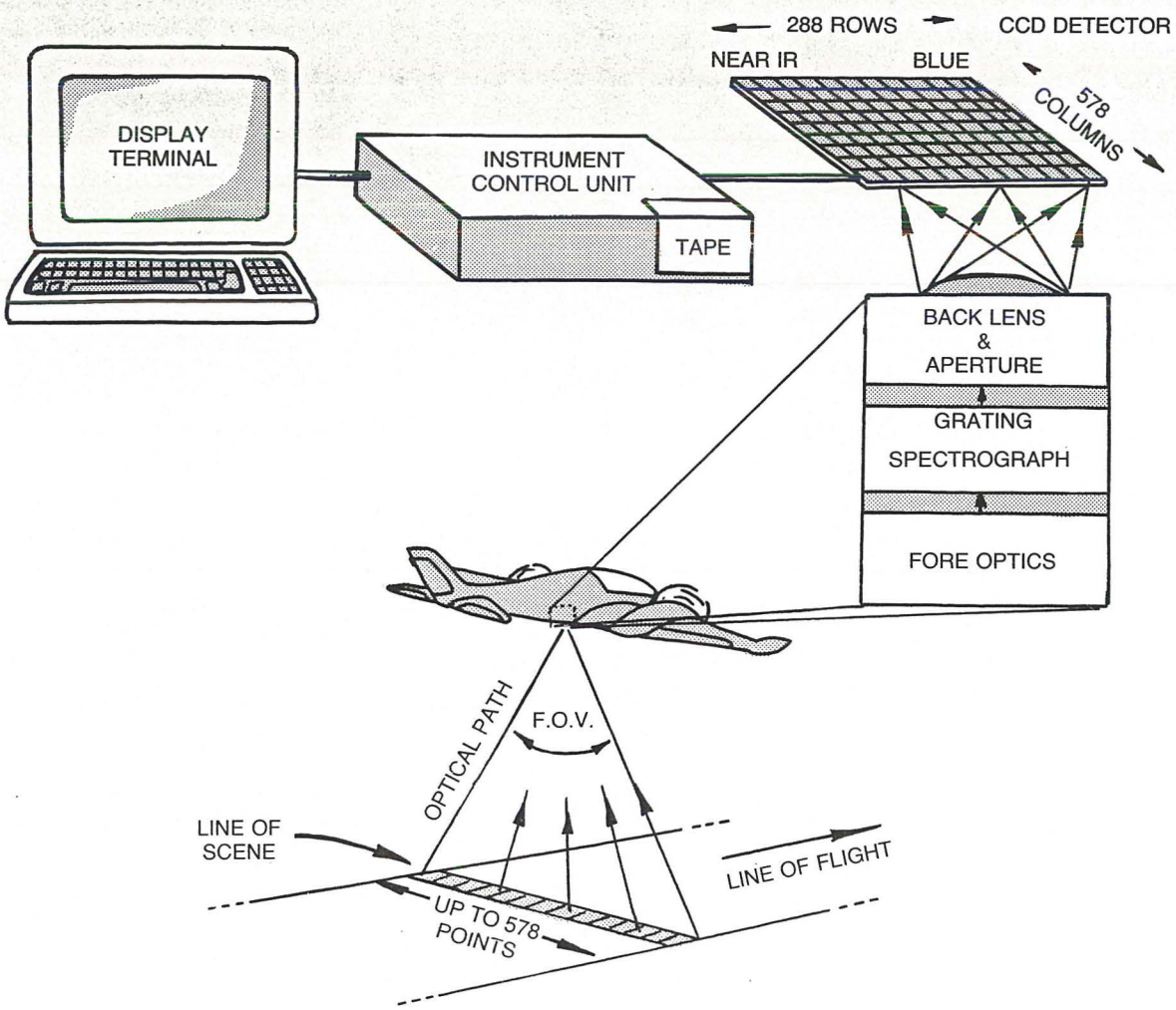
OCEANS & FISHERIES: ocean productivity, algae blooms, aquatic vegetation;
FORESTRY: reforestation vitality, speciation, inventory, forest stress from infestation or pollution;
INLAND WATERWAYS: surface water quality, aquatic vegetation, suspended solids;
ENFORCEMENT: waste regulation, effluent studies, contraband crop detection;
AGRICULTURE: crop vigor, disease, contamination;
GEOBOTANY; LAND USE; ENVIRONMENTAL IMPACT STUDIES.

CASI FEATURES:

★ **compact, lightweight, requires only 250 W of power;**
ideal for low cost platform such as helicopter, light aircraft, or lift truck
★ **quick installation eliminates standby cost;**
★ **288 channels of 1.8 nm spectral width;**
collect full spectral detail over several ''look directions''
★ **channel definition fully programmable;**
collect data with several configurations for multiple applications on a single flight
★ **modular and expandable;**
expand resolution / change spectral range
★ **application specific;**
configure **CASI** channels for optimal discrimination
★ **continuous collection of downwelling irradiance spectra;**
directly compute reflectance spectra
★ **operates as lab or field unit for proof-of-concept work;**
★ **high sensitivity; operates under high cloud.**

CASI: the Pushbroom Imaging Spectrograph:

As a **"Pushbroom Imager"**, **CASI** detects an entire row or line of image at one time with its CCD (Charge Coupled Device) detector. This allows a longer dwell time per pixel than with scanners and results in high sensitivity. Each line or image consists of a series of elements of ground information. The light from each scene element is dispersed spectrally across the second dimension of the two dimensional sensor array. Spatial resolution and spectral band selection are completely controlled by the readout configuration, strategically summing or discarding certain bands of wavelength. In **CASI,** a 578 x 288 pixel CCD is used. This results in the availability of up to 288 spectral bands and 578 spatial resolution across track, including downwelling irradiance spectral data which is simultaneously recorded if desired.



IMAGING MODE DATA COLLECTION:

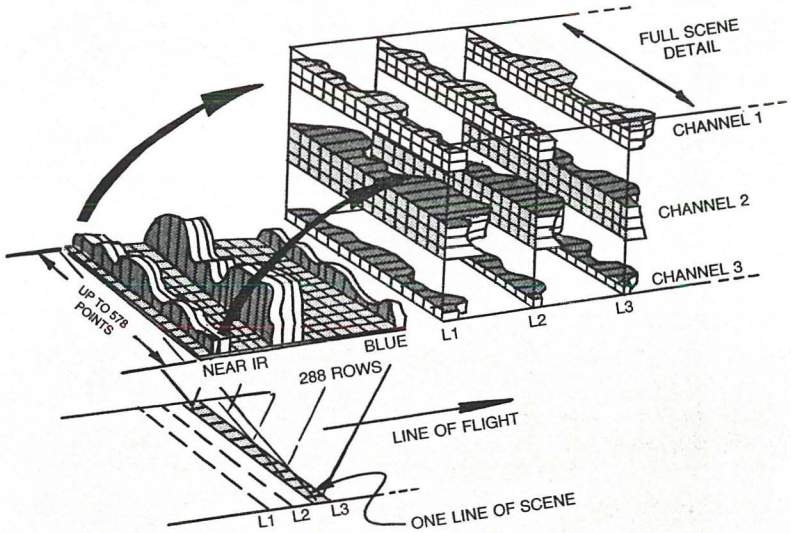
Bands of adjacent 1.8 nm wide spectral lines are summed, effectively providing programmable width/programmable centre spectral filters (bands) for each of up to 578 scene points.

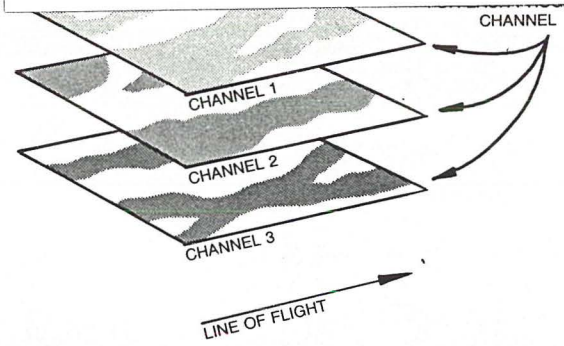
itres RESEARCH

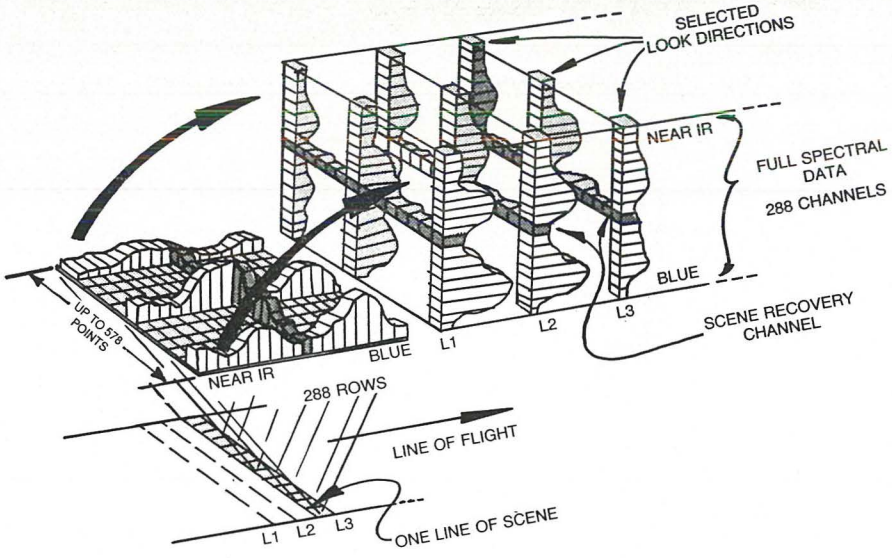
Cathy Wrightson, B.Sc.
Customer Support/Applications Development

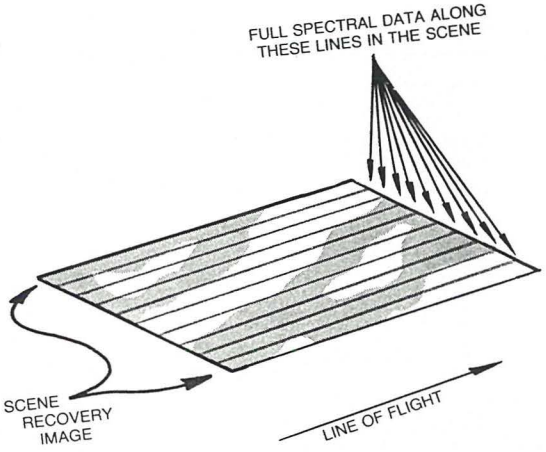
Suite 110, 6815 - 8th Street N.E.
Calgary, Alberta, Canada T2E 7H7

Fax: (403) 295-3570 **Tel: (403) 274-7440**



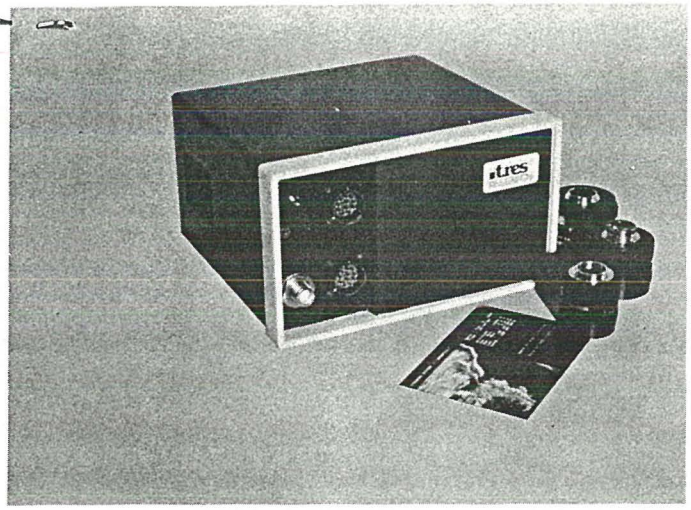




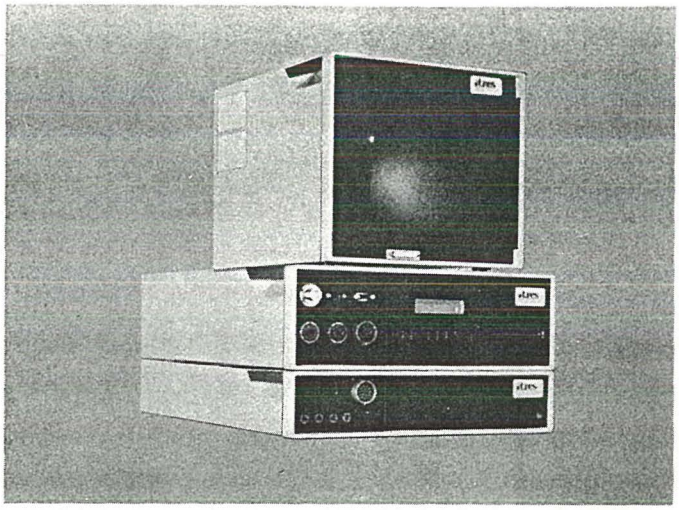


MULTISPECTROMETER MODE DATA COLLECTION:

For a programmable number of points in a scene ("look directions") full spectral data may be collected providing a "Rake Spectrograph". Simultaneously a single spectral imaging band is collected (scene recovery band) to allow identification of scene features in relation to spectral data points.



Camera Head



Monitor, Control Unit, and Power Supply

CASI Specifications: Pushbroom Imaging Spectrograph

Swath (FOV)	—	15-60 degrees
Spectral Range	—	400-900 nm (other ranges available)
Spatial Resolution	—	up to 578 pixels
Spectral Resolution	—	up to 288 rows, 1.8nm each
Spectral Bands	—	Programmable location and width
Aperture	—	Electronically controlled
Line Rate	—	Up to 100 lines/sec.
Dynamic Range	—	12 bits
Electronics	—	Rugged, low power, low noise design
Recording	—	Digital Helical scan tape 2 Gbyte or 2 hour maximum storage per tape
Sensitivity	—	.03μW/cm²/sr/nm @ 30 line/sec @ 575nm
Realtime Display	—	
Imaging Mode:		Colour display of selected channel; dynamic range indication for all channels;
Multispectrometer Mode:		Colour display of scene recovery channel; display of full spectrum from any "look direction"
Operator Control	—	Menu driven or from configuration files
Weight	—	120 lbs. (55 kg.)
Power	—	110V 2.5 A
Thermal	—	Operating: 5 to 40 C
		Non-operating: -20 to 60 C

note: specifications are subject to change

CASI8907

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SUITE 110, 6815 - 8 ST. N.E
CALGARY, ALBERTA, CANADA T2E 7H7
(403) 274-7440 — Fax: (403) 295-357(
contact: Richard Adamsor

Fax Message
from the EPA Office of Water

Number of Pages To Follow 2
Transmit to Fax Number FTS-8-868-2467

Sent by NANCY JONES

Comments BRIAN/STEVE - THIS looks much better. Thanks! NANCY

Please deliver immediately to:

Name BRIAN ROSS / STEVE BUCHER

Organization EPA

Room

Telephone FTS-8-868-2461

To Confirm Receipt or Report Transmission Problems, Please Contact

Name NANCY JONES

Voice 'Phone FTS-8-382-5700

Sent via Fujitsu Dex 140 (202) 382-5711

AAFT

REVISED FR NOTICE OUTLINE 10/24/90 Version

I. Introduction

Purpose of document

- Primary purpose to present draft Restoration Work Plan and proposed 1991 Restoration Program for public comment
- Secondary purpose, to report on the results of 1990 RPWG activities, including 1990 Feasibility Studies, etc.

Background

- Spill stats, etc. (canned language)
- Incl discussion on NRDA process and its overall goal to provide for restoration of injured resources ...

II. Draft Restoration Work Plan

Chapter Intro

- Relationship to response and damage assessment
- Dynamic process, information still being assessed
- Leads to final restoration plan after settlement of damage claim
- Commitment to public involvement
- Timeline

Work Plan Components

- Determine need for restoration
- NRDA data, feasibility studies, lit. review, etc.
- Develop restoration alternatives and approaches
  - Public involvement, workshops, reports, etc.
  - Summary of restoration alternatives proposed to date
- Evaluation of restoration alternatives and approaches for each injured resource as information becomes available
  - Three types of restoration to be addressed (direct, replacement, acquisition of equivalent resources)
  - Matrix approach, through PI/Peer Review meetings
  - Application of "factors to be considered" (based on DOJ "proofs")
  - Summary of potential restoration actions that may be taken, depending on specific injury to the resource
- Develop and implement restoration projects as necessary prior to settlement
  - Peer review process prior to implementation
  - Public comment prior to implementation
- Develop and implement final Restoration Plan following settlement
  - Peer review process prior to implementation
  - Public comment prior to implementation

AAFT

REVISED FR NOTICE OUTLINE 10/24/90 Version

III. Proposed 1991 Restoration Program

Proposed 1991 Restoration Projects Options (* We need to make it clear we envision doing some but not all of these, depending on funds available, though don't want to say it that way.)

- Specific proposals for:
  - a) Coastal/Intertidal resources
  - b) Fish/Shellfish
  - c) Birds
  - d) Mammals
  - e) Recreational resources
  - f) Cultural resources

Proposed 1991 Feasibility Projects

Literature Review
- Natural recovery lit. review, etc.

Development of overall restoration monitoring plan
- Measure and provide public accountability for success of restoration actions
- To ensure efficient integration and sharing of agency monitoring data

Opportunities for Public Participation
- Comment on FR notices (draft and final documents)
- Other?

IV. Summary of 1990 Restoration Feasibility Studies

- 1990 Feasibility Study descriptions/preliminary results/status
- 1990 Technical Support Study descriptions/preliminary results/status

1990 Feas. Study.
File
(Beach Programs = FS # 3)

September 10, 1990

John Bauer
Department of Environmental Conservation
2550 Denali, Suite 705
Anchorage, AK 99503

Dear Mr. Bauer:

On August 30, 1990, I examined six beach areas where possible damage to Beach Wildrye (Elymus arenarius E. mollis) communities may have occurred. The beach segments examined were:

Danger Island	DA002
Latouche	LA15C
Bainbridge	BA004
Knight Island	KN408
Ingot Island	IN022
Eleanor/Block	EL011

Of these beaches, only Latouche 15C, Knight Island KN408 and the fuel storage area between Elenor and Block Islands EL011 show any indication of damage to the Beach Wildrye communities. It is possible that this damage could result in accelerated erosion of the beaches, or the upland communities adjacent to the Beach Wildrye could be significantly impacted by beach encroachment. The most significant damage was noted on Knight Island 408. This damage can be directly associated with clean-up activity. Gravel removal and/or cleaning has resulted in damage to the Beach Wildrye communities. Also, although not a severe environmental problem, the haphazard (unnatural) placement of drift logs has caused the beach to become unsightly. This latter concern, although noted, is beyond the scope of my investigation and can be worked around if Beach Wildrye restoration is attempted.

REHABILITATION PLAN FOR KN408 BEACH WILRYE COMMUNITY

I recommend that this Beach Wildrye community be repaired using a combination of transplanting and fertilization. The transplanting effort would only require a single band of Beach Wildrye placed approximately ten feet from the present log piles running parallel to the water's edge. This would require approximately 1,000 Beach Wildrye sprigs. A heavy application of 20-20-10 fertilizer (800 pounds per acre) would encourage the undamaged and transplanted Beach Wildrye to recolonize its former niche. I estimate that the restoration on this beach will take six man days.

REHABILITATION PLAN FOR LATOUCHE 15C BEACH WILDRYE COMMUNITY

On August 30, 1990, this beach was still undergoing clean-up. The damage being done was similar to that observed on KN408, however this beach has not been as significantly impacted as KN408. If the clean-up continued as it was proceeding during my inspection, I expect that this Beach Wildrye community can be restored with fertilizer only. I do not believe a transplant operation will be necessary on LA15C. However, a fertilizer program similar to that recommended for KN408 should restore the site. I estimate two man days to complete the work.

REHABILITATION PLAN FOR THE FUEL STORAGE AREA AT EL-011

This small disturbance should be corrected after fuel storage tanks and related fueling structures are removed. The containment berms should be leveled to match existing contours and the entire area should be sprigged with Beach Wildrye and fertilized at a rate equal to 800 pounds of 20-20-10 per acre. Beach Wildrye transplants can be obtained from adjacent undisturbed stands. The transplant spacing should be four feet on center. After the grading work and equipment removal is complete, the restoration activity should take two man days.

ADDITIONAL NOTE

Ingot Island 022 has not been listed in this report, but the vegetation is showing signs of stress and should be monitored. Stress was noted in both the Beach Wildrye and wetland communities.

If you have any questions or if you require additional assistance in Beach Wildrye restoration or wetland rehabilitation, please contact me at 745-4469.

Sincerely,

Stoney Wright

Stoney J. Wright, Manager
Alaska Plant Materials Center

SJW/ds

cc: Mark Broderson

10/25 09:52 #01 7307137

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Environmental Research Laboratory
CORVALLIS OR 97333

&EPA FACSIMILE REQUEST AND COVER SHEET

PLEASE PRINT IN BLACK INK ONLY

TO: BRIAN LOSS

OFFICE/PHONE

FAX #: 868-2467
CONF. #:

REGION/LAB: REGION X

~~FROM~~: BILL WILLIAMS / KIBBY

PHONE: FTS 420-4679

MAIL CODE:

OFFICE: ERL-C

DATE: 10/25/90

NUMBER OF PAGES TO INCLUDE THIS COVER SHEET: 6

Please number all pages

INFORMATION FOR SENDING FACSIMILE MESSAGES

EQUIPMENT	FACSIMILE NUMBER	VERIFICATION NUMBER
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CONFIRMED: _____

CERL-24

PAGE ___ OF ___ PAGES

Title

Restoration of Tidal Marshes Affected by the Exxon Valdez Oil Spill.

Background

The March 1989 Exxon Valdez oil spill (EVOS) impacted approximately one thousand miles of coastal resources in the Prince William Sound (PWS) and Gulf of Alaska (GOA), directly affecting the region's habitat and its related animal populations as well as its recreational, educational, and aesthetic values. Tidal marshes occupy a relatively small percentage of the affected coastline, but are important components of the coastal ecosystem and were among the habitats impacted by the spill. Although PWS and GOA tidal marshes are limited in areal extent, they are ecologically important, serving as feeding and resting areas for birds, and possibly as alternative food sources for grazing mammals. It is therefore necessary to ensure that affected tidal marshes are restored to approximately pre-spill ecological conditions.

Historical attempts to clean oil from marshes have shown that clean-up methods which disturb the soil or hydrology of the marsh will have long term effects equal to or more severe than direct oiling. At the same time, oil removal from marshes by natural processes is slow because marshes are sedimentary, anaerobic habitats with minimal flushing. Following the EVOS, most affected marshes received only minor or patchy insult as a result of either initial oiling or clean-up efforts. However, some marshes were heavily oiled, and remained significantly impacted following the 1990 cleanup season. Restoration activities in these marshes may be expected to require both substantial effort and extended time periods (possibly more than 2 or 3 years). The presence of oil in high concentrations at a site may complicate restoration efforts, and regrowth in these areas may occur slowly, if at all. The scientific literature does not clearly establish the threshold oil concentration where tidal marsh plants can be successfully reestablished.

Actions taken to restore a tidal marsh will facilitate recovery of the ecosystem. Restoration actions are used to initiate the recovery process, and enhance the prospects and rates of natural recovery over time. Restoration "success" can be measured in terms of increased cover of tidal marsh vegetation over time.

A restoration planning process was initiated in late 1989 to begin addressing ways to help restore resources impacted by the EVOS. A restoration planning Progress Report, prepared by the interagency Restoration Planning Work Group (RPWG) was released in August, 1990. This report defines restoration as "actions undertaken to return an injured resource to its baseline condition, as measured in terms of the injured resources's physical, chemical, or biological properties or the services it previously provided" (RPWG, 1990). A draft Restoration Workplan, including proposed 1991 restoration projects, will be finalized by the end of 1990.

The Project Area

Field observations in both PWS and the GOA indicate that some tidal marsh sites, particularly those which were not physically cleaned, are still visibly oily with little natural regeneration of vegetation. This is particularly the case in heavily and moderately oiled tidal marshes, probably a result of too much oil still present in the substrate to permit natural recovery. The natural recovery of oil impacted marshes in PWS and the GOA may occur slowly because these marshes are isolated, small, and occupy low energy sites. These factors also limit opportunities for natural recolonization through seeding or propagule dispersal.

marshes satisfy the minimum requirements for restoration through site assessment, and the vegetation cover is less than 20 percent, then transplanting using compatible plant materials from nearby areas will be recommended. If more than 20 percent of a marsh has vegetation that shows visual symptoms of stress or is dying back but vegetation cover is greater than 20 percent, a nutrient analysis of the soil will be conducted and, if warranted, fertilizer application to strengthen the existing plants and aid in recovery will be recommended. Fertilization of planted areas will also be prescribed if conditions warrant this treatment. Numbers of transplants needed, fertilizer application rates, and personnel time requirements will be calculated from estimates of the areal extent of each marsh recommended for treatment.

Site Restoration

The first annual planting will be undertaken in the spring of 1991 with subsequent supplemental plantings through 1994 or until suitable restoration has been attained. Planting will employ well documented methods. Briefly, we intend to plant bare root transplants collected from nearby donor marshes. Transplanting will be made at a planting density of nine plantings/m^2. Each planting will include two to three individual culms per hole. Specifics of the fertilizing scheme will depend upon site-specific analyses, to be described in the detailed proposal.

Site Monitoring

The areal cover of living aboveground vegetation at restored sites will serve as our primary indicator for monitoring restoration success. Plant cover will be monitored in the spring and fall of 1991 and at the end of the growing season in subsequent years to determine if restoration activities have succeeded. Minimal standards for determining restoration success will be developed and presented in the detailed study plan.

We suspect that two heavily oiled sites, the Bay of Isles and Tonsina Bay on the Kenai Peninsula, may not be amenable to successful restoration the first year due to the high oil concentrations, and will be the subject of a slightly more intensive monitoring effort. Plant survival count, standing stock (i.e., percent cover, biomass), elevation and soil data (for oil fraction analysis and grain size) will be collected from these two sites annually. Care will be taken to minimize activity at and disturbance of plantings at these heavily oiled sites. Work will be restricted to approximately 15 days at each site for initial site characterization and restoration in the spring of 1991, with 5 days of follow-up monitoring in the early fall of 1991. Monitoring restoration success at these sites will require approximately 5 days of activity in the spring and fall of each subsequent year.

Supplemental Restoration Actions

Supplemental restoration actions will follow the guidelines we have outlined above. We suspect that the heavily oiled sites in the Bay of Isles and Tonsina Bay on the Kenai Peninsula may require remedial actions. However, we expect that remedial actions will decrease in intensity over time.

Project Goals

The overall goals of the project are to accelerate natural recovery of PWS and GOA tidal marshes impacted by the Exxon-Valdez oil spill, and to determine and apply the appropriate restoration techniques to individual tidal marshes.

The restoration program will consist of five components:

- o Site assessment to identify tidal marshes that should be restored
- o Site planning to identify appropriate methods to be used at each restoration site
- o Restoration activities at each selected site
- o Reassessment to monitor the success of restoration activities
- o Remedial actions to supplement any initially unsuccessful restoration efforts

A detailed proposal is being prepared which discusses fully the selection criteria to be used in determining the most appropriate restoration techniques for each tidal marsh selected for restoration.

Methodology

Field work will begin in the spring of 1991 and will consist of a five step process including: (1) site assessment, (2) site planning, (3) site restoration activities, (4) site monitoring and reassessment, and (5) site remedial restoration activities, as necessary. Summaries of each phase of the processes are provided below; additional information will be provided in a detailed study plan.

Site Assessment

We propose to visit each tidal marsh known to be, or potentially affected by, EVOS oil (determined by existing oil maps and "word of mouth"). Our survey will start in the Bay of Isles, a tidal marsh known to be heavily oiled, and move progressively down the PWS and, subsequently, into the GOA. On potentially impacted marshes the extent of living versus dead (above and belowground) vegetation cover will be visually estimated. At each marsh it will be estimated if more than 20 percent of the area of a marsh, or an area greater than 10 m^2 has been impacted. These are considered the minimum areas that might be reliably detected statistically. They also are considered the minimum size criteria for restoration activities. Soil samples will be collected from apparently affected areas, removed to a laboratory and total plant available N and P will be determined. Additional information that will be determined at the site are the areal proportions of plant mortality and reduced vigor, which will be estimated visually. Ancillary information, including: dominant species present, proximity to a suitable donor site, historical record of treatment, elevation and substrate type will be noted. Specific methods and field forms will be developed for inclusion in the detailed study proposal.

Site Planning

Site assessment information will be used to determine the restoration prescription and to determine the logistical effort necessary for prescription implementation. If tidal

Initial Literature Review

1. Baker, J.M. 1970. The effects of oils on plants, Environmental Pollution, 1:27-44.

2. _____. 1971. Seasonal effects of oil pollution on salt marsh vegetation, Oikos, 22:106-110.

3. Cairns, J. and A.L. Buikema, eds. 1984. Restoration of Habitats Impacted by Oil Spills. Butterworth Publishers.

4. Dicks, B. and K Iball. 1981. Ten years of salt marsh monitoring - the case history of a Southamton water salt marsh and a changing refinery effluent discharge. In Proceedings of the 1981 World Oil Spill Conference. Atlanta, GA:EPA/API/USCG.

5. Thorhaug, A. 1980. Recovery patterns of restored major plant communities in the United States. In Recovery Process in Damaged Ecosystems, J. Cairns, ed. Ann Arbor Sciences Publishers.

6. Alaska Departments of Fish and Game, Natural Resources, and Environmental Conservation; U.S. Departments of Agriculture, Commerce, and Interior; U.S. Environmental Protection Agency. 1990. Restoration Planning Following the Exxon Valdez Oil Spill. August 1990 Progress Report.

Cost Estimate

Sr. Scientist (6 mos)	$	30,000
Technicians (6 for 4mos)		70,000
Personnel OH		80,000
Travel		50,000
Ship Time estimated 90 days @ $2000		180,000
Helicopter (70 Hours at $600)		42,000
Float Plane (125 Hours at $350)		43,750
Chemical Analysis		50,000
Lab Space Rental		20,000
Supplies and Equipment OH		64,500
Misc. Equipment/Supplies (Incl. Fertilizer, etc.)		15,000
Total	$	645,250

$645,250 each year (1991, 1992)
$100,000 each year (1993, 1994)

NOAA'S NATURAL RECOVERY MONITORING PROGRAM
FOLLOWING THE *EXXON VALDEZ* OIL SPILL

TITLE: *Exxon Valdez* crude oil in sediments and mussels; and rates of recovery of impacted biota on selected intertidal beaches in Prince William Sound (PWS), Alaska.

PRINCIPAL INVESTIGATORS: John Karinen and Malin Babcock

BACKGROUND: This study continues sampling mussels and sediments at intertidal sites that were sampled under the NRDA Coastal Habitat Contract to Auke Bay Laboratory. The first analyses of 1989 samples (sediments for hydrocarbons and photographic quadrats for abundance and diversity) are currently being conducted. We propose to monitor hydrocarbons levels at these sites, and to expand the design to measure rates of recovery and recolonization on selected intertidal areas.

In 1989, we resampled 10 historically (1977-1981) established intertidal hydrocarbon baseline sites in Prince William Sound in response to the *Exxon Valdez* oil spill. Additionally, 10 sites were established along the spill trajectory before oiling, and sampled after oiling to measure the increase of hydrocarbon levels in sediments and mussels resulting from the spill. Sampling was continued in 1990 (April, June, and August). We propose to continue monitoring activity (hydrocarbons in sediments and mussels) at these sites to provide a continuum of measurements following impact of *Exxon Valdez* oil.

Most of the sites established referred to in the first paragraph are low energy, fine-grained beaches at the head of embayments and were not subject to the rigors of intense cleaning activities; the biota is relatively healthy compared to beaches where vigorous cleaning action by the "Omnibarge" or other means occured. In contrast, Houghton et al (in Press) found that in areas that were subjected to vigorous washing and other intrusive cleaning activities, intertidal surfaces were fairly devoid of mussels, barnacles and other biota that comprise the natural communities in this ecosystem.

OBJECTIVES

1. For all established sites under the NRDA process - to estimate the hydrocarbon concentrations in mussels and sediments such that the estimate is within 10% of the actual concentration 95% of the time when total aromatic concentrations are greater than 200 ng/g dry wt.

2. To estimate recovery and recolonization rates of key ecosystem components [particularly, mussels (*Mytilus trossulus*) and barnacles (*Semibalanus balanoides* or *Balanus glandula*) which are dominant filter feeders in the intertidal area of much of Prince William Sound] on sheltered rocky and mixed soft substrates and 2 conditions of oiling/treatment. We propose to estimate rates of recruitment, growth and survival on these sites. The null hypothesis is that recolonization, recruitment, survival and growth in mussels and barnacles will be the same under all conditions.

METHODS

Historical Sites - Monitoring. Sampling will be done in April and in August, 1991. Sediment transects (30 m) are located parallel to the water line at -0.75 m to +0.75 m (depending on specific site). We will collect triplicate sediment samples at each site by compositing 10 cores (dia 3.2 cm x depth 1.25 cm) taken at random along a 30 meter transect for each sample. Mussel transects are located usually just up (~+1 m tide level) from the sediment transects. Triplicate mussel samples will be collected, approximately 30 2-5 cm. mussels at random.

Recovery Processes. To the extent possible, sites for this project will be chosen to minimize logistic problems and to build on previous data sets and studies. Sites can be drawn from the following: NOAA HAZMAT sites and sites used previously in other NRDA studies; e.g. FSHSHFSH 4; Coastal Habitat; ADF&G's Clam Study, etc. Triplicate sites will be stratified by morphology (sheltered rocky and mixed soft) and disturbance (unoiled and oiled/treated). One of the proposed sites will be the "Omnibarge" site for which Houghton et al (In Press) has pre- and post- treatment data for 1989. This will create a 3x2x2 matrix for a total of 12 sites.

Triplicate 30-m vertical transects on each site will be established and permanently marked. These transects will span the middle elevation of the intertidal area and will encompass the general area of mussels and barnacle. Triplicate quadrats (0.25-m^2) will be randomly located along this line and permanently marked for non-destructive sampling. Barnacles and mussels and other major epibenthic fauna will be counted and measured in the quadrats. Algal cover (%) will be visually estimated. Triplicate, composite sediment samples for hydrocarbon analyses will be secured at each site. In the nearshore area off each site, 3 sets of artificial substrates will be placed at a depth of 1 m to document that mussel and barnacle larva are present in an adjacent area and presumably be available for settling/colonization.

All sampling procedures will follow protocol and guidelines which have been established under the NRDA process.

BUDGET

Line Item	OBJ #1	OBJ #2	Combined
Labor	34.0	40.0	74.0
Travel	20.0	20.0	40.0
Contracts: Helicopter	20.0		20.0
Vessel Charter		84.0	84.0
Data generation, entry	7.0	5.0	12.0
Supplies & Equipment	10.0	10.0	20.0
TOTAL	**91.0**	**159.0**	**270.0**

Note: $ for hydrocarbon analyses are not included above. Analyses for OBJ #1 is estimated to be 84K, and for OBJ #2 - 108K.

LITERATURE CITED

Houghton, Jonathan P., William B. Driskell, Dennis C. Lees and Alan J. Mearns. In Press. Impacts of the *EXXON VALDEZ* spill and subsequent cleanup on intertidal biota - 1 year later. Submitted to Oil Spill Conference, 3. 1991.

NOAA'S NATURAL RECOVERY MONITORING PROGRAM
FOLLOWING THE EXXON VALDEZ OIL SPILL

Title: Near Shore Seawater Quality Monitoring using Caged, Uncontaminated Mussels as Bioconcentration Organisms.

Principal Investigators: Jeffrey W. Short and Patricia Rounds

Introduction:

This study extends a part of the NRDA Air/Water #3 study, which involved the deployment of caged, uncontaminated mussels along the Exxon Valdez oil spill trajectory. These caged mussels act as extremely sensitive indicators of ambient water quality, because they accumulate biologically available hydrocarbons integrated over time.

Preliminary analysis of 1989 of petroleum hydrocarbons in tissues of caged mussels found hydrocarbon levels at several impacted sites higher than levels in caged mussels at Olsen Bay (reference site) or in the mussels prior to field exposure. Although analysis of 1990 caged mussels is not complete, continued elevated hydrocarbon levels relative to reference and unexposed mussels are expected. The determination that nearshore waters in Prince William Sound have returned to pre-spill hydrocarbon levels is necessary to establish that the potential of damage directly from polluted water is negligible , a determination important to restoration projects proposing transplanting key organisms damaged by initial oiling and cleanup to impacted areas.

Methods:

We propose in 1991 to expose caged "clean" mussels for one month at a minimum of one reference and 11 impacted sites in PWS (see appended site list) during the Spring, and again during the Fall. At each site mussel cages will be deployed at 1, 5, and 25m depths. Deployment and collection of mussels well be consistent with methods described in NDRA project Air Water 3 study plans for 1989 and 1990.

Other sites may be added in areas scheduled for berm relocation or washing. If analysis demonstrates continued elevated hydrocarbon levels, a single exposure will be proposed in 1992.

Budget:

Major costs in 1991 will be salaries, travel and vessel support. Mooring hardware purchased in 1989 and 1990 can be reused.

Line Item	Cost in Thousands of dollars
Labor	62
Travel	16
Vessel Charter	60
Supplies & Equipment	12
TOTAL	150

(These costs do not include the cost chemical analysis of approximately 80 mussel tissue samples for aliphatic and aromatic hydrocarbons, estimated at $45,000).

NOAA'S NATURAL RECOVERY MONITORING PROGRAM
FOLLOWING THE EXXON VALDEZ OIL SPILL

Project Title: Monitoring Natural Recovery of Subtidal Marine Sediment Resources in Prince William Sound.

Principal Investigators: Stanley D. Rice and Charles E. O'Clair

Introduction:

Subtidal marine sediments in Prince William Sound have become contamined with pertoleum hydrocarbons from the Exxon Valdez oil spill probably largely as a result of transport of hydrocarbons from the intertidal region mediated by physical and biological processes. The degree of contamination varies spatially and temporally. Preliminary gas chromatographic/mass spectrometric analyses of subtidal sediments collected by the Auke Bay Laboratory from 20 locations in Prince William Sound have shown detectable contamination of sediments from the intertidal region to a depth of 100 m in at least one heavily comtaminated bay. At seven additional locations where sediments have been analysed contamination extended to a depth of 20 m. The Auke Bay Laboratory proposes to monitor hydrocarbon levels in sediments at contaminated and reference sites in order to provide information necessary to track the trajectory of recovery of sediment resources to pre-spill conditions.

Objectives:

A. Determine occurrence, persistence, and chemical composition of petroleum hydrocarbons in subtidal marine sediments during period of recovery.

B. Provide marine sediment data to assist agencies in modeling the time course of recovery to pre-spill conditions.

C. Examine the relationship between the retention of hydrocarbons in sediments and the effect on benthic meiofauna during the period of recovery.

Methods:

Sediments will be sampled at 15 sites in Prince William Sound (6 reference sites and 9 contaminated sites). Sampling will be conducted during two periods (May and September). Sediment collections will be made at depths of 0 (MLLW) and at 3, 6, 20, 40 and 100 m below MLLW. Samples will be collected at low tide (0 m) or by divers (3, 6 and 20 m) At these shallow depths three samples each a composite of 8 subsamples will be collected randomly along a 30 m transect laid parallel to the shoreline or along the appropriate isobath. Samples taken at depths below 20 m will be collected with a Smith-McIntyre grab. Three cores will be taken at each depth. Four subsamples will be removed at

randomly selected points within each core. The subsamples will be combined to form one sample per core. All samples will be taken from the surface (top 0-2 cm) of the sediment column. Sampling procedures will follow the standard operating procedures developed by the Auke Bay Laboratory for damage assessment of the Exxon Valdez oil spill.

Budget:

Salaries	**Travel**	**Vessel**	**Contracts**	**Supplies**	**Equipment**	**Total**
(Cost is in thousands of dollars)						
71	12	100	35	21	16	$255

Analytical cost will be $148.5.

Steve Jewett
Tom Dean

Coastal Habitat -Subtidal

1.0 Summary of potential damages (preliminary)

1.1 Silled fjords

- Dead starfish, fish, infauna in anoxic layer in 1989
- Some recovery to epibenthos in 1990. (Data on infauna not analyzed)
- Possible sublethal effects on infauna (lessions on polychaetes) in 1990

1.2 Laminaria and eelgrass habitats in bays

- Oil present in sediments to depths of 20 m
- Possible effects on infauna (not yet analyzed)
- Possible decrease in flowering of eelgrass
- Possible increase in parasitism of starfish (Dermasterias)

2.0 Recommendations for restoration

2.1 No "direct restoration" is recommended

- Few indications of decrease in density or biomass of "restorable" populations such as eelgrass, though some sublethal effects.
- Lack of feasible restoration techniques

2.2 Continued monitoring of damaged resources

- Emphasis on Laminaria and eelgrass habitats in bays and fjords
- Emphasis on infauna, eelgrass, starfish, forage fish and other potentially damaged resources

- Emphasis on monitoring rates of recovery or decline (especially declines due to secondary impacts such as lack of predation pressure)

2.3 Long term monitoring of indicator species in selected habitats

- Provide quantitative background data lacking in present damage assessment

3.0 Recommended research

3.1 Develop criteria for establishing paired impact and control sites and test their adequacy

3.2 Develop and test methods for sampling indicator species based on present results

FAX FORM
U.S. FISH AND WILDLIFE SERVICE
REGION 7
1011 E. TUDOR ROAD
ANCHORAGE, ALASKA 99503
FAX NUMBER: Commercial (907) 786-3520
FTS 869-3350

FAX to 271-2467

TO: Brian Ross + Stan Senner RPW6	**DATE/TIME:** 10/22/90
FROM: Carol Gorbics	**CALL**_____**TO HAVE PICKED UP**
SUBJECT: USFWS Restoration + Feasibility Projects as of 10/19/90	

This is a complete list and set of the submittals to date. All the Bird info was faxed to Michael Fry 10/20/90. Let me know if there is anyone else you want this provided to.

Carol
786-3467
or 3520

FWS Restoration Feasibility Proposals as of 10/19/90

Birds

1. Identification and protection of important bald eagle habitats in the Exxon Valdez oil spill area.

2. Delineation and protection of prey resources for bald eagles in the Exxon Valdez oil spill area.

3. Reduction of potential sources of disturbance for bald eagles in the Exxon Valdez oil spill area.

4. Long-term population monitoring for bald eagles in the Exxon Valdez oil spill area.

5. Effects of intertidal restoration on black oystercatchers.

6. Removal of introduced animals on selected colonial seabird nesting islands (modified from initial submission).

7. Identification of upland habitats used by wildlife, particularly the marbled murrelet, affected by the Exxon Valdez oil spill.

8. Temporal and spatial differences in food habits of black-legged kittiwakes, pigeon guillemots and marbled murrelets in Prince William Sound.

* 9. Population status and reproductive success of pigeon guillemots in Prince William Sound.

* 10. Population status and reproductive success of arctic terns in Prince William Sound.

* 11. Population status and reproductive success of mew gulls in Prince William Sound.

* 12. Reproductive success of black-legged kittiwakes in Prince William Sound.

* 13. Reproductive success of marbled murrelets in Prince William Sound.

* 14. Identify, characterize and rank colonial seabird nesting, foraging and wintering habitats that need protection, either through purchase or legislation.

* 15. Identify marbled murrelet nesting habitat that needs protection, either through purchase or legislation.

* 16. Designate Prince William Sound as Marine Sanctuary, Estuarine Reserve or Critical Habitat area.

* 17. Educate tourists, tour operations and commercial fishing industry in seabird conservation, protection and viewing etiquette.

* 18. Determine the importance or the subsistence harvest of birds to Alaska Natives in Prince William Sound, Kenai Peninsula and Kodiak Island.

Marine Mammals - Sea Otters

1. Determination of key sea otter prey species in western Prince William Sound for enhancement of restored or non-contaminated sea otter habitat.

2. Consumption of contaminated prey by sea otters in Prince William Sound.

3. Variation in effects of oil exposure among sea otters living in areas affected by the Exxon Valdez oil spill.

4. Determination of sea otter foraging depths in western Prince William Sound for population and habitat restoration.

Birds and Marine Mammals

1. Population monitoring of marine birds and mammals in the Exxon Valdez oil spill area.

2. Aerial surveys of birds and marine mammals

3. Development of a conceptual ecosystem model for Prince William Sound.

4. Determine distribution, relative abundance and spatial and temporal variability of fish, foraging birds and mammals.

* Study description not available.

Draft Restoration Feasibility Projects, 1991

Title: Determination of Key Sea Otter Prey Species in Western Prince William Sound for Enhancement of Restored or Non-contaminated Sea Otter Habitat.

Submitted by: Angela Doroff and James Bodkin, U.S. Fish and Wildlife Service, Alaska Fish and Wildlife Research Center, Sea Otter Project.

Introduction:

While acute affects of oil contamination may have been evident, the sea otter population in Western Prince William Sound may be suffering impacts from secondary exposure to hydrocarbons from contaminated food resources. In damage assessment studies for sea otters, spatial movement patterns, reproductive success, survival of weanling and adult female otters and sublethal physiologic and genetic changes in adult male otters are currently being monitored to address secondary exposure. The result of these studies will address the over all long-term impacts to the sea otter population and will be used in modeling population recovery.

Nearshore benthic invertebrate populations are crucial to the continuance and recovery of the sea otter population in areas impacted by oil. Information from 6 independent coastal habitat damage assessment studies sampling tissues from benthic invertebrates comprising part of the prey guild for sea otters in Prince William Sound has been reviewed. To date, only 5 of 20 potential prey species (A. Johnson unpub. data) have had tissue submitted for hydrocarbon analysis. To more directly link contaminated prey species and the recovery and restoration of the sea otter population, we must determine key species being selected for by otters. If these prey items have not been adequately sampled for contamination by other studies, then samples need to be obtained and submitted for toxicological analysis. Ultimately, information on prey contamination and prey selection will provide the restoration working groups with information necessary for the enhancement of key sea otter prey species in non-contaminated or restored sea otter habitat.

Methods:

Prey selection will be determined from shore based observations around Green Island. Observations will be made with high resolution 10X binoculars and a 50X Questar telescope. Data recorded will include dive time, surface time, success rate and prey item to lowest taxon. A sample of 300 identifiable prey items will be used to compare prey item and foraging success to historic data collected at Green Island (A. Johnson, unpublished species list).

Draft Restoration Feasibility Projects, 1991

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Sea otter prey will be collected from forage areas by diving and contaminant levels will be determined by standard analytical laboratory procedures.

Estimated Budget:

Travel and Field Camp:	3,000.00
Boat Fuel:	1,300.00
Equipment	
Dive Gear:	6,000.00
Compresor:	3,000.00
Questar:	3,000.00
Binoculars:	800.00
Analysis:	2,500.00
Misc:	500.00
Toxicological analyses:	?
Salaries:	6,000.00
Total:	30,400.00

Title: Consumption of contaminated prey by sea otters in Price William Sound

Submitted by: Brenda Ballachey, James Bodkin, and Daniel Monson,
U.S. Fish and Wildlife Service
Alaska Fish and Wildlife Research Center
Sea Otter Project

Introduction:

Principal prey of sea otters include crabs, mussels, urchins, and clams (Estes et al. 1981, Estes et al. 1982). As a result of the Exxon Valdez oil spill, sea otters, as well as their prey, were subjected to oil contamination. Continued exposure of otters to petroleum contaminants may result from consumption of prey, which may have accumulated and concentrated contaminants. Preliminary analysis of sea otter blood parameters indicate considerable variation within the oil spill area. If this variation is related to oil exposure, it may be associated with differential prey selection by sea otters of prey items with elevated levels of contaminants.

Previous work by DeGange and Vacca (1989) and Kvitek et al. (in review), suggests sea otters have the ability to discriminate between prey (clams) containing paralytic shellfish toxins (PST) and those that did not, preferentially consuming clams without PST. In contrast, after an initial adjustment period, mink offered a choice of food contaminated with oil versus non-contaminated food did not demonstrate a preference (J. Blake and M. Sousa, personal communication). It appears likely that contamination of prey species will be somewhat patchy, depending on the amount and persistence of oil (this information should be available from coastal habitat studies). If sea otters discriminate between prey species based on the presence of contaminants, restoration efforts could be concentrated in areas where contamination is most widespread, with lower priority going to areas of greater patchiness.

The objective of this study is to determine if sea otters demonstrate the ability to select prey based on the presence or absence of petroleum contaminants.

Methods:

Sea otters will be captured from the wild and held in floating, temporary pens for several days. Animals will be offered both contaminated and non-contaminated prey of the same species, and consumption of each will be recorded.

Estimated Budget:

Sea otter capture		$6,000
Sea otter prey		$4,000
Equipment (holding pens, generator, refrigerator)		$6,500
Salaries (4 person months @ $3,000/mo)		$12,000
	Total	$28,500

References:

Estes, J. A., R. J. Jameson, and A. M. Johnson. 1981. Food selection and some foraging tactics of sea otters. pp. 606-641, In J. A. Chapman and D. Pursley (eds.) Worldwide Furbearer Conf. Proc., Aug. 3-11, 1980. Frostburg, Maryland.

Estes, J. A., R. J. Jameson, and E. B. Rhode. 1982. Activity and prey selection in the sea otter: influence of population status on community structure. Am. Nat. 120(2):242-258.

DeGange, A. R. and M. M. Vacca. 1989. Sea otter mortality at Kodiak Island, Alaska, during Summer 1987. J. Mammal. 70:836-838.

Kvitek, R. G., A. R. DeGange, and M. K. Beitler. In review. Paralytic shellfish toxins mediate sea otter food preference and distribution, and therefore marine community structure. Submitted to Limnology and Oceanography.

Draft Restoration Feasibility Projects, 1991

Title: Variation in effects of oil exposure among sea otters living in areas affected by the EVOS.

Submitted by: Brenda Ballachey and James L. Bodkin, U.S. Fish and Wildlife Service, Alaska Wildlife Research Center, Sea Otter Project

Introduction:

Sea otters residing from western Prince William Sound to the Kodiak Archipelago were potentially affected by the EVOS. Degree of oiling and weathering of oil varied among the habitat areas. To date, sea otter damage assessment studies have compared western PWS (oiled area) with eastern PWS (non-oiled control). However, in the sea otter studies, no effort has been made to subdivide the western sound into areas of greater versus lesser oil impact. The Kenai Peninsula and Kodiak Archipelago were also oiled, but no information has been gathered on sea otters presently living in those areas. If restoration efforts are initiated for sea otters, it would be valuable to identify areas showing the greatest impact (measured by blood parameters of resident otters) in order to establish priorities for restoration.

Preliminary analyses of blood data collected in the winter of 1989-90 demonstrate differences in certain parameters between sea otters living in WPWS vs EPWS. Furthermore, there appears to be variation in blood parameters among otters living in different areas of western PWS but the extent and significance of this variation is not known.

The objective of this study is to determine whether or not alterations in blood parameters vary significantly among sea otters living in areas affected by the EVOS. Locations to be studied will include the Kodiak Island area. Information gained will be used to prioritize areas of sea otter habitat under consideration for restoration efforts.

Methods:

Initially, existing blood data from sea otters in western PWS will be further analyzed and categorized by capture location of the otters. Comparisons can be made among otters from various locations in the WPWS. Because these otters have been implanted with radio transmitters, their movements can be related to their capture locations and blood data. Information in degree of oiling for these locations will also be related to the blood data.

To verify differences in impact among otters residing in different areas, further blood samples will be obtained from otters living in three areas: 1) a heavily oiled area in WPS; 2) a lightly oiled area in WPWS; and 3) the Kodiak Peninsula.

Proposed Budget:

Equipment and Supplies		
Computer analysis		$6,000
Capture		
Western Prince William Sound		$10,000
Kodiak		$5,000
Travel & per diem		$3,000
Blood analysis		$1,350
Equipment and supplies		$2,000
Salaries (8 person months @ $3,000/mo)		$24,000
	Total	$51,350

Draft Restoration Feasibility Projects, 1991

Title: Determination of sea otter foraging depths in Western Prince William Sound for population and habitat restoration.

Submitted by: James L. Bodkin, U.S. Fish and Wildlife Service, Alaska Wildlife Research Center, Sea Otter Project.

Introduction:

Sea otter restoration efforts will consider the effects of the Exxon Valdez oil spill on sea otters, both directly, and indirectly as a result of foraging on contaminated prey. Enhancement of restored or non-contaminated sea otter habitat should consider the extent of habitat use based on bathymetric discrimination. Restoration of habitat should be most effective if concentrated in areas of greatest sea otter use.

The abundance of sea otters may ultimately be determined by the quantity and quality of available habitat. Sea otter habitat may be defined by two primary components, the sea floor where prey are gathered and the sea surface where resting, feeding, grooming and social interactions occur. Foraging habitat may be further defined as a band of sea floor extending seaward from the high intertidal to a depth beyond which otters do not forage. Maximum dive depths and therefore the width of this habitat band remain undefined. Additionally, the distribution of foraging within this band is unknown.

The objectives of this study are to provide an estimate of the maximum depth of sea otter foraging and a profile of the distribution of foraging activity within this defined band. This information will aid in defining habitat and prey species that may be best suited in restoration of sea otter populations and habitat.

Methods:

Time/depth recorders will be deployed on one externally attached flipper tag (Temple Tag Co.). An external radio transmitter will be attached on the opposing flipper tag. Radio transmitters will facilitate monitoring movements of active time/depth recorders and recapture of instrumented animals. Up to 40 recorders and radios will be deployed with an anticipated return of 20 instruments. Capture methods will include tangle nets, dip nets and underwater capture methods.

Estimated Budget:

Sea otter capture equipment	
Rebreathers 3 @ $6,000	$18,000
Underwater traps and Tangle nets	$4,000

Time/depth recorders 30 @ $1,400		$42,000
Radio transmitters, external 30 @ $200		$6,000
Dive gear		$9,000
Capture and recapture (fuel, food, vessel support)		$10,000
Travel		$6,000
Aerial radio tracking		$6,000
Salaries (4 persons @ $3,000/mo x 3 months)		$36,000
	TOTAL	$137,000

MEMORANDUM STATE OF ALASKA

TO: Stan Senner **Date:** September 25, 1990

FROM: Dana Schmidt and Bruce Barrett
Commercial Fisheries Division
Kodiak

SUBJECT: Restoration Program

We offer the following comments in response to your restoration matrix and request for 1991 restoration feasibility/research studies.

We can anticipate a reduced salmon harvest in the Kodiak Management Area (KMA) if the overescapement that occurred from the EXXON Valdez spill in 1989 causes negative impacts. The KMA salmon stocks are managed on escapement goals with harvest opportunity permitted only when there are fish surplus to escapement requirements. Thus we inherently have a restoration mechanism built into our salmon fisheries management plan with the restoration accomplished at the expense of lost harvest opportunity to ensure escapement.

Meeting escapement goals by decreasing fishing time would restore fish available for non-marine wildlife to the same levels as non-impacted systems. Marine species which feed on salmon would be affected but should be recovered in a single generation by meeting escapement goals of returning fish. The above mechanism would not be true only if impacts were of such a magnitude that escapement goals were not met. In that case, multiple years may be necessary to restore runs to pre-spill levels. Standard enhancement practices such as those used by the FRED Division could accelerate the restoration process and mitigate potential future damages to commercial, subsistence, and sport fisheries and wildlife dependent upon salmon.

Within the Kodiak Management Area there are several important salmon producing systems which could be better managed for commercial, subsistence, and sport interests with more precise monitoring of escapements. These include the Karluk, Ayakulik, and Buskin Rivers. Currently the annual salmon escapements into these systems are counted though rigid aluminum weirs which are operated by seasonal employees. These weirs regularly do not withstand flood events and carcass buildups associated with massive pink salmon escapements. Since the salmon runs to these systems are regulated on escapement counts, management precision is compromised each time a weir washout occurs which can often be several times a year. The installation and operation of floating weirs on these systems would likely permit ADF&G to obtain complete escapement counts through flood events and pink salmon carcass buildup periods. In turn this would permit more precise fisheries management for ensuring that escapement requirements are met

and resource users are afforded an ample opportunity to harvest surplus fish. If restoration research funds were made available this year, a floating weir design could be tested on the Karluk, Ayakulik, and Buskin Rivers as early as 1991.

cc: L. Nicholson
C. Meachum