16.11.4

1997 Restoration Workshop

JANUARY 23-25

ANCHORAGE, ALASKA

COMMUNITY INVOLVEMENT

PROJECT 97052

SCHEDULE FOR BREAKOUT SESSIONS

		Phone	Fax
Other Funding Sources 10:30 -12:00 Thursday	Ed Deaux Cindy Adams	(907) 258-0875 (907) 455-4105	(907) 258-5035 (907) 455-4815
Remote Site Reports 1:00- 1:45 PM Thursday	Molly Burton	(9070 224-3118	(907) 224-5874
Pacific Herring 2:00-3:00 PM Thursday	Evelyn Brown Jody Seitz	(907) 424-5916 (907) 424-5916	(907) 424-5906 (907) 424-5906
Harlequin Duck 3:45-4:30 PM Thursday	Dan Rosenberg	(907) 267-2453	(907) 267-2433
Sea Otter 4:30-5:30 PM Thursday	Brenda Ballachey	(403) 210-1812	(403) 210-1988
Archaeology To be determined	Lora Johnson	(907) 562-4155	(907) 563-2891
Traditional Knowledge 1:00 - 2:30 PM Friday	Pam Colorado Henry Huntington		
Harbor Seal 2:30-3:30 PM Friday	Kathy Frost Kate Wynne	(907) 459-7213 (907) 486-1517	(907) 452-6410 (907) 486-1540
Clams 3:45-5:00 PM Friday	Tom Dean Jeff Hetrick	619) 727-2004 907) 288-3667	(619) 727-2207 (907) 288-3667
General Questions To be determined	Bob Spies Stan Senner	(510) 373-7142 (907) 278-8012	(510) 373-7834 (907) 276-7178

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						Implicit social characteristics
Ecosystem Management principles	Landscape ecology	Systematic data dollection & synoptic interpretation	Ecological integrity in mapping units	Heterogeneity governed by disturbance regime	Pre-industrial landscape as standard	*biotic system* — independent of institutions
Human Priorities in utilization	Sovereignty & property	Owner's knowledge	Boundaries set by human use, institutions, & memories	Homogeneity within use class; high productivity	Maximization of (long-term) utility	*historical* — bound by precedent & institutional tradition; individual-rational
Change strategies	Co-management	Bioregional framework: gather and present information using ecosystems as units		Adaptive management	Social utility: public trust; conserve natural capital; socialize risk	divided authority; decentralized power; scientific complexity and uncertainty
Barriers	Property rights; commercial links among ecosystems; edge, stem, common-mode effects	Fragmented authority, institutionally entrenched routines for data collection, analysis & distribution		Value of information (vs. prudence)	Intertemporal tradeoffs (incl social continuity)	Scarce consensus; chaotic processes

Sources: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station 1994. *Ecosystem Management: Principles and Applications*. Volume II of *Eastside Forest Ecosystem Health Assessment*. M.E. Jensen and P.S. Bourgeron, tech. eds. Section 2.

Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1995. *Upstream: Salmon and Society in the Pacific Northwest*. Washington: National Academy Press. Chap. 13.

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NATURAL AND SOCIAL SCALES IN ECOSYSTEM MANAGEMENT*

Kai N. Lee§

I'm delighted to visit Alaska at a time of year when none of my colleagues will accuse me of playing rather than working. I'm pleased to be invited to this gathering which Exxon has funded with such reluctant generosity.

[ecosys mgt = realignment]

I'd like to put a simple hypothesis before you: ecosystem management is an attempt to realign the scales of human activities so that they become compatible with the scales and rhythms of ecosystems valuable to humans. I'd like to consider this hypothesis by exploring three ideas — learning, scales, and communities.

Your work deals with two kinds of communities — ecological and human. You engage with human communities mainly through archaeology and public participation. I suggest that that isn't enough. (The trustee council's logo, like the research most of you do, focuses only on the *non*-human elements of the ecosystem.) A striking feature of the trustee council's work is that the large stream of resources it administers will mostly come to an end, for practical purposes, in the foreseeable future. But the burden of responsibility will not end. Rather, stewardship will

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* Keynote Lecture, annual restoration workshop, *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska, January 24, 1997. I am grateful to Stan Senner and Molly McCammon for their hospitality and good sense. Many of these ideas were developed while I served on the Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Research Council. I am indebted to Courtland L. Smith, Bonnie McCay, Peter A. Bisson, and David Policansky for helpful conversations and criticism during our work on that committee. John Volkman's salutary influence is also apparent in this essay. Criticisms and comments welcome, at the address below.

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DRAFT comments welcome

return to the humans of Prince William Sound — the folks who did that job, largely unassisted, until March 24, 1989. I shall return at the end of my talk to this point: that the transition from today's trustee council to a sustainable management for the indefinite future is a task that you should begin now to design.

"Ecosystem management" is a label for a set of controversial purposes — the notion that humans should take responsibility for whole habitats, even when they cross property lines and governmental jurisdictions, even when taking responsibility forces people to acknowledge their own destructive effects upon the natural world, even when taking responsibility means that we must address conflicts that make all disputing parties uncomfortable. Ecosystem management is not a simple thing to strive to do; the alternative — to abandon our responsibilities to natural habitats — may often be easier.

I have found the idea of scale helpful in organizing the difficulties of ecosystem management. I'd like to begin by saying what I mean by that word, since I mean something similar to what ecologists mean, but not exactly the same. Second, I'd like to illustrate the problems that ecosystem management encounters as a social activity, and finish with some comments about the historical process of redefining stewardship after a major social transition like the one triggered by the oil spill.

Let me say that the questions about ecosystem management raised in my talk are not arguments *against* an ecosystem approach. Rather, my purpose is to improve the probability of success in the difficult challenge of seeking to manage at the ecosystem scale by sharing experience and potential lessons.

Scale mismatches

Environmental problems result from mismatches between the scale of human utilization of natural resources and ecosystem function. These mismatches occur in three dimensions. (Lee 1993b)

[scale mismatches]

In his famous paper on the tragedy of the commons, Garrett Hardin (1968; cf. McCay and Acheson 1987) observed that overuse of common-pool resources reflects institutional failure. If no single person or organization owns a resource to which all have access, then no exploiter of that resource has reason to conserve. That which belongs to all is cared for by none.

SCALE MISMATCH	CHARACTERISTIC PROBLEM
Spatial	Pollution, e.g., release of combustion products into air.
Functional	Deadlock, e.g., misallocation of water.
Temporal	Unsustainable harvest, e.g., catch in excess of reproduction rates.

Human responsibilities often do not match natural scales.

This table generalizes that argument: when human responsibility does not match the spatial, temporal, or functional scale of natural phenomena, unsustainable use of resources is likely, and it will persist until the mismatch of scales is cured. Because the natural world is rich in patches, unsustainable use can continue for long enough for humans to assume it can be permanent, as in the case of our institutionalized dependence on fossil fuels. The risk that became reality in March 1989 is one consequence of that dependence. Yet the recipe for reform implicit in this analysis — to get the scales right — is made considerably harder by the fact that our knowledge of natural processes is limited. (National Research Council 1995)

Hardin's parable of the pasture depicts a spatial mismatch. Shepherds own their animals but not the land that nourishes them. It is accordingly rational for individuals to overexploit the range, reaping a positive return until the land is ruined. Similarly, pollution is the dumping of waste products into air, land, or water because the dumper has no responsibility to care for these commons to which there is unrestrained access.

Pollution has been restrained by a variety of social controls. Your work here is the enactment of one of them — the idea that pollution can be restrained by having those guilty of pollution pay to compensate those who have suffered from it.

A second form of mismatch is functional. Because the natural world is complex, human activities in it are specialized. These specialized activities generally owe much to tradition and precedent and little to science or efficiency. An example is the allocation of water. A doctrine called "prior appropriation" runs through western water law: it says that the water user with the older claim on water diverted from a stream must be fully satisfied before a more-junior user may receive any water (see Wilkinson 1989).

Prior appropriation made sense under conditions in which water was the key to farming and the stability of agricultural settlement was highly valued by an expanding, colonizing society. Today, virtually all agriculture is maintained, regulated, and manipulated by policy and subsidies. Western water law has become an anachronism, providing incentives to waste water so that one's claims will be preserved in future years. That waste deprives watercourses of their natural flow because water in a streambed has no legal claim — it is a commons, to be overexploited.

The critique that functional responsibilities are drawn too narrowly leads naturally toward comprehensive control. Yet Big Government has toppled in once-socialist states and retreats in nominally capitalist ones. Comprehensive control is neither politically feasible nor believed to be workable even if it could be established. How to manage the problems of functional mismatch in protecting environmental quality over time remains an open question.

Third, consider temporal mismatches, especially the overexploitation of living populations: harvesting at rates that cannot be sustained because inadequate time is permitted to regrow the populations that are depleted. A student writing about forestry put it this way: trees may grow faster in bank accounts than they do in the woods. Harvesting populations at unsustainable speed — mining the resource — can be rational if the earnings from harvest produce financial assets whose value appreciates more rapidly than the resource would regenerate.

Deliberate social strategies for restraining the mismatch between biological time and human time remain underdeveloped, and notions of property in industrialized nations have not often put high value on stewardship, the idea that present generations owe their descendants something beyond goods that can be reduced to financial measurements.

Illustrations from the salmon ecosystem

What I've said about scale is abstract. Let me illustrate some concrete scale mismatches by discussing the Columbia River salmon ecosystem (see National Research Council 1995) not far south of here. It's a situation that is importantly different from the one you face here — a point to which I'll return in a few minutes.

[slide: France]

The Columbia basin has a land area roughly the size of France. It's roughly twice the size of the oil spill affected area.

[slide: salmon]

The Columbia and other rivers draining into the North Pacific have been colonized by seven species of anadromous salmonids, genus *Oncorhynchus*, the fish that displays a hook-nosed appearance when it enters the freshwater breeding phase of its life-cycle.

[slide: Indians fishing]

Salmon in the Northwest were so plentiful that the first people to inhabit this landscape did not practice agriculture. Their harvests swam in each year, worshipped but not cultivated, in runs that ranged to more than 10 million fish in a single year.

[slide: fishing boat]

Columbia River fish, now caught largely in the open ocean, remain highly prized, even though their numbers have dwindled sharply, and many stocks originating in the upper river basin are now so depleted that they verge on extinction.

The lifecycle of salmon, with migrations as long as 10,000 miles, is a great drama of natural history. The salmon lifecycle is immense in spatial scale, diverse in the habitats sampled by the fish, and exacting in what it requires in those habitats. Salmon survive only in high-quality environments. Their decline is, accordingly, a classic example of the canary in the mineshaft. If salmon aren't doing well, then many other life forms may follow.

[slide: McNary dam]

Humans have modified the salmon habitat drastically over the past 120 years. The most visible manifestation is the building of dozens of multiple-purpose dams on the major rivers of the Northwest.

[slide: transmission lines]

These dams generate electric power from falling water — in the Columbia basin alone, roughly enough to supply the needs of New York City.

[slide: aluminum pour]

That electricity, in turn, has made possible energy-intensive industries like aluminum refining.

[slide: irrigation sprinklers]

The dams were built in the 1930s to provide irrigation for a depressed agricultural society in the semi-arid lands of the inland Northwest. Today, potatoes, apples, cherries, and other crops contribute to the prosperity of that land.

[slide: barge]

And the crops are brought to market, in many cases, by low-cost water transportation that relies on navigation locks in the dams.

[slide: Portland]

DRAFT comments welcome

What most people see of the Northwest are its national parks and cities, like Portland. Here too, low-cost electricity from hydropower has become a vital, if often unnoticed component of a comfortable existence.

[slide: Vernita Bar]

By the 1970s, when the Columbia's network of dams was completed, there was only one stretch of the river's main stem where salmon spawned on their own, here at a lonely spot in eastern Washington called Vernita Bar. The annual salmon runs, more than 10 million in aboriginal times, had dwindled to two to three million, and more than two-thirds of the remaining salmon population began its lives in hatcheries.

The salmon's decline is a monument to mismatch:

- In spatial terms, the migrations of salmon from the Columbia to the Gulf of Alaska have led different groups of fish harvesters to compete with one another for the dwindling catch. Before 1985 there was not even an institutional framework for overall assessment of the stocks during the harvest season. It was impossible to tell who caught which portions of the run until the season had ended. The work you've done in otolith marking and other means of identifying fish in mixed-stock fisheries lays the technical basis for advances in management.

- In functional terms, salmon have been only one claimant among many to the bounty of the river. Their voice has not been influential until very recently, and it's never been commanding. Migrating fish evolved in the presence of large springtime flows, as snow melted from the mountainous interior. Juveniles were carried to sea by the spring freshet, often covering hundreds of miles in several days' time. Now, the water is held back in storage dams, because the value of electricity is highest in the winter, when people need heat, not in the spring, when there's already a lot of water running and not so much demand for power. The spring migrants now spend weeks rather than days getting to salt water. Along the way they are exposed to predators in the slackwater reservoirs and the rigors of passing the dams. Amazingly, a lot make it through each dam; but the cumulative mortality of a series of dams is high enough to depress the abundance of upriver stocks dangerously.

- And in temporal terms, the large-scale modifications of the past century have yet to be taken into account. The rivers have been impounded, the forests cleared, and the landscape transformed — yet there has been little understanding that salmon habitat has been drastically altered. Harvesters and fishery managers did not foresee the vulnerability of large populations sustained by hatcheries. And human actions have tended to assume that the abundance of the past would be readily restored, even as the environmental capital needed to regain productivity was being destroyed or altered beyond biological recognition (Larkin 1979).

[slides off]

The story of the Columbia is one with many parallels. The Columbia demonstrates clearly the profound impact of human scales of action that do not match ecological requirements. What's different about the salmon is that people care a lot about its decline, but the way salmon declined is a dynamic repeated often in other places.

Yet it's important to bear in mind a major difference between damage to the salmon ecosystem and the damage done by the *Exxon Valdez* spill. The salmon is the victim of routine, profitable activities — dams, irrigation, cities. These activities yield a steady stream of revenues, part of which has been diverted to salvaging the salmon ecosystem, so far with little to show for it.

The oil spill was not a routine event; it is, in fact, the opposite, producing a one-time disturbance and a one-time settlement agreement. The challenge you face is to fashion a meaningful restoration from that settlement — a task in which nature has been your ally already, in which the people of coastal Alaska can be too, I think. The challenge in the Pacific Northwest salmon ecosystem is to achieve a sustainable fishery in the permanently altered world of the industrialized Columbia; it isn't clear whether nature will permit that, and it is certainly unclear whether the human institutions that manage parts of the salmon ecosystem are willing to make, or even find, the necessary accommodations.

Ecosystem management

In response to the dwindling of salmon and other valued species, the idea has gradually grown that species are not the right unit of conservation. For if we want to take advantage of the quality and productivity of valuable species, then we must protect and manage their ecosystems, rather than attempt to supersede or to substitute for those ecosystems by artificial culturing methods like hatcheries. Phil Janik quoted the new chief of the Forest Service, Mike Dombeck, to that effect just yesterday. It is the logic that propelled the Sound Ecosystem Assessment into being, as Ted Cooney said yesterday; it is a hope that hangs in the mist over the Everglades, the Grand Canyon, and even the Columbia.

A Forest Service framework...

There is no single method of ecosystem management. Let me, for the sake of clarity, pick a thoughtful example put forward by two analysts at the U.S. Forest Service.

[ecosystem management defn]

- Landscape ecology should be the conceptual template...
- Informed by systematic data collection and interpretation,

  using ecological mapping units.
- Landscapes are heterogeneous and controlled by disturbance regimes operating through time.
- Ecological integrity is maintained by sustaining or restoring pre-settlement landscapes.

Ecosystem Management (after Jensen and Bourgeon , USDA 1994)

These principles should be familiar to you.

...operating in a historical context

Consider, then, how they contrast with the historical assumptions that shape land use.

[ecosystem management vs. human priorities]

In place of landscape ecology, humans have emphasized sovereignty and property.

In place of systematic data collection, humans have relied upon the knowledge of owners: an understanding of land and water that is shaped by and often limited to past uses, instead of the ecological character of the land and sea. Owner's knowledge is rooted in place — in place-dependent economic activities like farming, on time scales organized by human tenure, inheritance, and land speculation, and on spatial scales shaped by human mobility (Jackson 1970). Owner's knowledge is different from, sometimes a great deal more humane than the scientist's geographic information system or species lists. These differences underlie a good deal of mutual suspicion (e.g., Berry 1989). Consider how long it's taken the trustee council to give Traditional Ecological Knowledge a place on your agenda, and how even that place is labeled with an acronym that makes this kind of knowledge TEK ...but not high-TEK.

ECOSYSTEM MANAGEMENT	HUMAN PRIORITIES IN UTILIZATION
Landscape ecology	Sovereignty & property
Systematic data collection & synoptic interpretation	Owner's knowledge
Ecological integrity in mapping units	Boundaries set by human use, institutions, & memories
Heterogeneity governed by disturbance regime	Homogeneity within use class; high productivity
Pre-industrial landscape as standard	Maximization of (long-term) utility
biotic system — independent of institutions	*historical* — bound by precedent & institutional tradition; individual-rational

Ecosystem Management vs. Human Priorities

The prevalence of owner's knowledge means, in turn, that humans divide and conceive of landscapes in particular ways. Here is a map, taken from a document discussing the Northern spotted owl. It shows the key watersheds to be managed because they lie within the geographic range of the owl.

[overhead: key watersheds]

Compare this map to another one, of the county governments in that same geographic area.

[overhead: counties]

You can see the qualitative difference. The ranges of biota are governed by precipitation and topography. Humans choose readily defensible borders, such as rivers, to mark jurisdiction and property. Or else we draw straight lines on the land.

Rivers are of course the centers of drainages, not their edges, and the boundaries of plant or animal dispersal rarely fall along straight lines. Drawing straight lines upon the land is arbitrary. Relying on rivers as borders is critically inappropriate, separating human interests along lines where human concerns should be unitary or at least coherent.

[return to ecosys mgt vs. human priorities]

Instead of heterogeneous landscapes resulting from natural disturbance regimes, human control has traditionally aimed at homogeneity and, in the case of cultivated lands, at installing and maintaining ecosystems at early successional stages where productivity is high. That is, humans take pre-development landscapes as starting point for transformation, not a benchmark for conservation or restoration.

The contrast between ecosystem management and human exploitation as ways of looking at the land is a contrast between sets of assumptions. Ecosytem management takes as its organizing premise the communities of biota. But ecosystem management envisions a landscape shaped primarily by disturbances of non-human origin, over times that are long compared to human temporal horizons. In short, ecosystem management operates on different scales than nearly all types of human utilization. Such a perspective operates independent of institutional considerations, in sharp contrast to human ownership and transformations of land.

The harmonizing of human and natural scales called for in ecosystem management is accordingly difficult.

Three responses

The rise of ecosystem management in U.S. policy coincided with the dwindling capacity of the federal government to govern. Interior Secretary Bruce Babbitt's frustrating career in that post is a graphic demonstration of both the importance of ecosystem management as an idea and the political difficulty of pursuing its governmental realization.

[three responses]

Instead of national policy, three rather different and somewhat complementary approaches have been tried as ways to harmonize human and natural. I want briefly to review these ideas — co-management, bioregionalism, and adaptive management — and explore how they might become part of a way to think about ecosystems inhabited and used by humans.

Each of these approaches responds to the two principal roots of environmental conflict in American politics. First, the management of public resources is shaped by the fragmentation of formal authority and political power. Authority is divided between federal and state governments and power is dispersed among a wide variety of business, citizen, media, and governmental organizations. Cooperative action requires compromise whenever there is conflict. Second, the economy is technically complex and environmental questions face uncertainties at every turn. Managing ecosystems — which are owned by private and public entities with conflicting agendas affecting one another and other neighboring and distant interests — requires recognizing conflict, stimulating negotiations, and providing technical analyses to illuminate disputes. Co-management, bioregionalism, and adaptive management each seek to do this, and each can be carried out with only the acquiescence of the federal government — they do not require large-scale funding.

Co-management

Let me begin with co-management. For most of the past century, public lands in the U.S. have been managed on a model of expert neutrality (Hays 1987). Agencies like the U.S. Forest Service have been charged with managing public lands in the public interest. But rising conflict has make it impossible to define the public interest non-controversially.

Bringing in those who are affected became an attractive alternative to increasingly embattled agencies. The result has been co-management: "power-sharing in the exercise of resource management between a government agency and a community or organization of stakeholders." (Pinkerton 1992, p. 331)

The idea of co-management is simple: get the contending interests together so they can work out something all can live with. Co-management recognizes the central role of equity and fairness in managing ecosystems that are owned by and affect people in diverse circumstances. Human communities can avoid a tragedy of the commons (Ostrom 1990); they do so by fostering monitoring of resource users and effective enforcement of those who violate the rules of equitable use. That is, managing ecosystems is a people issue. Co-management seeks to tackle that people problem head-on.

But this approach is not a cure-all. As the number of competing interests in a resource increases, the costs, procedural complications, and complex tradeoffs increase as well, often in apparent disproportion to the scope of involvement.

Moreover, most cooperative arrangements have not been designed but are the residue of conflict and negotiation among opposed parties. Such a history often brings with it a range of problems — lowest-common denominator positions, blaming as a substitute for analysis, and emphasizing short-term remedies with anticipated early payoffs, such as salmon hatcheries. On the other hand, over time periods of a decade or more, as Pinkerton (1992) showed for state forest management, both the agenda of disputing and the institutions within which disputes are conducted can evolve toward durable accommodations. In sum, co-management is a tool; it can't do everything, but it can do some essential things.

Bioregional scope

Consider next management organized around bioregion. From an ecological perspective the most straightforward strategy of reform is to shift the margins of human control and responsibility to match natural boundaries. Indeed, the notion of ecosystem management is rooted in the claim that ecosystems are the best scale at which to manage. What I've learned here is that you have had the courage to define ecosystems so that they include both terrestrial and marine components; that's important and difficult and novel.

Let me emphasize "difficult." Straight-line boundaries like the eastern border of Alaska are in place. Trade routes have tied together different biogeographic provinces: highways, transmission lines for electricity, water diversions on land, shipping lanes at sea and in the sky. Along these human paths flow commercial transactions in which human values define the relative scarcity of specific resources, including the crops harvested from managed vegetation and animal populations. Any attempt to shift human jurisdictions so as to focus attention on the welfare of an ecosystem must begin with these boundaries and networks (Volkman and Lee 1988).

Even a more modest aim, to map reality in ecosystemic terms, runs afoul of human priorities. Much of what is needed to make maps and data bases that make sense ecologically would come from observations made on private lands. Gathering that information relies, in turn, on land-owners' perception that sharing data is in their interest. But the use of biological information for regulation undermines this perception. The result has been the strange struggle over the National Biological Survey, fueled by land-owners' fears of the Endangered Species Act. This battle is one measure of how far we remain from bioregional governance of ecosystems.

Adaptive learning

[back to Three Responses]

Let me turn now to the third of the responses to scale mismatch, adaptive management.

[AM defn]

Because human understanding of nature is imperfect, human interactions with nature should be experimental. *Adaptive* management applies the concept of experimentation to the design and implementation of natural-resource and environmental policies. (Holling 1978, Walters 1986, Lee 1993a, Gunderson, Holling & Light 1995) An adaptive policy is one that is designed from the outset to test clearly formulated hypotheses about the behavior of an ecosystem being changed by human use. If the policy succeeds, the hypothesis is affirmed. But if the policy fails, an adaptive design still permits learning, so that future decisions can proceed from a better base of understanding.

[cartoon]

Adaptive management makes sense when there is a lot of uncertainty, but the adaptive approach is not free: two problems are the costs of information gathering and the political risks of having clearly identified failures (Volkman and McConnaha 1993). An adaptive approach has been tried in practice in several arenas over the past 15 years. Recent studies (Halbert and Lee 1990, Walters, Goruk and Radford 1993, Hilborn and Winton 1993, Lee 1993, Volkman and McConnaha 1993) provide appraisals of the successes and limitations of the adaptive process.

[learning under adaptive mgt]

This body of experience has produced lessons about the practicability of adaptive management and the institutional conditions that affect the conditions under which experiments at the scale of ecosystems can be conducted.

- Learning takes a long time — decades to centuries. Patience, particularly in institutional settings such as government that work on much faster cycles, is both necessary and difficult.
- Systematic record-keeping and monitoring is essential if learning is to be possible. But collecting information is expensive and often hard to justify at the outset and during times of budget stringency because the benefits of learning are hard to estimate quantitatively.
- Experimentation within the context of resource use depends critically upon the collaboration of resource users.
- Adaptive management does not eliminate political conflict, but can affect its character in important, if indirect, ways.

[adaptive management cycle]

Adaptive management looks like a planning cycle, but rarely conforms to that orderly image. Because it is experimental, adaptive management will encounter surprises *if it works* as intended.

[adaptive management cycle, with conflict]

Given the fragmented jurisdictions and conflicting claims that characterize all contested ecosystems, surprise and its companion, disappointment, spawn disputes. Disputes in turn focus around funding and high-visibility decisions, points at which conflict can produce change for those who find the surprises worrying or costly.

These destabilizing elements, which appear to be *inherent* in the social dynamics of adaptive processes, underscore the importance of patience, persistence, and a politically grounded determination to make constructive use of inevitable conflicts. Disputes are sure to arise within the spans of space, time, and functional interaction that characterize the mismatched cycles of human endeavor.

Not solutions but frontiers

As my comments have suggested, co-management, bioregionalism, and adaptive management each bring important ideas to the pursuit of a sustainable and just ecosystem management. But none seems to provide an overall answer. We have ideas, not solutions. These ideas help to clarify the conflicts but they cannot reliably resolve the disputes.

I have tried to summarize my discussion in a chart that I've handed out.

[overhead: chart]

The first two rows reproduce the table I showed you earlier, comparing the ideas of ecosystem management to the patterns of human behavior and institutions. The third row arrays the three change strategies I've just described — co-management, bioregional governance, and adaptive management — along the spectrum of ecosystem management principles. Co-management is a direct attempt to engage with the need to manage at the landscape scale; bioregionalism seeks to bring an ecological unity to human information gathering and perception; and adaptive management is a way to bridge the homogeneous uses that humans impose upon heterogeneous ecosystems, so that we may learn from both rehabilitating ecosystems and from domesticating others.

The two pairs of crossed arrows in the lower part of the chart are meant to suggest that the social ideas that make sense in thinking about ecosystem management are likely to have inconsistencies. For example, the sharing of authority that is central to co-management empowers land-owners and the fragmented, narrow understandings that I called owner's knowledge earlier. The voices of owners, in turn, are likely to come into conflict with the bioregional insistence upon perceiving the landscape as a connected biotic system. And in turn, the notion that an ecosystem has integrity that deserves protection chips away at the idea of property rights. We know already that the defense of property rights is a vigorous one.

Similarly, the experimental mood of adaptive management promotes not only learning but questioning, including questioning of the inter-generational tradeoffs that are unavoidable if human endeavors are to take into account the time scales of ecosystems (Lee 1993a, chap. 8). Conversely, the environmentalist's instinct for prudence in the face of uncertain change must face the reality that learning by experiment requires manipulation of ecosystems. Although we have an economy increasingly devoted to the production and handling of information, we have few widely shared guidelines about the value of information. As a result, it is hard to judge — and even hard to argue over — whether a proposed modification of an ecosystem is likely to produce valuable information.

[overhead off]

Ecosystem management in coastal Alaska

In short, ecosystem management encounters the fundamental challenge of democratic public policy — the challenge of reconciling rational ideas with historical circumstance. In that context, I'd like to share some thoughts about the relationship between the scientific ideas that you work with and the historical setting of the *Exxon Valdez* oil spill.

In opening this workshop yesterday, Molly McCammon drew attention to the 171 publications — referreed journals and theses — that have emerged so far from your research program. Collectively, these publications are an important milestone, marking the *reliable* knowledge your creativity and energy have produced. We've seen ample evidence in the posters, in the talks, — and perhaps most of all in the idealism of the kids in the Prince William Sound Youth Area Watch — of the determination that goes into making knowledge reliable. It's the refereed journals that certify this determination.

But few people can read 171 publications, certainly not when they range over the technical fields you all work in. And the value of these publications goes beyond the scientific audiences served by the refereed journals. How should the trustee council bridge the gap between reliable knowledge and its meanings to society?

DRAFT comments welcome

There is one group that knows those 171 papers and theses: the peer review panel chaired by Bob Spies. That panel should write a synthesis of the work coming out of the trustee council's research program, aiming to publish it in *Science*, *Nature*, or another of the widely read (but still refereed) national magazines. Such a paper should be written every two or three years.

So long as I'm offering unsolicited advice, let me say something about people as well as science. Something an outsider finds surprising about what you do here is the way you focus on the natural world. As three three ecosystem studies implicitly acknowledge, the trustee council's jurisdiction isn't one ecosystem but many. What defines the spatial scope of your work is disturbance — a human disturbance, the oil spill. That disturbance created a large but finite pool of resources, the settlements that the council administers. Although you work in the natural world, the scope, structure, and resource base of your activities is touchingly human. What you do arises from grief and worry, from the pursuit of justice — from values that are incomprehensible without humans in the landscape.

Yet the restoration, protection, and research activities you carry out have only accidental ties to the *future* human presence in Prince William Sound. There has been debate recently about what "restoration" should mean. But, more than halfway into the payment period for the trustee funds, that argument strikes me as far less important than the question of what "stewardship" should mean.

As the funds under the council's supervision are spent, the pace of land acquisition, research, and other activities will necessarily subside.

Isn't that the practical meaning of "restoration": the state of Prince William Sound when the money runs out?

Alaskans are famously skeptical of outsiders from the Lower 48. I won't press my luck here today, beyond saying that the meaning of words like "stewardship" and "restoration" are human words, invested with social meaning. Looking at the abstracts of the impressive range of science done with council sponsorship over the past year, I see the raw materials for meaning. Your most recent annual report is graced by the phrase, "where there is life there is hope." By the turn of the century, a lot more than hope will be needed. What is needed, to my way of thinking, is a way to understand the oil spill and the restoration as a historical period in coastal Alaska's natural and human communities. That understanding must draw upon the scientific knowledge and restoration activities you have carried out. But it must be framed by and rooted in the human communities that will go on beyond the restoration period. I don't know how that should be done; it just seems to me that the conversation isn't very audible yet, at least to an outsider.

Concluding thoughts

[slide: Earth from space]

Ecosystem management is, in concept, a strategy for organizing social responsibility in natural systems. The name of the strategy misleads in three ways: first, as ecological scientists know, ecosystems are human constructs, rather than biological units given by nature (Allen and Hoekstra 1992); second, what is being managed in ecosystem management is people, not just non-human elements of ecosystems; and third, as I have emphasized here, the management process is political and cultural rather than managerial in the usual sense of command and control.

That the activity of ecosystem management is so different from the ordinary-language implications of the name "ecosystem management" reflects, I think, the deep ambivalence industrial societies have about the natural world and the place of our species within it. Our growing ability to link together, control, destroy, and remake significant portions of the biosphere raises the question of how to make our presence more deliberate, less careless, and perhaps over time wiser. That is the question of harmonizing this familiar view of the biosphere to a quite different one.

[slide: Earth at night]

The natural planet is powered by the sun — atmosphere, ocean, and biota all derive their motive energy from solar radiation. This image, Earth at Night, assembled by the astronomer Woodruff Sullivan from weather-satellite photographs, shows us the human planet, illuminated by energies of human origin.

Whether they are the fires lit to clear lands for agriculture in the tropics, or the flaring of natural gas in the oil fields of Siberia, or the brilliance of urban landscapes, these are lights that are both recent in the places where they shine and temporary on time scales of ecological relevance. In Earth at Night only the aurora and possibly some wood-fueled fires are sustainable. A challenge for ecosystem management is to find a way for civilization to persist in the face of this historical context. I'm glad to be here with you to pursue that search.

Thank you.

DRAFT comments welcome

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						Implicit social characteristics
Ecosystem Management principles	Landscape ecology	Systematic data dollection & synoptic interpretation	Ecological integrity in mapping units	Heterogeneity governed by disturbance regime	Pre-industrial landscape as standard	*biotic system* — independent of institutions
Human Priorities in utilization	Sovereignty & property	Owner's knowledge	Boundaries set by human use, institutions, & memories	Homogeneity within use class; high productivity	Maximization of (long-term) utility	*historical* — bound by precedent & institutional tradition; individual-rational
Change strategies	Co-management	Bioregional framework: gather and present information using ecosystems as units		Adaptive management	Social utility: public trust; conserve natural capital; socialize risk	divided authority; decentralized power; scientific complexity and uncertainty
Barriers	Property rights; commercial links among ecosystems; edge, stem, common-mode effects	Fragmented authority, institutionally entrenched routines for data collection, analysis & distribution		Value of information (vs. prudence)	Intertemporal tradeoffs (incl social continuity)	Scarce consensus; chaotic processes

Sources: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station 1994. *Ecosystem Management: Principles and Applications*. Volume II of *Eastside Forest Ecosystem Health Assessment*. M.E. Jensen and P.S. Bourgeron, tech. eds. Section 2.

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Questions and Answers to Dr. Kai Lee's Keynote Speech
1997 Annual Science Workshop, The Hotel Captain Cook
Friday, January 24, 1997

Deborah Williams: What do you see as the role of the human population in ecosystem management?

Dr. Lee: It's different for different ecosystems. The striking fact that I think very few people outside the scientific-demographic community understand, is that the rate of human population growth has been slowing all over the world. This slowing has been quite dramatic in the poor countries, even though they have as yet to become rich. Prosperity has been the most powerful contraceptive in the human history to our knowledge. Now the problem is that there is still a lot of demographic momentum: the countries that have expanded rapidly, primarily the tropical poorer countries, still have the age structure characteristic of a rapidly expanding population, that is they have a lot of young people. As those young people mature and go through their child bearing years, they can be expected to continue to expand the absolute numbers. So that even though the rate of population growth is slowing, the estimates of the demographers are that we will be facing a doubling or a tripling of human population before stability arrives sometime in the next hundred years or so. This means that there are going to be severe problems of getting human populations accommodated to localized carrying capacities of the ecosystems they have been depending on in agrarian societies. It's quite clear already that there is not enough agricultural capacity in the world, and probably we can't make enough agricultural capacity, to feed everybody an American-scale diet. All that nice talk about Mac attacks and junk-food fish, they'll be eating sand lances before you know it at the rate in which we're going.

A much more severe problem in the kind of ecosystems that we work in, the temperate-zone ecosystems, is consumption rather than population. Consumption has been rising, as you know, throughout our life times. In fact, if you look at the economic production data that has been studied by economic historians, you can see that a long-term growth rate of about 2% has prevailed in most human populations for the last 250 years. That is about the time the industrial revolution took off. We are now beginning to experiment with modifications of global-scale ecosystems by altering the atmospheric composition by increasing its carbon dioxide content. That is something that depends on consumption, and I'm sorry to say Americans contribute disproportionately to that because we are among the richest people in the world. The worst news is that we are not going to be responsible for the lion's share of the growth, because the lion's share of the growth is going to come from East Asia, where there are lots of poor people that are getting un-poor real fast. So those of you that are concerned about the environmental future of the planet, learning Chinese is not a bad thing to do.

Question: Is there an institutional structure that might encourage stewardship?

Dr. Lee: This is a softball question for which I will give a softball answer. If the *Exxon Valdez* Trustee Council could find a way to take the funds it's setting aside and create an independent foundation that is responsive and accountable to the people in some way, without necessarily being governmental and politicized, that is something that would help a great deal in this ecosystem. The cost of the information that you've already collected, the cost of archiving, maintaining the monitoring series already, if my experience is any judge, already would strain the limits of the income you could hope to get from the $108 million reserve fund that you are going to set aside. So you already need to think very seriously about how to do that. I think that one way to have the time to think about it is to get the politicians' hands off the control of that pot of money. I don't think it can be independent of the people permanently, if only because eventually the people that become the Trustees of that legacy are going to be influenced in the way the Supreme Court judges are influenced by society that they live in. So you have some time to think about this. I think that is a very important option to take, but don't think it's more than about a five-to-fifteen-year window, and I would encourage you to think that through. More generally, I would say the answer social science has to offer is that if you want to have stewardship, you've got to have monitoring and enforcement so that you can get information about who is abusing the resource and you have a series of steps to take to discourage people who continue to abuse the resource.

Monitoring is no easy task as all of you know. It's hard for me to say that to those in the room who have sweated and frozen over things like extracting blood from reluctant animals out there in the wild, so you can monitor these effects. So I think you are already very clearly aware of the cost and difficulty of doing a lot of monitoring.

Enforcement is another matter entirely, a governmental one in which I think, we're again, still at the beginning of figuring out what to do. My sense is that, from the Columbia basin, it would certainly be nice if Exxon and other producers from the North Slope were to create a trust fund so that monitoring against oil spills could take place. Particularly the problems of chronic and routine spillage of oil, which is as I'm sure most of you know, a much larger environmental problem around the world than the catastrophic disturbance events like the *Exxon Valdez*. So, we've got a lot of work to be done out there and the big intellectual problem, which I was in a way pleading with you to engage with is, that we don't yet have a good way of meshing social science and natural science because of all these scale mismatches that I talked about. And one thing that I would urge you all as natural scientists to do, is to be alert to how to convey the information that you collect to the people in the human communities who are operating in a social-scientific template so that they can understand what it is that you are saying and what it means for the actions that they are to take. I'm going to be here for the rest of the day. I'd be happy to talk with you but I'm always fearful, as an experienced teacher must be, of standing in the way of a student's lunch.

16.11.4 L

NATURAL AND SOCIAL SCALES IN ECOSYSTEM MANAGEMENT*

Kai N. Lee§

I'm delighted to visit Alaska at a time of year when none of my colleagues will accuse me of playing rather than working. I'm pleased to be invited to this gathering which Exxon has funded with such reluctant generosity.

[ecosys mgt = realignment]

I'd like to put a simple hypothesis before you: ecosystem management is an attempt to realign the scales of human activities so that they become compatible with the scales and rhythms of ecosystems valuable to humans. I'd like to consider this hypothesis by exploring three ideas — learning, scales, and communities.

Your work deals with two kinds of communities — ecological and human. You engage with human communities mainly through archaeology and public participation. I suggest that that isn't enough. (The trustee council's logo, like the research most of you do, focuses only on the *non*-human elements of the ecosystem.) A striking feature of the trustee council's work is that the large stream of resources it administers will mostly come to an end, for practical purposes, in the foreseeable future. But the burden of responsibility will not end. Rather, stewardship will

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* Keynote Lecture, annual restoration workshop, *Exxon Valdez* Oil Spill Trustee Council, Anchorage, Alaska, January 24, 1997. I am grateful to Stan Senner and Molly McCammon for their hospitality and good sense. Many of these ideas were developed while I served on the Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Research Council. I am indebted to Courtland L. Smith, Bonnie McCay, Peter A. Bisson, and David Policansky for helpful conversations and criticism during our work on that committee. John Volkman's salutary influence is also apparent in this essay. Criticisms and comments welcome, at the address below.

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return to the humans of Prince William Sound — the folks who did that job, largely unassisted, until March 24, 1989. I shall return at the end of my talk to this point: that the transition from today's trustee council to a sustainable management for the indefinite future is a task that you should begin now to design.

"Ecosystem management" is a label for a set of controversial purposes — the notion that humans should take responsibility for whole habitats, even when they cross property lines and governmental jurisdictions, even when taking responsibility forces people to acknowledge their own destructive effects upon the natural world, even when taking responsibility means that we must address conflicts that make all disputing parties uncomfortable. Ecosystem management is not a simple thing to strive to do; the alternative — to abandon our responsibilities to natural habitats — may often be easier.

I have found the idea of scale helpful in organizing the difficulties of ecosystem management. I'd like to begin by saying what I mean by that word, since I mean something similar to what ecologists mean, but not exactly the same. Second, I'd like to illustrate the problems that ecosystem management encounters as a social activity, and finish with some comments about the historical process of redefining stewardship after a major social transition like the one triggered by the oil spill.

Let me say that the questions about ecosystem management raised in my talk are not arguments *against* an ecosystem approach. Rather, my purpose is to improve the probability of success in the difficult challenge of seeking to manage at the ecosystem scale by sharing experience and potential lessons.

Scale mismatches

Environmental problems result from mismatches between the scale of human utilization of natural resources and ecosystem function. These mismatches occur in three dimensions. (Lee 1993b)

[scale mismatches]

In his famous paper on the tragedy of the commons, Garrett Hardin (1968; cf. McCay and Acheson 1987) observed that overuse of common-pool resources reflects institutional failure. If no single person or organization owns a resource to which all have access, then no exploiter of that resource has reason to conserve. That which belongs to all is cared for by none.

SCALE MISMATCH	CHARACTERISTIC PROBLEM
Spatial	Pollution, e.g., release of combustion products into air.
Functional	Deadlock, e.g., misallocation of water.
Temporal	Unsustainable harvest, e.g., catch in excess of reproduction rates.

Human responsibilities often do not match natural scales.

This table generalizes that argument: when human responsibility does not match the spatial, temporal, or functional scale of natural phenomena, unsustainable use of resources is likely, and it will persist until the mismatch of scales is cured. Because the natural world is rich in patches, unsustainable use can continue for long enough for humans to assume it can be permanent, as in the case of our institutionalized dependence on fossil fuels. The risk that became reality in March 1989 is one consequence of that dependence. Yet the recipe for reform implicit in this analysis — to get the scales right — is made considerably harder by the

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fact that our knowledge of natural processes is limited. (National Research Council 1995)

Hardin's parable of the pasture depicts a spatial mismatch. Shepherds own their animals but not the land that nourishes them. It is accordingly rational for individuals to overexploit the range, reaping a positive return until the land is ruined. Similarly, pollution is the dumping of waste products into air, land, or water because the dumper has no responsibility to care for these commons to which there is unrestrained access.

Pollution has been restrained by a variety of social controls. Your work here is the enactment of one of them — the idea that pollution can be restrained by having those guilty of pollution pay to compensate those who have suffered from it.

A second form of mismatch is functional. Because the natural world is complex, human activities in it are specialized. These specialized activities generally owe much to tradition and precedent and little to science or efficiency. An example is the allocation of water. A doctrine called "prior appropriation" runs through western water law: it says that the water user with the older claim on water diverted from a stream must be fully satisfied before a more-junior user may receive any water (see Wilkinson 1989).

Prior appropriation made sense under conditions in which water was the key to farming and the stability of agricultural settlement was highly valued by an expanding, colonizing society. Today, virtually all agriculture is maintained, regulated, and manipulated by policy and subsidies. Western water law has become an anachronism, providing incentives to waste water so that one's claims will be preserved in future years. That waste deprives watercourses of their natural flow because water in a streambed has no legal claim — it is a commons, to be overexploited.

The critique that functional responsibilities are drawn too narrowly leads naturally toward comprehensive control. Yet Big Government has toppled in once-socialist states and retreats in nominally capitalist ones. Comprehensive control is neither politically feasible nor believed to be workable even if it could be established. How to manage the problems of functional mismatch in protecting environmental quality over time remains an open question.

Third, consider temporal mismatches, especially the overexploitation of living populations: harvesting at rates that cannot be sustained because inadequate time is permitted to regrow the populations that are depleted. A student writing about forestry put it this way: trees may grow faster in bank accounts than they do in the woods. Harvesting populations at unsustainable speed — mining the resource — can be rational if the earnings from harvest produce financial assets whose value appreciates more rapidly than the resource would regenerate.

Deliberate social strategies for restraining the mismatch between biological time and human time remain underdeveloped, and notions of property in industrialized nations have not often put high value on stewardship, the idea that present generations owe their descendants something beyond goods that can be reduced to financial measurements.

						Implicit social characteristics
Ecosystem Management principles	Landscape ecology	Systematic data dollection & synoptic interpretation	Ecological integrity in mapping units	Heterogeneity governed by disturbance regime	Pre-industrial landscape as standard	*biotic system* — independent of institutions
Human Priorities in utilization	Sovereignty & property	Owner's knowledge	Boundaries set by human use, institutions, & memories	Homogeneity within use class; high productivity	Maximization of (long-term) utility	*historical* — bound by precedent & institutional tradition; individual-rational
Change strategies	Co-management	Bioregional framework: gather and present information using ecosystems as units		Adaptive management	Social utility: public trust; conserve natural capital; socialize risk	divided authority; decentralized power; scientific complexity and uncertainty
Barriers	Property rights; commercial links among ecosystems; edge, stem, common-mode effects	Fragmented authority, institutionally entrenched routines fór data collection, analysis & distribution		Value of information (vs. prudence)	Intertemporal tradeoffs (incl social continuity)	Scarce consensus; chaotic processes

Sources: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station 1994. *Ecosystem Management: Principles and Applications*. Volume II of *Eastside Forest Ecosystem Health Assessment*. M.E. Jensen and P.S. Bourgeron, tech. eds. Section 2.

Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1995. *Upstream: Salmon and Society in the Pacific Northwest*. Washington: National Academy Press. Chap. 13.

Illustrations from the salmon ecosystem

What I've said about scale is abstract. Let me illustrate some concrete scale mismatches by discussing the Columbia River salmon ecosystem (see National Research Council 1995) not far south of here. It's a situation that is importantly different from the one you face here — a point to which I'll return in a few minutes.

[slide: France]

The Columbia basin has a land area roughly the size of France. It's roughly twice the size of the oil spill affected area.

[slide: salmon]

The Columbia and other rivers draining into the North Pacific have been colonized by seven species of anadromous salmonids, genus *Oncorhynchus*, the fish that displays a hook-nosed appearance when it enters the freshwater breeding phase of its life-cycle.

[slide: Indians fishing]

Salmon in the Northwest were so plentiful that the first people to inhabit this landscape did not practice agriculture. Their harvests swam in each year, worshipped but not cultivated, in runs that ranged to more than 10 million fish in a single year.

[slide: fishing boat]

Columbia River fish, now caught largely in the open ocean, remain highly prized, even though their numbers have dwindled sharply, and many stocks originating in the upper river basin are now so depleted that they verge on extinction.

The lifecycle of salmon, with migrations as long as 10,000 miles, is a great drama of natural history. The salmon lifecycle is immense in spatial scale, diverse in the habitats sampled by the fish, and exacting in what it requires in those habitats. Salmon survive only in high-quality environments. Their decline is, accordingly, a classic example of the canary in the mineshaft. If salmon aren't doing well, then many other life forms may follow.

[slide: McNary dam]

Humans have modified the salmon habitat drastically over the past 120 years. The most visible manifestation is the building of dozens of multiple-purpose dams on the major rivers of the Northwest.

[slide: transmission lines]

These dams generate electric power from falling water — in the Columbia basin alone, roughly enough to supply the needs of New York City.

[slide: aluminum pour]

That electricity, in turn, has made possible energy-intensive industries like aluminum refining.

[slide: irrigation sprinklers]

The dams were built in the 1930s to provide irrigation for a depressed agricultural society in the semi-arid lands of the inland Northwest. Today, potatoes, apples, cherries, and other crops contribute to the prosperity of that land.

[slide: barge]

And the crops are brought to market, in many cases, by low-cost water transportation that relies on navigation locks in the dams.

[slide: Portland]

What most people see of the Northwest are its national parks and cities, like Portland. Here too, low-cost electricity from hydropower has become a vital, --if often unnoticed component of a comfortable existence.

[slide: Vernita Bar]

By the 1970s, when the Columbia's network of dams was completed, there was only one stretch of the river's main stem where salmon spawned on their own, here at a lonely spot in eastern Washington called Vernita Bar. The annual salmon runs, more than 10 million in aboriginal times, had dwindled to two to three million, and more than two-thirds of the remaining salmon population began its lives in hatcheries.

The salmon's decline is a monument to mismatch:

- In spatial terms, the migrations of salmon from the Columbia to the Gulf of Alaska have led different groups of fish harvesters to compete with one another for the dwindling catch. Before 1985 there was not even an institutional framework for overall assessment of the stocks during the harvest season. It was impossible to tell who caught which portions of the run until the season had ended. The work you've done in otolith marking and other means of identifying fish in mixed-stock fisheries lays the technical basis for advances in management.

- In functional terms, salmon have been only one claimant among many to the bounty of the river. Their voice has not been influential until very recently, and it's never been commanding. Migrating fish evolved in the presence of large springtime flows, as snow melted from the mountainous interior. Juveniles were carried to sea by the spring freshet, often covering hundreds of miles in several days' time. Now, the water is held back in storage dams, because the value of electricity is highest in the winter, when people need heat, not in the spring, when there's already a lot of water running and not so much demand for power. The spring migrants now spend weeks rather than days getting to salt water. Along the way they are exposed to predators in the slackwater reservoirs and the rigors of passing the dams. Amazingly, a lot make it through each dam; but the cumulative mortality of a series of dams is high enough to depress the abundance of upriver stocks dangerously.

- And in temporal terms, the large-scale modifications of the past century have yet to be taken into account. The rivers have been impounded, the forests cleared, and the landscape transformed — yet there has been little understanding that salmon habitat has been drastically altered. Harvesters and fishery managers did not foresee the vulnerability of large populations sustained by hatcheries. And human actions have tended to assume that the abundance of the past would be readily restored, even as the environmental capital needed to regain productivity was being destroyed or altered beyond biological recognition (Larkin 1979).

[slides off]

The story of the Columbia is one with many parallels. The Columbia demonstrates clearly the profound impact of human scales of action that do not match ecological requirements. What's different about the salmon is that people care a lot about its decline, but the way salmon declined is a dynamic repeated often in other places.

Yet it's important to bear in mind a major difference between damage to the salmon ecosystem and the damage done by the *Exxon Valdez* spill. The salmon is the victim of routine, profitable activities — dams, irrigation, cities. These activities yield a steady stream of revenues, part of which has been diverted to salvaging the salmon ecosystem, so far with little to show for it.

The oil spill was not a routine event; it is, in fact, the opposite, producing a one-time disturbance and a one-time settlement agreement. The challenge you face is to fashion a meaningful restoration from that settlement — a task in which nature has been your ally already, in which the people of coastal Alaska can be too, I think. The challenge in the Pacific Northwest salmon ecosystem is to achieve a sustainable fishery in the permanently altered world of the industrialized Columbia; it isn't clear whether nature will permit that, and it is certainly unclear whether the human institutions that manage parts of the salmon ecosystem are willing to make, or even find, the necessary accommodations.

Ecosystem management

In response to the dwindling of salmon and other valued species, the idea has gradually grown that species are not the right unit of conservation. For if we want to take advantage of the quality and productivity of valuable species, then we must protect and manage their ecosystems, rather than attempt to supersede or to substitute for those ecosystems by artificial culturing methods like hatcheries. Phil Janik quoted the new chief of the Forest Service, Mike Dombeck, to that effect just yesterday. It is the logic that propelled the Sound Ecosystem Assessment into being, as Ted Cooney said yesterday; it is a hope that hangs in the mist over the Everglades, the Grand Canyon, and even the Columbia.

A Forest Service framework...

There is no single method of ecosystem management. Let me, for the sake of clarity, pick a thoughtful example put forward by two analysts at the U.S. Forest Service.

[ecosystem management defn]

- Landscape ecology should be the conceptual template...
- Informed by systematic data collection and interpretation,

  using ecological mapping units.
- Landscapes are heterogeneous and controlled by disturbance regimes operating through time.
- Ecological integrity is maintained by sustaining or restoring pre-settlement landscapes.

Ecosystem Management (after Jensen and Bourgeon , USDA 1994)

These principles should be familiar to you.

...operating in a historical context

Consider, then, how they contrast with the historical assumptions that shape land use.

[ecosystem management vs. human priorities]

In place of landscape ecology, humans have emphasized sovereignty and property.

In place of systematic data collection, humans have relied upon the knowledge of owners: an understanding of land and water that is shaped by and often limited to past uses, instead of the ecological character of the land and sea. Owner's knowledge is rooted in place — in place-dependent economic activities like farming, on time scales organized by human tenure, inheritance, and land speculation, and on spatial scales shaped by human mobility (Jackson 1970). Owner's knowledge is different from, sometimes a great deal more humane than the scientist's geographic information system or species lists. These differences underlie a good deal of mutual suspicion (e.g., Berry 1989). Consider how long it's taken the trustee council to give Traditional Ecological Knowledge a place on your agenda, and how even that place is labeled with an acronym that makes this kind of knowledge TEK ...but not high-TEK.

ECOSYSTEM MANAGEMENT	HUMAN PRIORITIES IN UTILIZATION
Landscape ecology	Sovereignty & property
Systematic data collection & synoptic interpretation	Owner's knowledge
Ecological integrity in mapping units	Boundaries set by human use, institutions, & memories
Heterogeneity governed by disturbance regime	Homogeneity within use class; high productivity
Pre-industrial landscape as standard	Maximization of (long-term) utility
biotic system — independent of institutions	*historical* — bound by precedent & institutional tradition; individual-rational

Ecosystem Management vs. Human Priorities

The prevalence of owner's knowledge means, in turn, that humans divide and conceive of landscapes in particular ways. Here is a map, taken from a document discussing the Northern spotted owl. It shows the key watersheds to be managed because they lie within the geographic range of the owl.

[overhead: key watersheds]

Compare this map to another one, of the county governments in that same geographic area.

[overhead: counties]

You can see the qualitative difference. The ranges of biota are governed by precipitation and topography. Humans choose readily defensible borders, such as rivers, to mark jurisdiction and property. Or else we draw straight lines on the land.

Rivers are of course the centers of drainages, not their edges, and the boundaries of plant or animal dispersal rarely fall along straight lines. Drawing straight lines upon the land is arbitrary. Relying on rivers as borders is critically inappropriate, separating human interests along lines where human concerns should be unitary or at least coherent.

[return to ecosys mgt vs. human priorities]

Instead of heterogeneous landscapes resulting from natural disturbance regimes, human control has traditionally aimed at homogeneity and, in the case of cultivated lands, at installing and maintaining ecosystems at early successional stages where productivity is high. That is, humans take pre-development landscapes as starting point for transformation, not a benchmark for conservation or restoration.

The contrast between ecosystem management and human exploitation as ways of looking at the land is a contrast between sets of assumptions. Ecosytem management takes as its organizing premise the communities of biota. But ecosystem management envisions a landscape shaped primarily by disturbances of non-human origin, over times that are long compared to human temporal horizons. In short, ecosystem management operates on different scales than nearly all types of human utilization. Such a perspective operates independent of institutional considerations, in sharp contrast to human ownership and transformations of land.

The harmonizing of human and natural scales called for in ecosystem management is accordingly difficult.

Three responses

The rise of ecosystem management in U.S. policy coincided with the dwindling capacity of the federal government to govern. Interior Secretary Bruce Babbitt's frustrating career in that post is a graphic demonstration of both the importance of ecosystem management as an idea and the political difficulty of pursuing its governmental realization.

[three responses]

Instead of national policy, three rather different and somewhat complementary approaches have been tried as ways to harmonize human and natural. I want briefly to review these ideas — co-management, bioregionalism, and adaptive management — and explore how they might become part of a way to think about ecosystems inhabited and used by humans.

Each of these approaches responds to the two principal roots of environmental conflict in American politics. First, the management of public resources is shaped by the fragmentation of formal authority and political power. Authority is divided between federal and state governments and power is dispersed among a wide variety of business, citizen, media, and governmental organizations. Cooperative action requires compromise whenever there is conflict. Second, the economy is technically complex and environmental questions face uncertainties at every turn. Managing ecosystems — which are owned by private and public entities with conflicting agendas affecting one another and other neighboring and distant interests — requires recognizing conflict, stimulating negotiations, and providing technical analyses to illuminate disputes. Co-management, bioregionalism, and adaptive management each seek to do this, and each can be carried out with only the acquiescence of the federal government — they do not require large-scale funding.

Co-management

Let me begin with co-management. For most of the past century, public lands in the U.S. have been managed on a model of expert neutrality (Hays 1987). Agencies like the U.S. Forest Service have been charged with managing public lands in the public interest. But rising conflict has make it impossible to define the public interest non-controversially.

Bringing in those who are affected became an attractive alternative to increasingly embattled agencies. The result has been co-management: "power-sharing in the exercise of resource management between a government agency and a community or organization of stakeholders." (Pinkerton 1992, p. 331)

The idea of co-management is simple: get the contending interests together so they can work out something all can live with. Co-management recognizes the central role of equity and fairness in managing ecosystems that are owned by and affect people in diverse circumstances. Human communities can avoid a tragedy of the commons (Ostrom 1990); they do so by fostering monitoring of resource users and effective enforcement of those who violate the rules of equitable use. That is, managing ecosystems is a people issue. Co-management seeks to tackle that people problem head-on.

But this approach is not a cure-all. As the number of competing interests in a resource increases, the costs, procedural complications, and complex tradeoffs increase as well, often in apparent disproportion to the scope of involvement.

Moreover, most cooperative arrangements have not been designed but are the residue of conflict and negotiation among opposed parties. Such a history often brings with it a range of problems — lowest-common denominator positions, blaming as a substitute for analysis, and emphasizing short-term remedies with anticipated early payoffs, such as salmon hatcheries. On the other hand, over time periods of a decade or more, as Pinkerton (1992) showed for state forest management, both the agenda of disputing and the institutions within which disputes are conducted can evolve toward durable accommodations. In sum, co-management is a tool; it can't do everything, but it can do some essential things.

Bioregional scope

Consider next management organized around bioregion. From an ecological perspective the most straightforward strategy of reform is to shift the margins of human control and responsibility to match natural boundaries. Indeed, the notion of ecosystem management is rooted in the claim that ecosystems are the best scale at which to manage. What I've learned here is that you have had the courage to define ecosystems so that they include both terrestrial and marine components; that's important and difficult and novel.

Let me emphasize "difficult." Straight-line boundaries like the eastern border of Alaska are in place. Trade routes have tied together different biogeographic provinces: highways, transmission lines for electricity, water diversions on land, shipping lanes at sea and in the sky. Along these human paths flow commercial transactions in which human values define the relative scarcity of specific resources, including the crops harvested from managed vegetation and animal populations. Any attempt to shift human jurisdictions so as to focus attention on the welfare of an ecosystem must begin with these boundaries and networks (Volkman and Lee 1988).

Even a more modest aim, to map reality in ecosystemic terms, runs afoul of human priorities. Much of what is needed to make maps and data bases that make sense ecologically would come from observations made on private lands. Gathering that information relies, in turn, on land-owners' perception that sharing data is in their interest. But the use of biological information for regulation undermines this perception. The result has been the strange struggle over the National Biological Survey, fueled by land-owners' fears of the Endangered Species Act. This battle is one measure of how far we remain from bioregional governance of ecosystems.

Adaptive learning

[back to Three Responses]

Let me turn now to the third of the responses to scale mismatch, adaptive management.

[AM defn]

Because human understanding of nature is imperfect, human interactions with nature should be experimental. *Adaptive* management applies the concept of experimentation to the design and implementation of natural-resource and environmental policies. (Holling 1978, Walters 1986, Lee 1993a, Gunderson, Holling & Light 1995) An adaptive policy is one that is designed from the outset to test clearly formulated hypotheses about the behavior of an ecosystem being changed by human use. If the policy succeeds, the hypothesis is affirmed. But if the policy fails, an adaptive design still permits learning, so that future decisions can proceed from a better base of understanding.

[cartoon]

Adaptive management makes sense when there is a lot of uncertainty, but the adaptive approach is not free: two problems are the costs of information gathering and the political risks of having clearly identified failures (Volkman and McConnaha 1993). An adaptive approach has been tried in practice in several arenas over the past 15 years. Recent studies (Halbert and Lee 1990, Walters, Goruk and Radford 1993, Hilborn and Winton 1993, Lee 1993, Volkman and McConnaha 1993) provide appraisals of the successes and limitations of the adaptive process.

[learning under adaptive mgt]

This body of experience has produced lessons about the practicability of adaptive management and the institutional conditions that affect the conditions under which experiments at the scale of ecosystems can be conducted.

- Learning takes a long time — decades to centuries. Patience, particularly in institutional settings such as government that work on much faster cycles, is both necessary and difficult.
- Systematic record-keeping and monitoring is essential if learning is to be possible. But collecting information is expensive and often hard to justify at the outset and during times of budget stringency because the benefits of learning are hard to estimate quantitatively.
- Experimentation within the context of resource use depends critically upon the collaboration of resource users.
- Adaptive management does not eliminate political conflict, but can affect its character in important, if indirect, ways.

[adaptive management cycle]

Adaptive management looks like a planning cycle, but rarely conforms to that orderly image. Because it is experimental, adaptive management will encounter surprises *if it works* as intended.

[adaptive management cycle, with conflict]

Given the fragmented jurisdictions and conflicting claims that characterize all contested ecosystems, surprise and its companion, disappointment, spawn disputes. Disputes in turn focus around funding and high-visibility decisions, points at which conflict can produce change for those who find the surprises worrying or costly.

These destabilizing elements, which appear to be *inherent* in the social dynamics of adaptive processes, underscore the importance of patience, persistence, and a politically grounded determination to make constructive use of inevitable conflicts. Disputes are sure to arise within the spans of space, time, and functional interaction that characterize the mismatched cycles of human endeavor.

Not solutions but frontiers

As my comments have suggested, co-management, bioregionalism, and adaptive management each bring important ideas to the pursuit of a sustainable and just ecosystem management. But none seems to provide an overall answer. We have ideas, not solutions. These ideas help to clarify the conflicts but they cannot reliably resolve the disputes.

I have tried to summarize my discussion in a chart that I've handed out.

[overhead: chart]

The first two rows reproduce the table I showed you earlier, comparing the ideas of ecosystem management to the patterns of human behavior and institutions. The third row arrays the three change strategies I've just described — co-management, bioregional governance, and adaptive management — along the spectrum of ecosystem management principles. Co-management is a direct attempt to engage with the need to manage at the landscape scale; bioregionalism seeks to bring an ecological unity to human information gathering and perception; and adaptive management is a way to bridge the homogeneous uses that humans impose upon heterogeneous ecosystems, so that we may learn from both rehabilitating ecosystems and from domesticating others.

The two pairs of crossed arrows in the lower part of the chart are meant to suggest that the social ideas that make sense in thinking about ecosystem management are likely to have inconsistencies. For example, the sharing of authority that is central to co-management empowers land-owners and the fragmented, narrow understandings that I called owner's knowledge earlier. The voices of owners, in turn, are likely to come into conflict with the bioregional insistence upon perceiving the landscape as a connected biotic system. And in turn, the notion that an ecosystem has integrity that deserves protection chips away at the idea of property rights. We know already that the defense of property rights is a vigorous one.

Similarly, the experimental mood of adaptive management promotes not only learning but questioning, including questioning of the inter-generational tradeoffs that are unavoidable if human endeavors are to take into account the time scales of ecosystems (Lee 1993a, chap. 8). Conversely, the environmentalist's instinct for prudence in the face of uncertain change must face the reality that learning by experiment requires manipulation of ecosystems. Although we have an economy increasingly devoted to the production and handling of information, we have few widely shared guidelines about the value of information. As a result, it is hard to judge — and even hard to argue over — whether a proposed modification of an ecosystem is likely to produce valuable information.

[overhead off]

Ecosystem management in coastal Alaska

In short, ecosystem management encounters the fundamental challenge of democratic public policy — the challenge of reconciling rational ideas with historical circumstance. In that context, I'd like to share some thoughts about the relationship between the scientific ideas that you work with and the historical setting of the *Exxon Valdez* oil spill.

In opening this workshop yesterday, Molly McCammon drew attention to the 171 publications — referreed journals and theses — that have emerged so far from your research program. Collectively, these publications are an important milestone, marking the *reliable* knowledge your creativity and energy have produced. We've seen ample evidence in the posters, in the talks, — and perhaps most of all in the idealism of the kids in the Prince William Sound Youth Area Watch — of the determination that goes into making knowledge reliable. It's the refereed journals that certify this determination.

But few people can read 171 publications, certainly not when they range over the technical fields you all work in. And the value of these publications goes beyond the scientific audiences served by the refereed journals. How should the trustee council bridge the gap between reliable knowledge and its meanings to society?

There is one group that knows those 171 papers and theses: the peer review panel chaired by Bob Spies. That panel should write a synthesis of the work coming out of the trustee council's research program, aiming to publish it in *Science*, *Nature*, or another of the widely read (but still refereed) national magazines. Such a paper should be written every two or three years.

So long as I'm offering unsolicited advice, let me say something about people as well as science. Something an outsider finds surprising about what you do here is the way you focus on the natural world. As three three ecosystem studies implicitly acknowledge, the trustee council's jurisdiction isn't one ecosystem but many. What defines the spatial scope of your work is disturbance — a human disturbance, the oil spill. That disturbance created a large but finite pool of resources, the settlements that the council administers. Although you work in the natural world, the scope, structure, and resource base of your activities is touchingly human. What you do arises from grief and worry, from the pursuit of justice — from values that are incomprehensible without humans in the landscape.

Yet the restoration, protection, and research activities you carry out have only accidental ties to the *future* human presence in Prince William Sound. There has been debate recently about what "restoration" should mean. But, more than halfway into the payment period for the trustee funds, that argument strikes me as far less important than the question of what "stewardship" should mean.

As the funds under the council's supervision are spent, the pace of land acquisition, research, and other activities will necessarily subside.

Isn't that the practical meaning of "restoration": the state of Prince William Sound when the money runs out?

Alaskans are famously skeptical of outsiders from the Lower 48. I won't press my luck here today, beyond saying that the meaning of words like "stewardship" and "restoration" are human words, invested with social meaning. Looking at the abstracts of the impressive range of science done with council sponsorship over the past year, I see the raw materials for meaning. Your most recent annual report is graced by the phrase, "where there is life there is hope." By the turn of the century, a lot more than hope will be needed. What is needed, to my way of thinking, is a way to understand the oil spill and the restoration as a historical period in coastal Alaska's natural and human communities. That understanding must draw upon the scientific knowledge and restoration activities you have carried out. But it must be framed by and rooted in the human communities that will go on beyond the restoration period. I don't know how that should be done; it just seems to me that the conversation isn't very audible yet, at least to an outsider.

Concluding thoughts

[slide: Earth from space]

Ecosystem management is, in concept, a strategy for organizing social responsibility in natural systems. The name of the strategy misleads in three ways: first, as ecological scientists know, ecosystems are human constructs, rather than biological units given by nature (Allen and Hoekstra 1992); second, what is being managed in ecosystem management is people, not just non-human elements of ecosystems; and third, as I have emphasized here, the management process is political and cultural rather than managerial in the usual sense of command and control.

That the activity of ecosystem management is so different from the ordinary-language implications of the name "ecosystem management" reflects, I think, the deep ambivalence industrial societies have about the natural world and the place of our species within it. Our growing ability to link together, control, destroy, and remake significant portions of the biosphere raises the question of how to make our presence more deliberate, less careless, and perhaps over time wiser. That is the question of harmonizing this familiar view of the biosphere to a quite different one.

[slide: Earth at night]

The natural planet is powered by the sun — atmosphere, ocean, and biota all derive their motive energy from solar radiation. This image, Earth at Night, assembled by the astronomer Woodruff Sullivan from weather-satellite photographs, shows us the human planet, illuminated by energies of human origin.

Whether they are the fires lit to clear lands for agriculture in the tropics, or the flaring of natural gas in the oil fields of Siberia, or the brilliance of urban landscapes, these are lights that are both recent in the places where they shine and temporary on time scales of ecological relevance. In Earth at Night only the aurora and possibly some wood-fueled fires are sustainable. A challenge for ecosystem management is to find a way for civilization to persist in the face of this historical context. I'm glad to be here with you to pursue that search.

Thank you.

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DRAFT comments welcome

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DRAFT comments welcome

1997 Restoration Workshop
Draft Agenda (12/23/96)[1]

DRAFT

Day 1, Thursday, January 23

8:00 am	Registration
8:30	Introduction and Annual Report on EVOS Program, Announcements *Molly McCammon, Executive Director*
9:00	Trustee Perspective *Dr. Phil Janik (USFS), Federal Trustee*
9:15	Introduction to Ecosystem Projects and Ecological Syntheses *Dr. Robert Spies, Chief Scientist*
9:30	Break
10:00	Sound Ecosystem Assessment (SEA, /320) *Dr. Ted Cooney and others (to be named)*
12:00 Noon	Buffet Lunch (in hotel)
1:15 pm	Alaska Predator Ecosystem Experiment (APEX, /163) *Dr. David Duffy, Paul Anderson, Dr. Lew Haldorson, David Roseneau, Dr. John Piatt, and Dr. Dan Roby*
3:15	Break
3:45	Herring Reproductive Impairment, 96074, *Mark Carls* Herring Disease, 96162, *Dr. Richard Kocan* Cutthroat Trout/Dolly Varden Life History Forms, 96145, *Dr. Gordon Reeves* PWS Youth Area Watch, 96210, *Mel Henning with Evan Evanson, Brian Collier, Jonah Swiderski, and Iris O'Brien*
5:00	Adjourn plenary session

[1]Three break-out rooms will be available for side meetings on Thursday and Friday. One of these rooms, Adventure, will be dedicated to uses by the Community Facilitators, including for meetings with individual PIs to exchange information about subsistence resources and to discuss needs for traditional ecological knowledge.

DRAFT

5:30-7:30	Reception and Poster Session

Day 2, Friday, January 24

8:00 am	Killer Whale Contaminants & Genetics, 96012, *Craig Matkin* Port Dick Spawning Channel, 96139A2, *Nick Dudiak and Mark Dickson*
8:40	Nearshore Vertebrate Predator Project (NVP, /025) *Dr. Leslie Holland-Bartels, Dr. Terry Bowyer, Dr. Tom Dean, Dr. David McGuire, Dr. Brenda Ballachey, Dan Esler, and Jim Bodkin*
10:40	Break
11:00	Keynote address: Natural and Social Scales in Ecosystem Management *Dr. Kai Lee, Center for Environmental Studies, Williams College*
12:00 Noon	Buffet Lunch (in hotel)
1:30	Panel: Perspectives on Ecosystem Projects and Research Needed by Resource Managers *Dr. Jim Balsiger (NMFS), Dr. James Brady (ADFG), John Martin (USFWS), USFS (to be named)*
2:30	Panel: Building and Applying Ecological Models *Dr. Andy Gunther (moderator), Dr. Stuart Pimm, and Dr. Daniel Pauly*
3:30	New Court Orders on Sample Retention and Destruction *Craig Tillery (ADL) and Gina Belt (DOJ)*
3:50	Adjourn plenary session *Main Ballroom must be cleared by 4 pm (conflicting event)*
7:00-9:00	Informal Brainstorming Session: Is Another Ecosystem Shift Underway? *Optional session in the Voyager room.*

Day 3, Saturday, January 25

8:30 am	Marine Bird Boat Surveys, 96159, *Bev Agler & Steve Kendall* Status & Ecology of Kittlitz's Murrelet, 96142, *Dr. Robert Day* Harlequin Duck Genetics, 96161, *Buddy Goatcher & Dr. Kim Scribner* Harbor Seal Fatty Acids, 96064, *Dr. Kathy Frost*
9:50	Break

DRAFT

10:20	Chugach Region Clam Restoration, 96131, *Patty Brown-Schwalenberg and Jeff Hetrick* Archaeological Site Stewardship, 96149, *Doug Reger*
11:00	Reactions from Peer Reviewers *Drs. Robert Spies, Pete Peterson, Chris Haney, George Rose, Polly Wheeler, Andy Gunther, and Phil Mundy*
12:00 Noon	Closing Remarks (for the technical workshop) *Molly McCammon, Executive Director*
12:15	Lunch (on your own)
2:00	Welcome to Special Public Educational Session *Craig Tillery, State of Alaska Trustee*
2:10	Overview of Restoration Program and Update on Injury & Recovery *Molly McCammon, Executive Director* *Stan Senner, Science Coordinator*
2:30	An Ecosystem Approach to Restoration *Dr. Robert Spies, Chief Scientist*
2:40	Scientists at Work *Killer whales: Counting - Craig Matkin, 96012* *Harbor seals: Biosampling - Kate Wynne, 96244* *Clams: Hatchery Production - Carmen Young, 96131* *Sockeye: Genetic Sampling - Dr. Lisa Seeb, 96255* *Marbled Murrelets: Climbing Trees - Kathy Kuletz, 96031* *Harlequin Ducks: Kayak Roundup - Dan Esler, 96025*
3:30	Alaska SeaLife Center *Dr. John Hendricks, Executive Director*
3:40	For More Information--How to Get Involved *Molly McCammon, Executive Director*
3:45	Panel: Questions and Answers *Molly McCammon, Dr. Robert Spies, Stan Senner, and other presenters*
4:15	Adjourn

16.11.4 q

LEGACY OF AN OIL SPILL 10 YEARS AFTER EXXON VALDEZ

MARCH 23 -- 27, 1999
EGAN CIVIC AND CONVENTION CENTER
ANCHORAGE, ALASKA

Early Warning!

The 10-year anniversary of the Exxon Valdez oil spill will be marked by a five-day international symposium to be held in Anchorage. Day One will be a public session and overview highlighting status of recovery, Trustee Council programs, and oil spill prevention and response. Days Two through Four will showcase scientific achievements and endeavors during the previous 10 years. There will be no Restoration Workshop in 1999.

Put these dates in your calendar.

1997 Restoration Workshop

January 23-25

Hotel Captain Cook
Anchorage, Alaska

Exxon Valdez Oil Spill Trustee Council
645 G Street, Anchorage, AK, 99501
PH 907/278-8012 • FAX 907/276-7178

1997 Restoration Workshop

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Molly McCammon, Executive Director

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Phil Janik (USFS), Federal Trustee

9:15 **Introduction to Ecosystem Projects and Ecological Syntheses**
Dr. Robert Spies, Chief Scientist

9:30 **Break**

10:00 **Sound Ecosystem Assessment** *(SEA, /320)*
Dr. Ted Cooney and other SEA investigators

12 Noon **Buffet Lunch *(in hotel)***

1:15 pm **Alaska Predator Ecosystem Experiment** *(APEX, /163)*
Dr. David Duffy, Paul Anderson, Dr. Lew Haldorson, David Roseneau, Dr. John Piatt, and Dr. Dan Roby

3:15 **Break**

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10:40 **Break**

11:00 **Keynote address: Natural and Social Scales in Ecosystem Management**
Dr. Kai Lee, Center for Environmental Studies, Williams College

12 Noon **Buffet Lunch** *(in hotel)*

1:30 **Panel: Perspectives on Ecosystem Projects and Research Needed by Resource Managers**
Dr. Jim Balsiger (NMFS), James Brady (ADFG), John Martin (USFWS), & USFS representative

2:30 **Panel: Building and Applying Ecological Models**
Dr. Andy Gunther (moderator), Dr. Stuart Pimm, and Dr. Daniel Pauly

3:30 **New Court Orders on Sample Retention and Destruction**
Craig Tillery (ADL) and Gina Belt (DOJ)

3:50 **Adjourn plenary session**
Main Ballroom must be cleared by 4 pm (conflicting event)

7:00-9:00 **Informal Brainstorming Session: Is Another Ecosystem Shift Underway?**
Optional session in the Voyager room.

Traditional Ecological Knowledge

Friday	9-10 a.m.	Voyager Rm
Saturday	10-11 a.m.	Voyager Rm

Dr. Pam Colorado and Dr. Henry Huntington will be available to discuss Traditional Ecological Knowledge and its role with western science.

NOTE: Three break-out rooms will be reserved for use Thursday, Friday and Saturday. The *Adventure Room* will be used by the Community Facilitators for meetings with individual PIs to exchange information about subsistence resources and to discuss needs for traditional ecological knowledge. The *Whitby Room* will be available for presenters to preview slides, overheads and other materials. The *Voyager Room* will be open for side meetings as needed. Please check with the reservation desk if you are interested in reserving space for a meeting.

Day 3 • Saturday, January 25

8:30 am	**Marine Bird Boat Surveys,** 96159, *Bev Agler & Steve Kendall* **Status & Ecology of Kittlitz's Murrelet,** 96142, *Dr. Robert Day* **Harlequin Duck Genetics,** 96161, *Buddy Goatcher & Dr. Kim Scribner* **Harbor Seal Fatty Acids,** 96064, *Kathy Frost*
9:50	**Break**
10:20	**Chugach Region Clam Restoration,** 96131, *Patty Brown-Schwalenberg and Jeff Hetrick* **Archaeological Site Stewardship,** 96149, *Dr. Doug Reger*
11:00	**Reactions from Peer Reviewers** *Dr. Robert Spies, Dr. Pete Peterson, Dr. Chris Haney, Dr. George Rose, Polly Wheeler, Dr. Andy Gunther, and Dr. Phil Mundy*
12 Noon	**Closing Remarks** *(for the technical workshop)* *Molly McCammon, Executive Director*
12:15	**Lunch** *(on your own)*
2:00	**Welcome to Special Public Educational Session** *Craig Tillery, State of Alaska Trustee*
2:10	**Overview of Restoration Program and Update on Injury & Recovery** *Molly McCammon, Executive Director* *Stan Senner, Science Coordinator*
2:30	**An Ecosystem Approach to Restoration** *Dr. Robert Spies, Chief Scientist*
2:40	**Scientists at Work** **Killer whales: Counting -** *Craig Matkin, 96012* **Harbor seals: Biosampling -** *Kate Wynne, 96244* **Clams: Hatchery Production -** *Carmen Young, 96131* **Sockeye: Genetic Sampling -** *Dr. Lisa Seeb, 96255* **Marbled Murrelets: Climbing Trees -** *Kathy Kuletz, 96031* **Harlequin Ducks: Kayak Roundup -** *Dan Esler, 96025*
3:30	**Alaska SeaLife Center** *Dr. John Hendricks, Executive Director*
3:40	**For More Information—How to Get Involved** *Molly McCammon, Executive Director*
3:45	**Panel: Questions and Answers** *Molly McCammon, Dr. Robert Spies, Stan Senner, and other presenters*
4:15	**Adjourn**

16.11.4 H

1997 Restoration Workshop

JANUARY 23-25

ANCHORAGE, ALASKA

EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL
645 G STREET, ANCHORAGE, AK, 99501
PH 907/278-8012 • FAX 907/276-7178

COMMUNITY INVOLVEMENT

PROJECT 97052

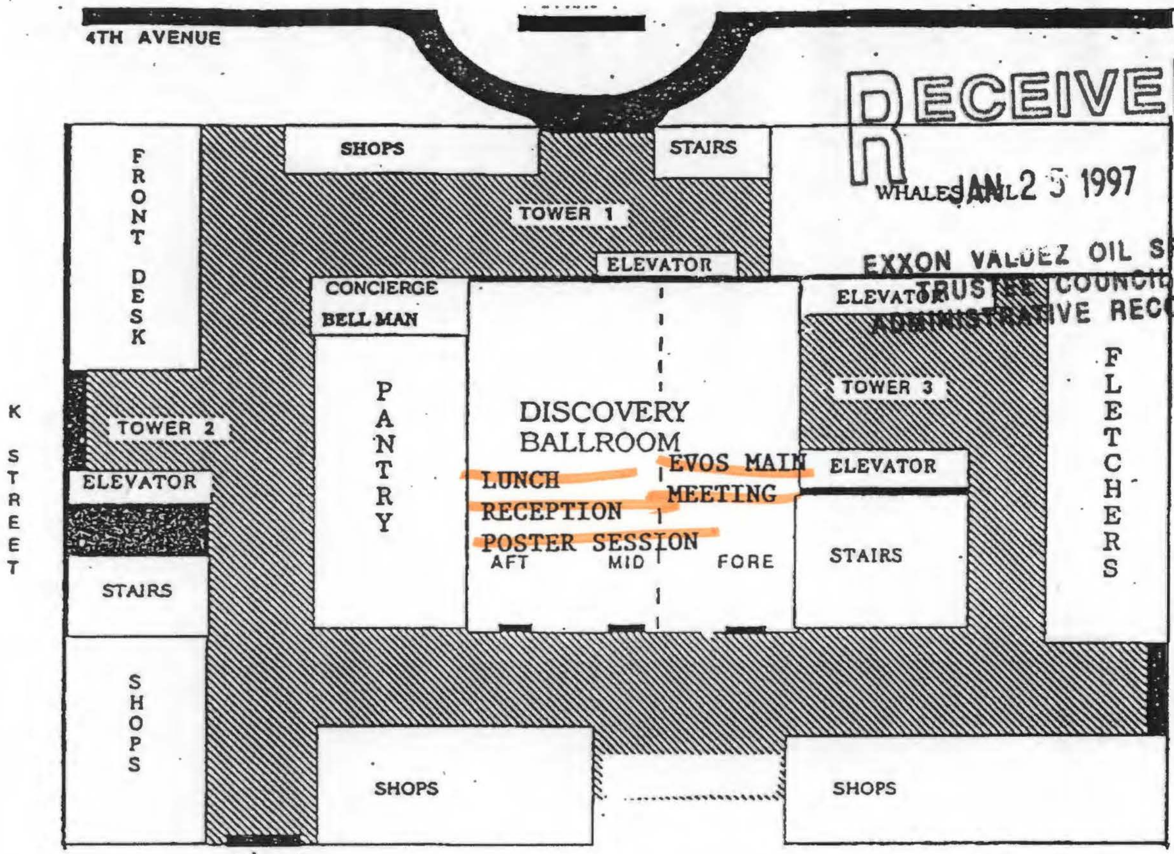
SCHEDULE FOR BREAKOUT SESSIONS

BETWEEN EVOS RESEARCHERS AND
COMMUNITY INVOLVEMENT FACILITATORS

Other Funding Sources 10:30 -12:00 Thursday	Ed Deaux Cindy Adams
Remote Site Reports 1:00- 1:45 PM Thursday	Molly Burton
Pacific Herring 2:00-3:00 PM Thursday	Evelyn Brown Jody Seitz
Harlequin Duck 3:45-4:30 PM Thursday	Dan Rosenberg
Sea Otter 4:30-5:30 PM Thursday	Brenda Ballachey
Archaeology To be determined	Lora Johnson
Traditional Knowledge 1:00 - 2:30 PM Friday	Pam Colorado Henry Huntington
Harbor Seal 2:30-3:30 PM Friday	Kathy Frost Kate Wynne
General Questions 4:00-5:00 PM Friday	Bob Spies Stan Senner
Clams 9:00-10:00 AM Saturday	Tom Dean Jeff Hetrick

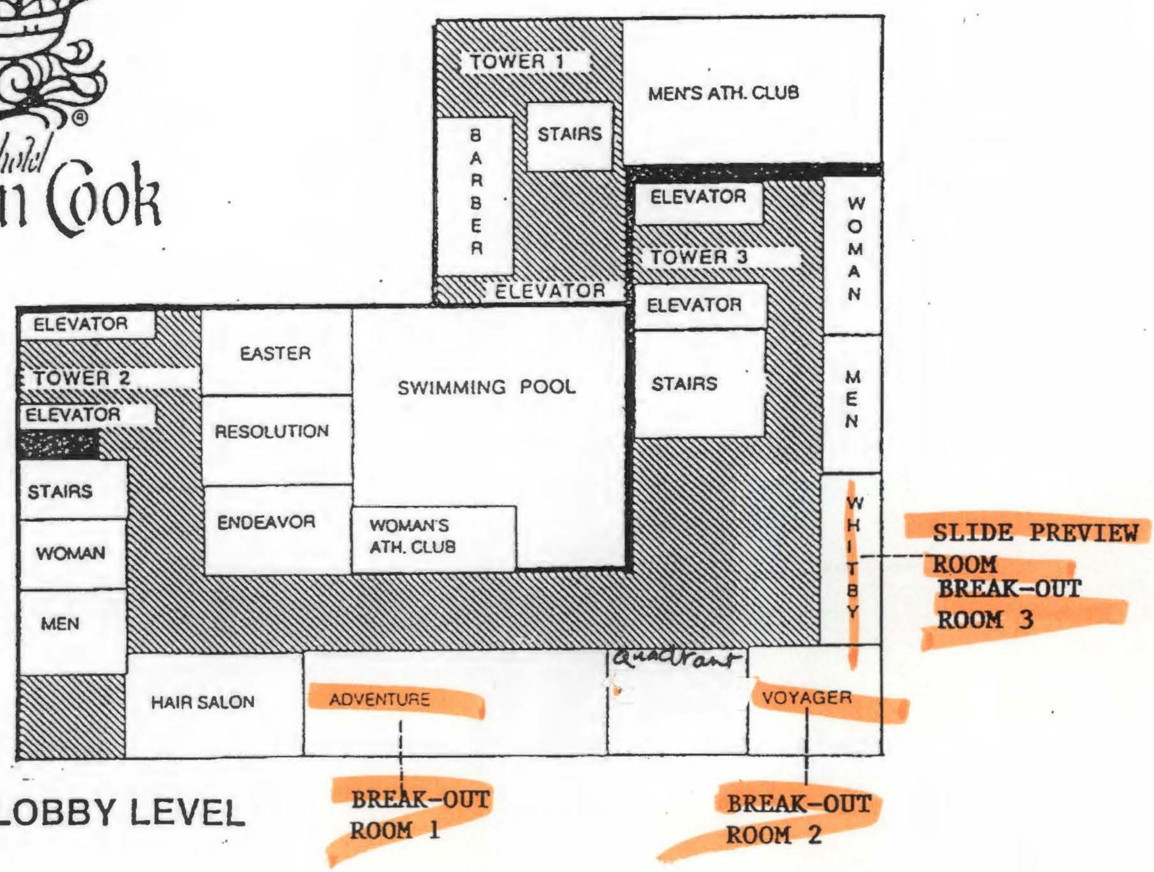
16.11.4 G

RECEIVED
JAN 2 5 1997
EXXON VALDEZ OIL SPILL
TRUSTEE COUNCIL
ADMINISTRATIVE RECORD



LOBBY LEVEL

The hotel Captain Cook



LOWER LOBBY LEVEL

KENAI PENINSULA

9/15/96

Exxon Valdez settlement funds benefit peninsula residents and visitors

Habitat protection

Research/Restoration

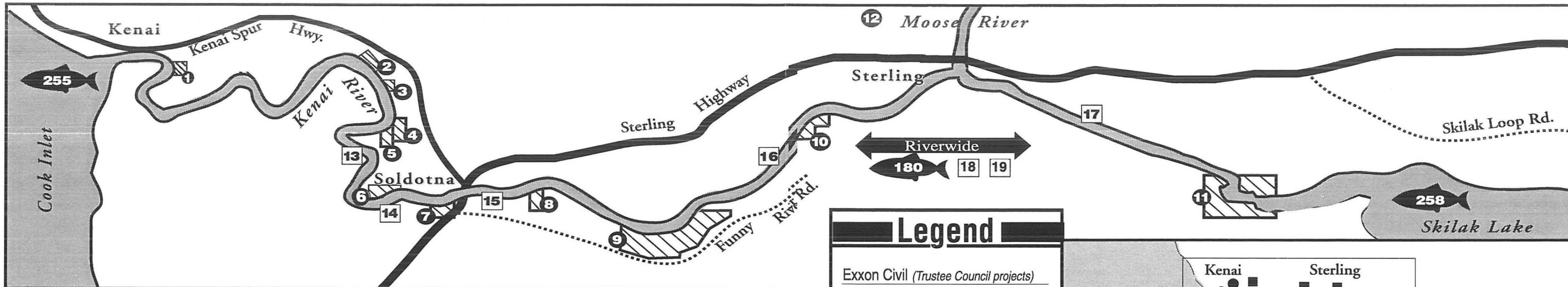
Subsistence

Commercial fishing

Archaeology

Recreation

Exxon Valdez Oil Spill Trustee Council



Habitat protection, recreation and scientific research

Exxon civil, criminal penalties to provide long-term benefits for Kenai Peninsula

Alaskans who take part in outdoor activities on the Kenai Peninsula are starting to see the benefits from dozens of projects funded by the Exxon Valdez criminal and civil settlements. If you enjoy a wilderness retreat in Kachemak Bay State Park, take part in the bounty of the Kenai River, tour the Alaska Sea Life Center in Seward, or set up camp along the Anchor River, you will find better facilities, better fishing success and more educational opportunities due to the many programs made possible by these funds. The following projects are in various stages of completion. Many acquisition projects depend on successful negotiations with the private land owners. Trustee Council projects (civil settlement) are in black. Projects using state or federal criminal settlement funds are shaded in gray.

Civil Settlement

The Exxon Valdez Oil Spill Trustee Council, funded by the $900 million civil settlement with Exxon, was created to help restore natural resources injured by the spill through habitat protection and scientific studies. This fund is limited to restoration activities in the oil spill region.

Criminal Settlement

The State of Alaska received half of the $100 million criminal restitution resulting from the spill. This money has been designated for many uses in the spill region, including recreational facilities, interpretive programs and habitat improvements on the Kenai River. Federal agencies are also using some of their $50 million criminal fund on Kenai Peninsula projects.

1 Cone Parcel — $600,000
100 acres near the mouth of the river along the Kenai River flats. Acquistion complete.

2 Oberts Parcel (The Pillars)
30-35 acres with 1400 feet of undisturbed shoreline in vital habitat area. Appraisal under review.

3 Oberts Parcel (Honeymoon Cove)
4.22 acres of undisturbed shoreline in high-impact recreational area. Appraisal under review.

4 Oberts Parcel (Big Eddy)
31.7 acres with about 1,200 feet of riverbank adjacent to the Kobylarz Parcel. Appraisal under review.

5 Kobylarz Parcel — $320,000
20 acres with 1100 feet of riverbank frontage located on the Kenai River at Big Eddy. Offer accepted.

6 Girves Parcel — $1,835,000
110 acres in a high use area of Soldotna. Acquisition complete.

7 Schilling Parcel
5.9 acres at confluence of the Kenai River and the Sterling Highway. Offer from landowner under consideration.

8 Patson Parcel — $375,000
76 acres on the Kenai River by the Soldotna Airport with 1/4-mile of river frontage. Offer under consideration.

9 Salamatof Parcel — $2,540,000
1,377 acres on the Kenai River with approximately 2 miles of riverbank frontage. Offer accepted.

10 River Ranch Parcel — $1,650,000
146 acres with more than one mile of Kenai River Frontage. Offer under consideration.

11 Stephanka Parcel
803 acres with 2-3 miles of Kenai River frontage. Part of the KNA package below.

12 Kenai Natives Association — $4,000,000
Acquiring 3,4254 acres in the Kenai River/Moose River drainage area north of the Sterling Highway. Package received Congressional approval.

13 Slikok Creek Access — $265,000
Ladders and boardwalks to and along river for fishing access, interpretive displays. (ADNR)

14 Habitat Restoration — $50,000
Contribution toward project to restore and protect severely damaged riparian habitat at Riverbend Campground. (ADF&G)

15 Soldotna Creek Park — $300,000
Restoration of heavily damaged park at Soldotna Creek. Includes elevated grate walk, vegetated biogrid, rootwad installation, bank revegetation. (ADF&G)

16 Morgan's Landing Access — $50,000
Ladders and boardwalks to and along river for fishing access, interpretive displays. (ADNR)

17 Bing's Landing Access — $200,000
Ladders and boardwalks to and along river for fishing access, interpretive displays. (ADNR)

18 Private Waterfront Projects — $60,000
Small-scale demonstration projects, restoration and protection of riparian habitat on Kenai River frontage parcels using elevated walks, bio-engineering, revegetation, with monitoring. (ADF&G)

19 Public Lands Protection — $250,000
Restoration of public riverbank damaged by use: Endicott sonar site, Kenai Keys site, Slikok Park, Centennial Park, the Sportsman's Lodge site, Ciechanski, and various campsites. (ADF&G)

Legend

Exxon Civil *(Trustee Council projects)*

- 28 — *habitat protection*
- 149 — *community/subsistence*
- *Salmon, seabird, harbor seal and clam research projects*

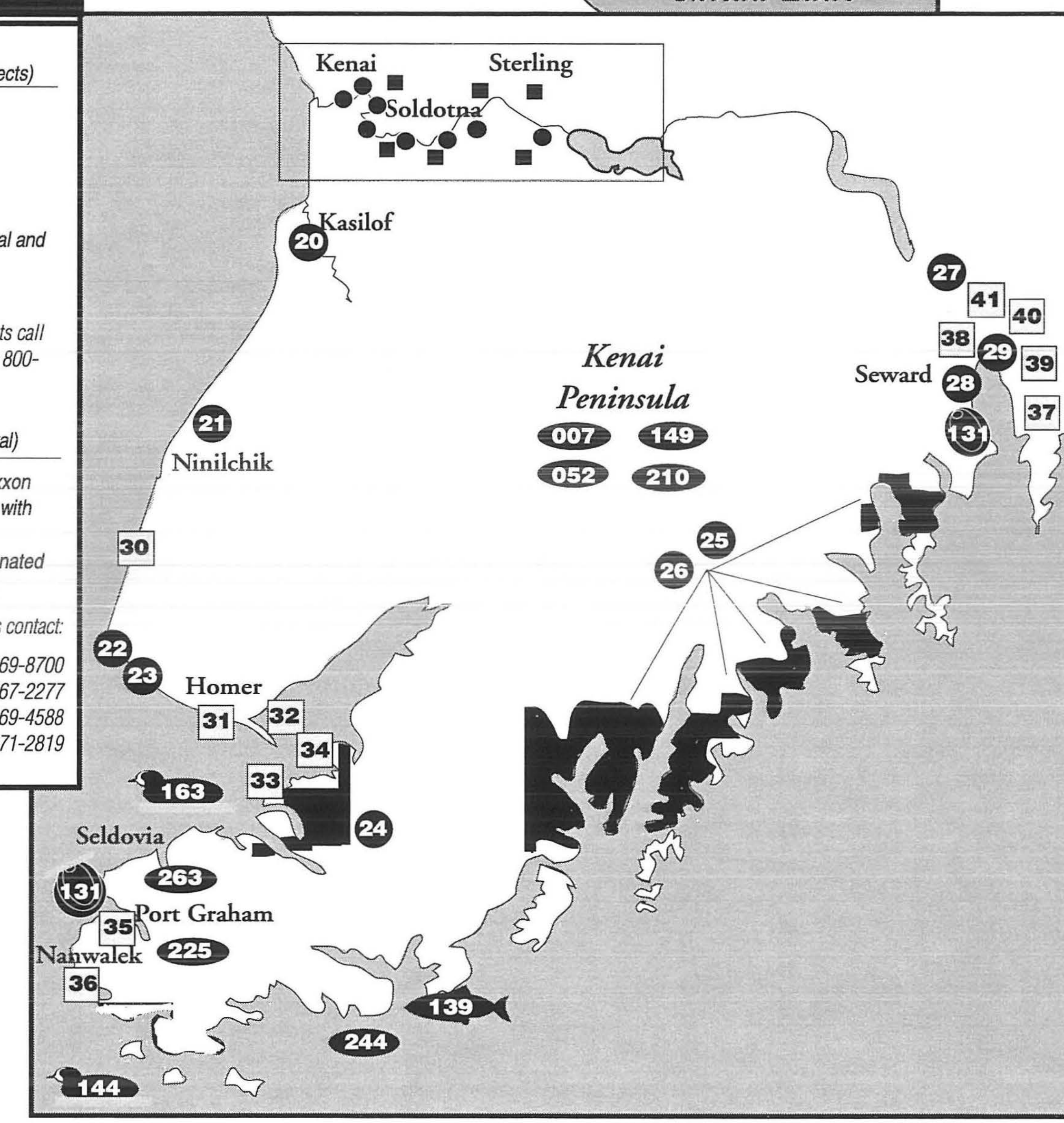
For more information on these projects call the Restoration Office at 278-8012 or 800-478-7745.

Exxon Criminal *(State and Federal)*

36 — *Each project funded by the Exxon criminal settlement is marked with gray shaded squares. The agency responsible for each project is designated at the end of the project description.*

For more information on these projects contact:

ADNR (Division of Parks)	269-8700
ADF&G (Habitat Division)	267-2277
DCRA	269-4588
USFS	271-2819



20 Coal Creek — $260,000
53 acres located at the confluence of Coal Creek and Kasilof River. Offer accepted.

21 Cooper Parcel — $48,000
The Ninilchik River flows through this 20 acre parcel two miles upstream from mouth. Offer under consideration.

22 Tulin Parcel — $1,200,000
220 acres with 3/4 mile of shoreline and 1/4 mile along Diamond Creek. Acquisition complete.

23 Overlook Park — $244,000
97 acres just below scenic overlook, with 3/4 mile of shoreline near tidal pools. Offer under consideration.

24 Kachemak Bay State Park — $7,500,000
Provided partial funding of $22 million package to acquire 23,800 acres of park inholdings. Acquisition complete. Criminal fund provided another $7 million and state's settlement with Alyeska provided $7.5 million.

25 English Bay
Possible purchase of 33,000 acres along the south shore of the Kenai Peninsula. Discussions ongoing.

26 Port Graham
Possible conservation easements and purchase of 46,170 acres along the south shore of the Kenai Peninsula. Discussions ongoing.

Continued on Page 6

Habitat Protection and Recreation Projects, continued

27 **Grouse Lake** **$211,000**
64 acre recreational site along western shore of Grouse Lake. Acquisition complete.

28 **Lowell Point** **$531,000**
19.4 acres includes 700 feet of shoreline popular for hiking, kayaking, beachcombing and fishing. Offer under review.

29 **Alaska SeaLife Center** **$24,900,00**
Partial funding of this $50.5 million center in Seward, due to open in 1998. Also $12.5 million from state criminal funds.

30 **Halibut Campground** **$300,000**
New 20-unit campground in the Anchor River area. (ADNR)

31 **Beluga Slough Trail** **$300,000**
Trail construction for wildlife viewing, interpretation, benches in Homer slough. (ADNR)

32 ***Mud Bay Boardwalk*** ***$150,600***
Construct boardwalk and viewing decks on Mud Bay at base of Homer Spit. (ADNR)

33 **Kachemak Bay State Park Improvements** *(ADNR)*

Campsites ***$60,000***
21 new campsites throughout the park with tent platforms, food caches, fire rings and toilets.

Public Use Cabins ***$200,000***
5 new public use cabins for Halibut Cove, Leisure Lake, Moose Valley, Sadie Cove.

Trail System ***$310,000***
Construct hiking trails in Kachemak Bay State Park.

Mooring Buoys ***$20,000***
New buoys in Tutka, China Poot, Mallard Bays and Halibut Cove areas.

Grewingk Creek Bridge ***$100,000***
Suspension bridge to link popular areas of the park and the trail system.

Cabin Acquisitions ***$350,000***
Acquire 5 private cabins suitable for public use.

34 **Halibut Cove Lagoon Dock** **$190,000**
Construct public dock in Halibut Cove for access to Kachemak Bay State Park. (ADNR)

35 **Port Graham Coho Project** **$438,800**
Restore the natural run of coho in Port Graham area stream to improve subsistence harvest. (DCRA)

36 **Nanwalek Sockeye Project** **$424,000**
Sockeye salmon project on English Bay River provides a subsistence resource and restores a natural run. (DCRA)

37 **Resurrection Bay Cabins** **$159,000**
Construct cabins, buoys, trails and latrines in Thumb Cove. (ADNR)

38 **Caines Head Alpine Trail** **$50,000**
Construct hiking trail from North Beach to alpine area. (ADNR)

39 **Resurrection Bay Trail** **$200,000**
Develop day use parking, beach trailhead and interpretive exhibits. Requires acquistion of 20 acres and is subject to negotiation with landowners. (ADNR)

40 **Interpretive Displays** **$40,000**
Construct interpretive exhibits at Kenai Fjords Visitor Center and at SeaLIfe Center. (ADNR)

41 **Darling Parcel** **$35,000**
99 acre parcel along the Snow River in the Chugach National Forest. Acquisition complete. (USFS)

Science, Subsistence and Archaeology

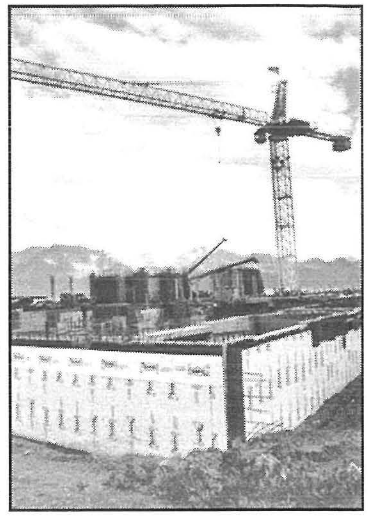
The following symbols represent science, subsistence and archaeology projects funded by the Trustee Council from Exxon civil funds. The numbers are the actual file numbers for each of the projects.

007 **Archaeological Site Monitoring**
Monitoring of archaeological sites on public land injured by vandalism and oiling.

052 **Community Involvement/Traditional Ecological Knowledge**
Community facilitators in Port Graham, Nanwalek, Seldovia, Seward and six other communities in spill region serve as liaisons between the Trustee Council, researchers, and communities.

131 **Clam Restoration**
Pilot project to establish subsistence clam populations near Native villages in the oil spill region. The Qutekcak hatchery in Seward is rearing littleneck clams to be seeded near Nanwalek and Port Graham. Success could lead to similar clam seeding near other communities.

139 **Port Dick Creek Restoration**
Port Dick Creek restoration will increase spawning habitat to strengthen native salmon stocks.



Construction of the Alaska SeaLife Center in Seward got underway this summer with opening scheduled for May 1998.

144 **Common Murre Population Monitoring**
This project provides information about common murre recovery by counting murres at Barren Islands.

149 **Archaeological Site Stewardship**
Provides training and coordination for volunteers in Port Graham and Nanwalek to monitor vandalized sites in the oil spill area. Vandalism was a serious problem after the spill. Long term protection and restoration will be most successful if undertaken by local people.

163 **APEX - Alaska Predator Ecosystem Experiment**
This project compares reproductive abilities and diets of seabirds in Prince William Sound with similar data from Cook Inlet, considered a more suitable food environment.

180 **Kenai Habitat Restoration/ Recreation Enhancement**
Approximately 19 miles of the Kenai River's 166 miles of shoreline have serious habitat loss. Public lands have 5.4 miles of degraded shoreline. This 3-year project restores and protect ssalmon habitat on public lands.

210 **Youth Area Watch**
Involves local youth with ongoing restoration projects, giving them the skill and knowledge to participate in restoration activities now and in the future.

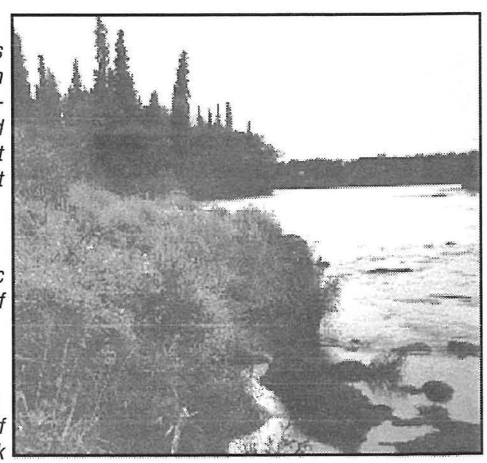
225 **Port Graham Pink Salmon Subsistence Project**
Enhances the Port Graham hatchery's ability to produce pink salmon for subsistence purposes. Because local runs of coho and sockeye salmon are at low levels, subsistence users are relying more on pink salmon.

244 **Community Based Harbor Seal Management**
Biological sampling of harbor seals is being done in Prince William Sound and Lower Cook Inlet. Village technicians in Port Graham, Seldovia, Nanwalek and six other communities are trained by the Harbor Seal Commission to collect samples for analysis.

255 **Kenai River Sockeye Genetics**
Five-year project identified genetic differences in Cook Inlet sockeye salmon. Information provided by this project is being used by fisheries managers to modify fishing areas and openings in order to improve management of Kenai River and other Upper Cook Inlet sockeye salmon stocks.

258 **Sockeye Overescapement**
Four-year project has produced scientific evidence to help evaluate the effects of overescapement.

263 **Assessment, Protection, Enhancement of Salmon Streams**
Provides inventory and assessment of four major salmon streams in Lower Cook Inlet with intent to improve habitat for better spawning success.



Trampling of the river banks due to fishing pressure results in erosion and loss of habitat.

16.11.4 E

Abstracts of 1996 Restoration Projects

ERRATUM

Please substitute the following abstract for project 99194 for the one in the abstract book. The units of measurement in the abstract printed in the book are in error.

Project Number and Title: 97194 - Pink salmon spawning habitat recovery.

Principal Investigators: Michael L. Murphy and Stanley D. Rice, NOAA NMFS, Auke Bay Laboratory, 11305 Glacier Hwy, Juneau, AK 99801 (Phone 907/789-6036).

Abstract: The objective of this study, which began in Fiscal Year 1997, is to examine the level of oil contamination in pink salmon streams in Prince William Sound to document initial levels of oil exposure and subsequent habitat recovery after the *Exxon Valdez* oil spill. Results of this study are meant to complement and help interpret other Trustee studies of oil-related embryo mortality in pink salmon.

To document initial exposure levels, this study is analyzing approximately 400 sediment samples from nearly 200 pink salmon streams that were collected by ADFG in 1989-90 but not analyzed. An additional 97 samples were collected from 12 of ADFG's sites (11 oiled, 1 non-oiled) in 1995 and are being analyzed to determine habitat recovery. Most samples were taken from stream banks immediately adjacent to pink salmon spawning areas. Samples are being fast-screened by ultraviolet fluorescence to measure total concentration of petroleum hydrocarbons, and representative samples are analyzed by gas chromatography/mass spectroscopy to determine concentrations of individual polynuclear aromatic hydrocarbon (PAH) analytes to confirm the oil source.

Initial results from 29 of ADFG's 1989 samples from 11 streams indicated that oil contamination varied widely by stream, with mean oil concentration ranging from 1 μg/g to over 45,000 μg/g. Petroleum hydrocarbons were still detected in sediment in 1995. At the 11 oiled sites sampled in 1995, mean oil concentration ranged from 1 μg/g to 240 μg/g, and individual sediment samples ranged up to 1,628 μg/g. These oil levels in sediment have been associated with impaired survival of pink salmon embryos in a Trustee-sponsored laboratory study (95191). Analysis of PAHs confirmed that the source of petroleum hydrocarbons was *Exxon Valdez* oil. Using an exponential decay model to interpolate between mean oil concentration in 1989 and 1995 indicated that oil levels in sediment probably still exceeded 1,000 μg/g at many oiled stream deltas until 1993.

These results indicate that initial levels of oil contamination at streams in Prince William Sound were sufficient to cause genetic damage in pink salmon eggs and embryos incubating in stream gravel. Although many streams had apparently recovered by 1995, some still had significant levels of oil in sediments adjacent to pink salmon spawning areas that could cause impaired growth and reproduction of pink salmon.

16.11.4 D

Abstracts of 1996 Restoration Projects

ADDITIONS (#2)

The following abstract was received after the abstract book was sent to be printed.

Project Number and Title: 94266 - Shoreline Assessment and Oil Removal (Stranded Oil Persistence and Degradation along National Park Coasts) ; Final Report Title: Geomorphic Position, Chemical Degradation, and Implications for Biotic Impacts of Persistent Stranded Oil Mousse on a High Energy Coastline Distant from the *Exxon Valdez* Spill Origin

Principal Investigators: Gail V. Irvine, U.S. Geological Survey, Biological Resources Division, 1011 East Tudor Rd., Anchorage, Alaska 99503 (Phone 907/786-3653); Daniel H. Mann, Alaska Quarternary Center and Institute of Arctic Biology, 907 Yukon Drive, University of Alaska, Fairbanks, Alaska 99775 (Phone 907/474-7925); Jeffrey W. Short, National Marine Fisheries Service, NOAA, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, Alaska 99801 (Phone 907/789-6065)

Abstract: Previous studies of shore-zone impacts by oil spilled from the *Exxon Valdez* focus on sites proximal to the spill in Prince William Sound. Characteristically, these sites experience relatively low wave energy and were contaminated by fluid crude oil.

We describe the geomorphic settings and chemical alteration through time of *Exxon Valdez* oil stranded as mousse on the coastline of Katmai National Park and Preserve, 480-640 km from the site of the spill. At these distal sites, wave energy is high and coastal geomorphology is fundamentally different from Prince William Sound.

Initial oiling occurred sporadically along the Katmai coast. Much of the initially deposited oil was either buried by sediments or removed by wave action, except on beaches with an armor of large lag boulders.

However, where it has persisted, oil has weathered little in the five years since 1989. Comparisons of mousse sampled in April 1989, autumn 1989, July/August 1992, and August 1994 indicate only negligible changes in polynuclear aromatic hydrocarbon (PAH) abundances for 22 of 25 samples collected.

The slowness of chemical weathering of the oil is related to several factors. Oil on the Katmai coast initially arrived in a more weathered state than it did in Prince William Sound. In mousse, the surface of the oil available for weathering is less per volume than for more fluid oil. Consequently, mousse may be more recalcitrant to weathering than fresher, more mobile oil. The oil along the KATM coast typically persists at sites high in the intertidal zone under boulders where it is beyond the reach of most wave action and is often sheltered from dessication and sun exposure.

The biotic effects of oil persisting on the Katmai coast probably are slight because the oil stranding was initially patchy and ultimately persisted only high in the intertidal of armored boulder beaches where marine plants and invertebrates are characteristically sparse. However, persistent oil still has the potential to affect biota if it is released through disturbance of the armoring substrate, e.g., through unusually high energy wave events.

16.11.4 C

Abstracts of 1996 Restoratioin Projects

ADDITIONS

The following abstracts were received after the abstract book was sent to be printed.

Project Number and Title: 96320R- Trophodynamic Modeling and Validation Through Remote Sensing

Principal Investigator: David L. Eslinger, University of Alaska Fairbanks, Institute of Marine Science, Fairbanks, AK 99708. (907-474-7797) eslinger@ims.alaska.edu

Abstract: The overall goal of the SEA project (\320) is to aid restoration efforts aimed at the Prince William Sound ecosystem, with a specific emphasis on pink salmon (*Oncorhynchus gorbuscha*) and Pacific Herring (*Clupea harengus pallasi*). This goal will be accomplished by gaining a comprehensive, ecosystem-based, understanding of the magnitude and sources of variability of the PWS ecosystem. The objectives of this portion of the SEA project (96320) are:

1. to understand and simulate the dynamics of the phytoplankton and zooplankton communities in Prince William Sound, and

2. to use satellite remote sensing technologies to observe physical and biological variables in PWS. These satellite observations can then be used in interpreting the shipboard and buoy-derived measurements of the same, or related, variables.

The model is a coupled biological/physical model which simulates the dynamics of two types of phytoplankton: flagellates and diatoms; and three types of zooplankton: large *Neocalanus*-like copepods, smaller *Pseudocalanus*-like copepods, and euphausiids. The model includes highly resolved vertical processes for both the physical (mixing and stratification) and biological (light attenuation, sinking, migration, etc.) subsystems. It can be run in either an one-dimensional mode or in a three-dimensional mode. It is driven by measured meteorological data sets, which are also collected as part of this project.

Major 1996 results include analyses of the interannual differences between 1995 and 1996, and the spatial differences across the sound, within a given year. The spring phytoplankton bloom in 1995 was longer in duration and had an overall lower phytoplankton biomass than in 1996. This was caused by differences in the winds and temperatures during the spring. High winds and cold temperatures in the first few, critical, days of the transition from winter to spring can cause dramatic changes in the phytoplankton bloom. Model zooplankton populations differ dramatically between years as well. The longer slower bloom of 1995 allowed the copepod populations time to graze the phytoplankton and produced large zooplankton populations. In contrast, the short, intense phytoplankton bloom in 1996, limited the amount of time that large quantities of phytoplankton were available to the zooplankton. Consequently, the zooplankton bloom was therefore smaller. Because the zooplankton are the primary food source for young pink salmon and Pacific herring, these results may explain some of the variability in the population of these two damaged resources.

Satellite imagery was used to analyze sea surface temperatures and sediment distributions for 1994, 195, and 1996. Temperatures varied both interannually and within the Sound. Sediment distributions were used to track inflow into the Sound. Please see the poster for sample images.

Project Number and Title: 96009D (closeout) - Survey of octopuses in intertidal habitats

Principal Investigator: D. Scheel, Prince William Sound Science Center, Box 705 Cordova, AK 99574; Tel: (907) 424-5800.

Abstract: Subsistence use of Giant Octopuses (*Octopus dofleini*) in Prince William Sound has led to reports that this species has declined in abundance. Octopuses may be considered an injured, non-recovering species under the general heading of Subtidal Organisms and Intertidal Organisms. Reduced octopus availability comprises a part of the decline in subsistance services. This project was designed to identify suitable habitats of octopuses in the Sound, examine subsitence use of octopuses and estimate the abundance of octopuses in shallow waters of the Sound.

We surveyed intertidal and subtidal habitats for *Octopus dofleini* in Prince William Sound and Port Graham, Alaska during two summers. In contrast to studies in other areas, we found octopuses primarily used intertidal and very shallow-water habitats. Even below the intertidal, we were more likely to find octopuses searching on shallow SCUBA dives (-3 to -5 m) than on deeper dives (-7 to -23 m). Octopuses used areas of shallow-sloped silt, sand, or gravel substrate at the base of rock ridges, where boulders resting on a soft substrate provided dens. Areas near kelp were preferred.

We tagged octopuses to determine turnover rates within a habitat patch. Tag recovery was low, possibly reflecting frequent movement out of the patch or a high rate of tag loss. Five sonic tags deployed in the summer of 1996 were retained by octopuses for up to 43 days and supported the idea that octopuses made frequent short-distance movements. Individuals equipped with sonic tags generally moved to ridges in deeper water after being disturbed in the intertidal, but returned to dens in less than 5 m of water within a few days. These patterns of habitat use by octopuses suggest that juveniles use the intertidal as a refuge from marine predators, including dogfish sharks, other fishes and sea otters.

16.11.4 B

Exxon Valdez Oil Spill Trustee Council

645 G Street, Suite 401, Anchorage, AK 99501-3451 907/278-8012 fax: 907/276-7178

MEMORANDUM

To: Participants, 1997 Restoration Workshop

From: Stan Senner, Science Coordinator Stan Senner

Subject: Bibliography of Research Publications Sponsored by the Trustee Council

Date: January 15, 1997

At the request of the Trustee Council and the Executive Director, Molly McCammon, Carrie Holba and I have prepared a draft of what is intended to be a comprehensive bibliography of peer-reviewed publications on research sponsored by the Trustee Council. Undoubtedly some already-published material was missed, and more work is published every month. If you find mistakes in any citations or want to let us know about additional citations, please give us the information on the back of this memorandum and return it to the registration desk (or mail to Stan Senner after the meeting).

This second (January 1997) version of the bibliography includes 171 citations. By publication type and topic, they include:

Type: Symposium proceedings (66%), Open journals (30%), and Other (e.g., theses) (4%);

Topic: Mammals (33%), Fish (21%), Intertidal/subtidal flora & fauna (14%), Birds (14%), Fate of oil (12%), Archaeological/Subsistence/Social/Cultural (5%), and Other (e.g., restoration planning) (1%).

attachment (1)

Note: ***Please return this form with corrections or additions to the registration desk at the 1997 Restoration Workshop or mail to Stan Senner at the Restoration Office (see address on letterhead).***

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DRAFT

Bibliography
of
***Exxon Valdez* Oil Spill Trustee Council Funded Research**

January 1997

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Exxon Valdez Oil Spill Restoration Plan

Update on Injured Resources and Services
September 1996

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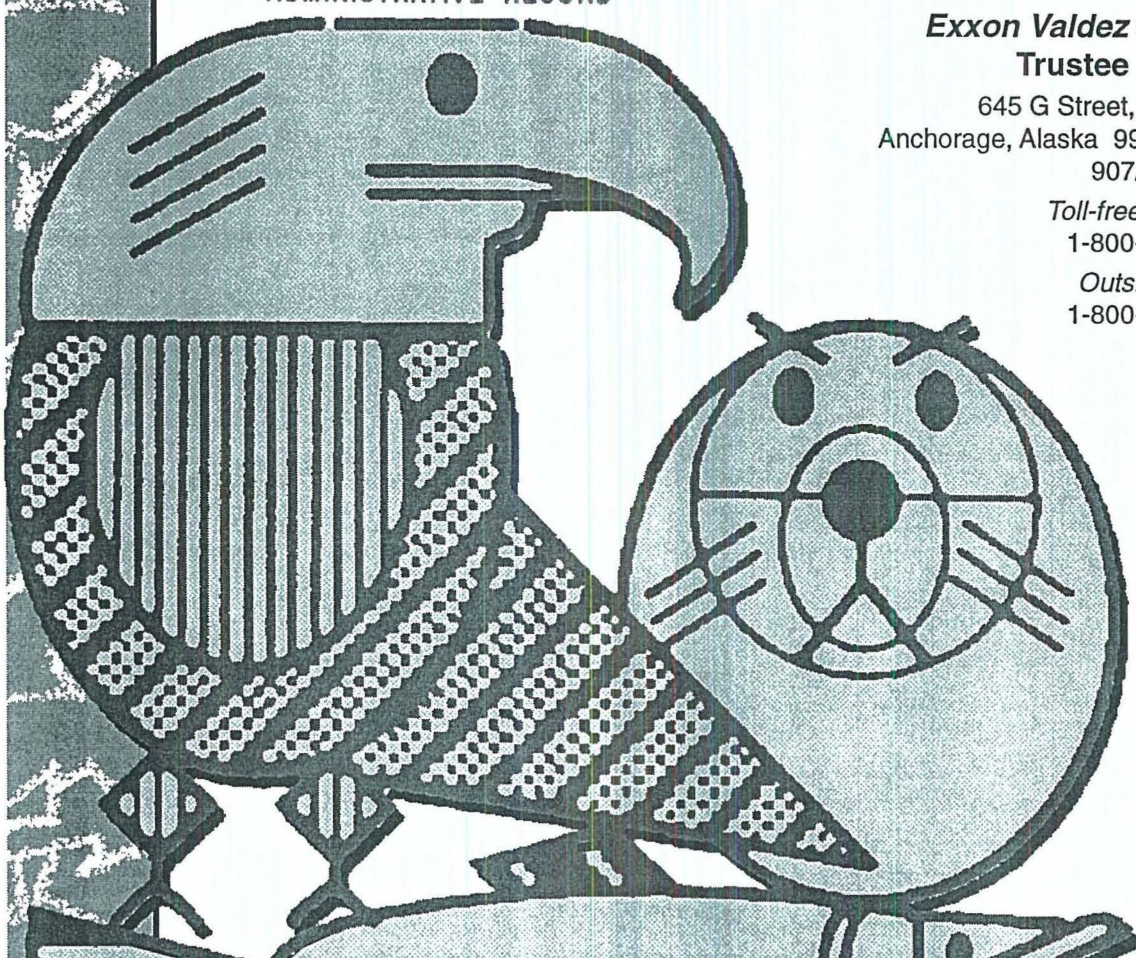

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September 1996

Dear Reader:

The Trustee Council adopted the *Exxon Valdez Oil Spill Restoration Plan* in November 1994 with the intent that the plan would be updated as needed to incorporate new scientific information.

The enclosed documents update two parts of the *Restoration Plan*: the List of Injured Resources and Services in Chapter 4 and the summaries of Injury and Recovery and the Recovery Objectives in Chapter 5.

List of Injured Resources and Services

Chapter 4 of the *Restoration Plan* indicates that the List of Injured Resources and Services (p. 32, Table 2) will be reviewed as new information is obtained. The approved revisions include changes to the recovery status of some resources (for example, moving Bald Eagles from the "recovering" category to "recovered") and additions to the list itself. In August 1995, the Council added Kittlitz's murrelets and common loons to the injured species list. In addition, the Council has now added three species of cormorants (red-faced, pelagic, and double-crested).

Chapter 5: Goals, Objectives & Strategies

Chapter 5 of the *Restoration Plan* (pp. 33-56) discusses general goals and strategies for restoring injured resources and services and also provides specific information on the status, recovery objectives, and restoration strategies for individual resources and services. In the attached document, the Council now provides updated information on the status of injured resources and services, as well as revisions to the Recovery Objectives for injured resources and services. Readers are referred to annual work plans and invitations to submit proposals (e.g., *Invitation to Submit Proposals for Federal Fiscal Year 1997*) for the most current information on the restoration strategies chosen by the Council to achieve its recovery objectives.

Thank you for your interest in restoration following the *Exxon Valdez* oil spill.

Sincerely,

Molly McCammon

Molly McCammon
Executive Director

enclosure

[Note to Readers: This document updates information on Injury and Recovery status and Recovery Objectives in Chapter 5 (pp. 33-56) and the List of Injured Resources and Services (p. 32) in the *Restoration Plan*.]

RESOURCES

ARCHAEOLOGICAL RESOURCES

Injury and Recovery

The oil-spill area is believed to contain more than 3,000 sites of archaeological and historical significance. Twenty-four archaeological sites on public lands are known to have been adversely affected by cleanup activities or looting and vandalism linked to the oil spill. Additional sites on both public and private lands were probably injured, but damage assessment studies were limited to public land and not designed to identify all such sites.

Documented injuries include theft of surface artifacts, masking of subtle clues used to identify and classify sites, violation of ancient burial sites, and destruction of evidence in layered sediments. In addition, vegetation has been disturbed, which has exposed sites to accelerated erosion. The effect of oil on soil chemistry and organic remains may reduce or eliminate the utility of radiocarbon dating in some sites.

Assessments of 14 sites in 1993 suggest that most of the archaeological vandalism that can be linked to the spill occurred early in 1989, before adequate constraints were put into place over the activities of oil spill clean-up personnel. Most vandalism took the form of "prospecting" for high yield sites. Once these problems were recognized, protective measures were implemented that successfully limited additional injury. In 1993, only two of the 14 sites visited showed signs of continued vandalism, but it is difficult to prove that this recent vandalism was related to the spill. Oil was visible in the intertidal zones of two of the 14 sites monitored in 1993, and hydrocarbon analysis has shown that the oil at one of the sites was from the *Exxon Valdez* spill. Hydrocarbon levels at the second site were not sufficient to permit identification of the source or sources of the oil.

Monitoring of archaeological sites in 1994 and 1995 found no evidence of new damage from vandalism. The presence of oil is being determined in sediment samples taken from four sites in 1995.

None of the archaeological artifacts collected during the spill response, damage assessment, or restoration programs is stored within the spill area. These artifacts are stored in the University of Alaska Museum in Fairbanks and in the Federal Building in Juneau. Native communities in the spill area have expressed a strong interest in having them returned to the spill area for storage and display.

The Alutiiq Archaeological Repository in Kodiak, whose construction costs were partly funded by the Trustee Council, is the only physically appropriate artifact storage facility in the spill area. In 1995 the Trustee Council approved funds for development of a comprehensive community plan for restoring archaeological resources in Prince William Sound and lower Cook Inlet, including strategies for storing and displaying artifacts at appropriate facilities within the spill area.

Recovery Objective

Archaeological resources are nonrenewable: they cannot recover in the same sense as biological resources. Archaeological resources will be considered to have recovered when spill-related injury ends, looting and vandalism are at or below prespill levels, and the artifacts and scientific data remaining in vandalized sites are preserved (e.g., through excavation, site stabilization, or other forms of documentation).

BALD EAGLES

Injury and Recovery
The bald eagle is an abundant resident of coast lines throughout the oil-spill area. Following the spill a total of 151 eagle carcasses was recovered from the oil-spill area. Prince William Sound provides year-round and seasonal habitat for about 5,000 bald eagles, and within the Sound it is estimated that about 250 bald eagles died as a result of the spill. There were no estimates of mortality outside the Sound, but there were deaths throughout the oil-spill area.

In addition to direct mortalities, productivity was reduced in oiled areas of Prince William Sound in 1989. Productivity was back to normal in 1990 and 1991, and an aerial survey of adults in 1995 indicated that the population has returned to or exceeded its prespill level in Prince William Sound.

Recovery Objective
Bald eagles will have recovered when their population and productivity have returned to prespill levels. Based on the results of studies in Prince William Sound, this objective has been met.

BLACK OYSTERCATCHERS

Injury and Recovery
Black oystercatchers spend their entire lives in or near intertidal habitats and are highly vulnerable to oil pollution. Currently, it is estimated that 1,500-2,000 oystercatchers breed in south-central Alaska. Only nine carcasses of adult oystercatchers were recovered following the spill, but the actual number of mortalities may have been considerably higher.

In addition to direct mortalities, breeding activities were disrupted by the oil and clean-up activities. In comparison with black oystercatchers on the largely unoiled Montague Island, oystercatchers at heavily oiled Green Island had reduced hatching success in 1989 and their chicks gained weight more slowly during 1991-93. Interpretation of these data on reproductive performance, however, are confounded by lack of prespill data. Productivity and survival of black oystercatchers in Prince William Sound have not been monitored since 1993, and the recovery status of this species is not known.

Recovery Objective
Black oystercatchers will have recovered when the population returns to prespill levels and reproduction is within normal bounds. An increasing population trend and comparable hatching success and growth rates of chicks in oiled and unoiled areas, after taking into account geographic differences, will indicate that recovery is underway.

Clams

Injury and Recovery

The magnitude of impacts on clam populations varies with the species of clam, degree of oiling, and location. However, data from the lower intertidal zone on sheltered beaches suggest that little-neck clams and, to a lesser extent, butter clams were killed and suffered slower growth rates as a result of the oil spill and clean-up activities. In communities on the Kenai Peninsula, Kodiak, and the Alaska Peninsula and in Prince William Sound concern about the effects of the oil spill on clams and subsistence uses of clams remains high (see Subsistence).

Recovery Objective

Clams will have recovered when populations and productivity have returned to levels that would have prevailed in the absence of the oil spill, based on prespill data or comparisons of oiled and unoiled sites.

Common Loons

Injury and Recovery

Carcasses of 395 loons of four species were recovered following the spill, including at least 216 common loons. Current population sizes are not known for any of these species, but, in general, loons are long-lived, slow-reproducing, and have small populations. Common loons in the oil-spill area may number only a few thousand, including only hundreds in Prince William Sound. Common loons injured by the spill probably included a mixture of resident and migrant birds, and their recovery status is not known.

Recovery Objective

No realistic recovery objective can be identified without more information on injury to and the recovery status of common loons.

Common Murres

Injury and Recovery

About 30,000 carcasses of oiled birds were picked up following the oil spill, and 74 percent of them were common and thick-billed murres (mostly common murres). Many more murres probably died than actually were recovered. Based on surveys of index colonies at such locations as Resurrection Bay, the Chiswell, Barren, and Triplet islands, and Puale Bay, the spill-area population may have declined by about 40 percent following the spill. In addition to direct losses of murres, there is evidence that the timing of reproduction was disrupted and productivity reduced. Interpretation of the effects of the spill, however, is complicated by incomplete prespill data and by indications that populations at some colonies were in decline before the oil spill.

Postspill monitoring of productivity at the colonies in the Barren Islands indicates that reproductive timing and success were again within normal bounds by 1993. Numbers of adult murres were last surveyed at those same colonies in 1994. At that time, the local population had not returned to prespill levels.

The Alaska Predator Ecosystem Experiment (APEX project), funded by the Trustee Council, is investigating the linkages among murre populations and changes in the abundance of forage fish, such as Pacific herring, sand lance, and capelin.

Recovery Objective
Common murres will have recovered when populations at index colonies have returned to prespill levels and when productivity is sustained within normal bounds. Increasing population trends at index colonies will be a further indication that recovery is underway.

CORMORANTS

Injury and Recovery
Cormorants are large fish-eating birds that spend much of their time on the water or perched on rocks near the water. Three species typically are found within the oil-spill area.

Carcasses of 838 cormorants were recovered following the oil spill, including 418 pelagic, 161 red-faced, 38 double-crested, and 221 unidentified cormorants. Many more cormorants probably died as a result of the spill, but their carcasses were not found.

No regional population estimates are available for any of the cormorant species found in the oil-spill area. The U.S. Fish and Wildlife Service Alaska Seabird Colony Catalog, however, currently lists counts of 7,161 pelagic cormorants, 8,967 red-faced cormorants, and 1,558 double-crested cormorants in the oil-spill area. These are direct counts at colonies, not overall population estimates, but they suggest that population sizes are small. In this context, it appears that injury to all three cormorant species may have been significant.

Counts on the outer Kenai Peninsula coast suggested that the direct mortality of cormorants due to oil resulted in fewer birds in this area in 1989 compared to 1986. In addition, there were statistically-significant declines in the estimated numbers of cormorants (all three species combined) in Prince William Sound based on pre- and postspill July boat surveys (1972-73 v 1989-91), and there were fewer cormorants in oiled than in unoiled parts of the Sound. More recent surveys (1993-94) did not show an increasing population trend since the oil spill. With support from the Trustee Council, these boat surveys will be repeated in 1996.

Recovery Objective
Pelagic, red-faced, and double-crested cormorants will have recovered when their populations return to prespill levels in the oil-spill area. An increasing population trend in Prince William Sound will indicate that recovery is underway.

CUTTHROAT TROUT

Injury and Recovery
Prince William Sound is at the northwestern limit of the range of cutthroat trout, and few stocks are known to exist within the Sound. Local cutthroat trout populations rarely number more than 1,000 each, and the fish have small home ranges and are geographically isolated. Cutthroat trout, therefore, are highly vulnerable to exploitation, habitat alteration, or pollution.

Following the oil spill, cutthroat trout in a small number of oiled index streams grew more slowly than in unoiled streams, possibly as a result of reduced food supplies or exposure to oil, and there is concern that reduced growth rates may have led to reduced survival. The difference in growth rates persisted through 1991. No studies have been conducted since then, and the recovery status of this species is not known.

Recovery Objective
Cutthroat trout will have recovered when growth rates within oiled areas are similar to those for unoiled areas, after taking into account geographic differences.

DESIGNATED WILDERNESS AREAS

Injury and Recovery
The oil spill delivered oil in varying quantities to the waters adjoining the seven areas designated as wilderness areas and wilderness study areas by Congress. Oil also was deposited above the mean high-tide line at these locations. During the intense clean-up seasons of 1989 and 1990, thousands of workers and hundreds of pieces of equipment were at work in the spill zone. This activity was an unprecedented imposition of people, noise, and activity on the area's undeveloped and normally sparsely occupied landscape. Although activity levels on these wilderness shores have probably returned to normal, at some locations there is still residual oil.

Recovery Objective
Designated wilderness areas will have recovered when oil is no longer encountered in them and the public perceives them to be recovered from the spill.

DOLLY VARDEN

Injury and Recovery
Like the cutthroat trout, there is evidence that Dolly Varden grew more slowly in oiled streams than in unoiled streams, and there is concern that reduced growth rates may have led to reduced survival. However, no data have been gathered since 1991. The recovery status of this species is not known.

Recovery Objective
Dolly Varden will have recovered when growth rates within oiled streams are comparable to those in unoiled streams, after taking into account geographic differences.

HARBOR SEALS

Injury and Recovery
Harbor seal numbers were declining in the Gulf of Alaska, including in Prince William Sound, before the oil spill. *Exxon Valdez* oil affected harbor seal habitats, including key haul-out areas and adjacent waters, in Prince William Sound and as far away as Tugidak Island, near Kodiak. Estimated mortality as a direct result of the oil spill was about 300 seals in oiled parts of Prince William Sound. Based on surveys conducted before (1988) and after (1989) the oil spill, seals in oiled areas had declined by 43 percent, compared to 11 percent in unoiled areas.

In a declining population deaths exceed births, and harbor seals in both oiled and unoiled parts of Prince William Sound have continued to decline since the spill. For the period 1989-1994, the average estimated annual rate of decline was about 6 percent. Changes in the amount or quality of food may have been an initial cause of this long-term decline. Although there is no evidence that such factors as predation by killer whales, subsistence hunting, and interactions with commerical fisheries caused the decline in the harbor seal population, these are among the on-going sources of mortality.

Harbor seals have long been a key subsistence resource in the oil-spill area. Subsistence hunting is affected by the declining seal population, and lack of opportunities to hunt seals has changed the diets of subsistence users who traditionally had relied heavily on these marine mammals.

Recovery Objective
Harbor seals will have recovered from the effects of the oil spill when their population is stable or increasing.

HARLEQUIN DUCKS

Injury and Recovery
Harlequin ducks feed in intertidal and shallow subtidal habitats where most of the spilled oil was initially stranded. More than 200 harlequin ducks were found dead in 1989, mostly in Prince William Sound. Many more than that number probably died throughout the spill area. Since the oil spill occurred in early spring, before wintering harlequins had left the oil-spill area, the impacts of the oil spill may have extended beyond the immediate spill area. The geographic extent of these impacts is not known.

Bile samples from harlequin ducks (combined with samples from Barrow's and common goldeneye) collected in eastern and western Prince William Sound and in the western Kodiak Archipelago in 1989-90 had higher concentrations of hydrocarbon metabolites than a small number of samples from harlequins and goldeneye collected at Juneau. Prespill data on harlequin populations and productivity are poor and complicated by possible geographic differences in habitat quality. However, the summer population in Prince William Sound is small, only a few thousand birds. There continues to be concern about poor reproduction and a possible decline in numbers of molting birds in western versus eastern parts of the Sound.

Recovery Objective

Harlequin ducks will have recovered when breeding and postbreeding season densities and production of young return to prespill levels. A normal population age- and sex-structure and reproductive success, taking into account geographic differences, will indicate that recovery is underway.

INTERTIDAL COMMUNITIES

Injury and Recovery

Portions of 1,500 miles of coastline were oiled by the spill in Prince William Sound, on the Kenai and Alaska peninsulas, and in the Kodiak Archipelago. Both the oil and intensive clean-up activities had significant impacts on the flora and fauna of the intertidal zone, the area of beach between low and high tides. Intertidal resources are important to subsistence users, sea and river otters, and to a variety of birds, including black oystercatchers, harlequin ducks, surf scoters, and pigeon guillemots.

Impacts to intertidal organisms occurred at all tidal levels in all types of habitats throughout the oil-spill area. Many species of algae and invertebrates were less abundant at oiled sites compared to unoiled reference sites. Other opportunistic species, including a small species of barnacle, oligochaete worms, and filamentous brown algae, colonized shores where dominant species were removed by the oil spill and clean-up activities. The abundance and reproductive potential of the common seaweed, *Fucus gardneri* (known as rockweed or popweed), was also reduced following the spill.

On the sheltered, bedrock shores that are common in Prince William Sound, full recovery of *Fucus* is crucial for the recovery of intertidal communities at these sites, since many invertebrate organisms depend on the cover provided by this seaweed. *Fucus* has not yet fully recovered in the upper intertidal zone on shores subjected to direct sunlight, but in many locations, recovery of intertidal communities has made substantial progress. In other habitat types, such as estuaries and cobble beaches, many species did not show signs of recovery when they were last surveyed in 1991.

Recovery Objective

Intertidal communities will have recovered when community composition on oiled shorelines is similar to that which would have prevailed in the absence of the spill. Indications of recovery are the reestablishment of important species, such as *Fucus* at sheltered rocky sites, the convergence in community composition on oiled and unoiled shorelines, and the provision of adequate, uncontaminated food supplies for top predators in intertidal and nearshore habitats.

KILLER WHALES

Injury and Recovery

More than 80 killer whales in six "resident" pods regularly use Prince William Sound within their ranges. Other whales in "transient" groups are observed in the Sound less frequently. There has been particular concern in Prince William Sound about the resident AB pod, which numbered 36 animals prior to the spill. Fourteen whales disappeared from this pod in 1989 and 1990, during which time no young were recruited into the population. Although four calves were added to the AB pod during 1992-94, surveys in 1994 and 1995 indicate the loss of five more adult whales. The link between these losses and the oil spill is only circumstantial, but the likely mortality of killer whales in the AB pod in Prince William Sound following the spill far exceeds rates observed for other pods in British Columbia and Puget Sound over the last 20 years. In addition to the effects of the oil spill, there has been concern about the possible shooting of killer whales, perhaps due to conflicts with long-line fisheries.

The AB pod may never regain its former size, but overall numbers within the major resident killer whale pods in Prince William Sound are at or exceed prespill levels. There is concern, however, that a decline in resightings of individuals within the AT group of transient killer whales has accelerated following the oil spill.

Recovery Objective

Killer whales in the AB pod will have recovered when the number of individuals in the pod is stable or increasing relative to the trends of other major resident pods in Prince William Sound.

KITTLITZ'S MURRELETS

Injury and Recovery

The Kittlitz's murrelet is found only in Alaska and portions of the Russian Far East, and a large fraction of the world population, which may number only a few tens of thousands, breeds in Prince William Sound. The Kenai Peninsula coast and Kachemak Bay are also important concentration areas for this species. Very little is known about Kittlitz's murrelets. However, they associate closely with tidewater glaciers and nest on scree slopes and similar sites on the ground.

Seventy-two Kittlitz's murrelets were positively identified among the bird carcasses recovered after the oil spill. Nearly 450 more *Brachyramphus* murrelets were not identified to the species level, and it is reasonable to assume that some of these were Kittlitz's. In addition, many more murrelets probably were killed by the oil than were actually recovered. One published estimate places direct mortality of Kittlitz's murrelets from the oil spill at 1,000-2,000 individuals, which would represent a substantial fraction of the world population.

Because of the highly patchy distribution of Kittlitz's murrelet, the difficulty of identifying them in the field, and the fact that so little is known about this species, the recovery status of the Kittlitz's murrelet is not known. The Trustee Council has funded an exploratory study on the ecology and distribution of this murrelet starting in 1996.

Recovery Objective
No recovery objective can be identified for Kittlitz's murrelet at this time.

MARBLED MURRELETS

Injury and Recovery
The northern Gulf of Alaska, including Prince William Sound, is a key area of concentration in the distribution of marbled murrelets. The marbled murrelet is federally listed as a threatened species in Washington, Oregon, and California; it is also listed as threatened in British Columbia.

The marbled murrelet population in Prince William Sound had declined before the oil spill. The causes of the prespill decline are unknown, but may be related to changing food supplies. It is not known whether the murrelet population was still declining at the time of the oil spill, but the spill caused additional losses of murrelets. Carcasses of nearly 1,100 *Brachyramphus* murrelets were found after the spill, and about 90 percent of the murrelets that could be identified to the species level were marbled murrelets. Many more murrelets probably were killed by the oil than were found, and it is estimated that as much as 7 percent of the marbled murrelet population in the oil-spill area was killed by the spill.

Population estimates for murrelets are highly variable. Postspill boat surveys do not yet indicate any statistically significant increase in numbers of marbled murrelets in Prince William Sound, nor is there evidence of any further decline.

Recovery Objective
Marbled murrelets will have recovered when its population is stable or increasing. Stable or increasing productivity will be an indication that recovery is underway.

MUSSELS

Injury and Recovery
Mussels are an important prey species in the nearshore ecosystem throughout the oil-spill area, and beds of mussels provide physical stability and habitat for other organisms in the intertidal zone. For these reasons, mussel beds were purposely left alone during *Exxon Valdez* clean-up operations.

In 1991, high concentrations of relatively unweathered oil were found in the mussels and underlying byssal mats and sediments in certain dense mussel beds. The biological significance of oiled mussel beds is not known, but they are potential pathways of oil contamination for local populations of harlequin ducks, black oystercatchers, river otters, and juvenile sea otters, all of which feed to some extent on mussels and show some signs of continuing injury.

About 30 mussel beds in Prince William Sound are known still to have oil residue, and 12 of them were cleaned on an experimental basis in 1994. By August 1995, these beds showed a 98 percent reduction in oil in the replacement sediments, compared to what had been there before. Mussel beds along the outer Kenai Peninsula coast, the Alaska Peninsula, and Kodiak

Archipelago were surveyed for the presence of oil in 1992, 1993, and 1995. Hydrocarbon concentrations in mussels and sediments at these Gulf of Alaska sites is generally lower than for sites in the Sound, but at some sites substantial concentrations persist.

Subsistence users continue to be concerned about contamination from oiled mussel beds. The Nearshore Vertebrate Predator project is focusing on mussels as a key prey species and component of the nearshore ecosystem.

Recovery Objective
Mussels will have recovered when concentrations of oil in the mussels and in the sediments below mussel beds reach background levels, do not contaminate their predators, and do not affect subsistence uses.

Pacific Herring

Injury and Recovery
Pacific herring spawned in intertidal and subtidal habitats in Prince William Sound shortly after the oil spill. A significant portion of these spawning habitats as well as herring staging areas in the Sound were contaminated by oil. Field studies conducted in 1989 and 1990 documented increased rates of egg mortality and larval deformities in oiled versus unoiled areas. Subsequent laboratory studies confirm that these effects can be caused by exposure to *Exxon Valdez* oil, but the significance of these injuries at a population level is not known.

The 1988 prespill year-class of Pacific herring was very strong in Prince William Sound, and, as a result, the estimated peak biomass of spawning adults in 1992 was at a record level. In 1993, however, there was an unprecedented crash of the adult herring population. A viral disease and fungus were the probable agents of mortality, and the connection between the oil spill and the disease outbreak is under investigation. Numbers of spawning herring in Prince William Sound remained depressed through the 1995 season. Preliminary results from the Sound Ecosystem Assessment (SEA) Project indicate the possible significance of walleye pollock as both competitors with and predators on herring, which may indicate that there is a connection between the lack of recruitment of strong year classes of herring and the presence of large numbers of pollock in Prince William Sound.

Pacific herring are extremely important ecologically and commercially and for subsistence users. Reduced herring populations could have significant implications for both their predators and their prey, and the closure of the herring fishery from 1993 through 1996 has had serious economic impact on people and communities in Prince William Sound.

Recovery Objective
Pacific herring will have recovered when the next highly successful year class is recruited into the fishery and when other indicators of population health are sustained within normal bounds in Prince William Sound.

Pigeon Guillemots

Injury and Recovery
Although the pigeon guillemot is widely distributed in the north Pacific region, nowhere does it occur in large numbers or concentrations. Because guillemots feed in shallow, nearshore waters, the guillemots and the fish on which they prey are vulnerable to oil pollution.

Like the marbled murrelet, there is evidence that the pigeon guillemot population in Prince William Sound had declined before the spill. The causes of the prespill decline are unknown. It is estimated that 10-15 percent of the spill-area population may have died following the spill. Guillemot nesting on the Naked Islands was well-studied in 1978-81. Postspill surveys using the same methods indicated a decline of about 40 percent in guillemots in the Naked Islands. Based on boat surveys, the overall guillemot population in the Sound declined as well.

Numbers of guillemots recorded on boat surveys are highly variable, and there is not yet any statistically significant evidence of a postspill population increase. The factors responsible for the guillemot's prespill decline may negate or mask recovery from the effects of the oil spill.

The Alaska Predator Ecosystem Experiment (APEX) project is investigating the possible link between pigeon guillemot declines to the availability and abundance of forage fish, such as Pacific herring, sand lance, and capelin. The Nearshore Vertebrate Predator (NVP) project also addresses the possibility that exposure to oil continues to limit the guillemot's recovery. Both projects are supported by the Trustee Council.

Recovery Objective
Pigeon guillemots will have recovered when their population is stable or increasing. Sustained productivity within normal bounds will be an indication that recovery is underway.

Pink Salmon

Injury and Recovery
About 75 percent of wild pink salmon in Prince William Sound spawn in the intertidal portions of streams and were highly vulnerable to the effects of the oil spill. Hatchery salmon and wild salmon from both intertidal and upstream spawning habitats swam through oiled waters and ingested oil particles and oiled prey as they foraged in the Sound and emigrated to the sea. As a result, three types of early life-stage injuries were identified: First, growth rates in juvenile pink salmon from oiled parts of Prince William Sound were reduced. Second, there was increased egg mortality in oiled versus unoiled streams. A possible third effect, genetic damage, is under investigation.

In the years preceding the spill, returns of wild pink salmon in Prince William Sound varied from a maximum of 21.0 million fish in 1984 to a minimum of 1.8 million in 1988. Since the spill, returns of wild pinks have varied from a high of about 14.4 million fish in 1990 to a low of about 2.2 million in 1992. There is a particular concern about the Sound's southwest management district, where returns of both hatchery and wild stocks have been generally weak since the oil spill. Because of the tremendous natural variation in adult returns, however, it is difficult to attribute poor returns in a given year to injuries caused by *Exxon Valdez* oil. For pink salmon, mortalities of eggs and juveniles remain the best indicators of injury and recovery.

Evidence of reduced juvenile growth rates was limited to the 1989 season, but increased egg mortality persisted in oiled compared to unoiled streams through 1993. The 1994 and 1995 seasons were the first since 1989 in which there were no statistically significant differences in egg mortalities in oiled and unoiled streams. These data indicate that recovery from oil-spill effects is underway.

The Sound Ecosystem Assessment (SEA) Project is exploring oceanographic and ecological factors that influence production of pink salmon and Pacific herring. These natural factors are likely to have the greatest influence over year-to-year returns in both wild and hatchery stocks of pink salmon.

Recovery Objective
Pink salmon will have recovered when population indicators, such as growth and survival, are within normal bounds and there are no statistically significant differences in egg mortalities in oiled and unoiled streams for two years each of odd- and even-year runs in Prince William Sound.

RIVER OTTERS

Injury and Recovery
River otters have a low population density and an unknown population size in Prince William Sound, and, therefore, it is hard to assess oil-spill effects. Twelve river otter carcasses were found following the spill, but the actual mortality is not known. Studies conducted during 1989-91 identified several differences between river otters in oiled and unoiled areas in Prince William Sound, including biochemical evidence of exposure to hydrocarbons or other sources of stress, reduced diversity in prey species, reduced body size (length-weight), and increased territory size. Since there were no prespill data and sample sizes were small, it is not clear that these differences are the result of the oil spill.

The Nearshore Vertebrate Predator project, now underway, will shed new light on the status of the river otter. In 1995 the Alaska Board of Game used its emergency authority to restrict trapping of river otters in western Prince William Sound to ensure that the results of this study are not compromised by the removal of animals from study areas on Jackpot and Knight islands.

Recovery Objective
The river otter will have recovered when biochemical indices of hydrocarbon exposure or other stresses and indices of habitat use are similar between oiled and unoiled areas of Prince William Sound, after taking into account any geographic differences.

ROCKFISH

Injury and Recovery
Very little is known about rockfish populations in the northern Gulf of Alaska. A small number of dead adult rockfish was recovered following the oil spill, and autopsies of five specimens indicated that oil ingestion was the cause of death. Analysis of other rockfish showed exposure to hydrocarbons and probable sublethal effects. In addition, closures to salmon fisheries apparently increased fishing pressures on rockfish, which may have adversely affected the rockfish population. However, the original extent of injury and the current recovery status of this species are unknown.

Recovery Objective
No recovery objective can be identified.

SEA OTTERS

Injury and Recovery
By the late 1800s, sea otters had been eliminated from most of their historical range in Alaska due to excessive fur harvesting by Russian and American fleets. Surveys of sea otters in the 1970s and 1980s, however, indicated a healthy and expanding population, including in Prince William Sound, prior to the oil spill. Sea otters are today an important subsistence resource for their furs.

About 1,000 sea otter carcasses were recovered following the spill, although additional animals probably died but were not recovered. In 1990 and 1991, higher-than-expected proportions of prime-age adult sea otters were found dead in western Prince William Sound, and there was evidence of higher mortality of recently weaned juveniles in oiled areas. By 1992-93, overwintering mortality rates for juveniles had decreased, but were still higher in oiled than in unoiled parts of the Sound.

Based on boat surveys conducted in Prince William Sound, there is not yet statistically significant evidence of an overall population increase following the oil spill (1990-94). This lack of a significant positive trend, however, may result from low statistical power in the survey, which will be repeated in 1996.

Based on observations by local residents, it is evident that the sea otter is abundant in much of Prince William Sound. There is no evidence that recovery has occurred, however, in heavily oiled parts of western Prince William Sound, such as around northern Knight Island. The Nearshore Vertebrate Predator project, which was started in 1995, should help clarify the recovery status of the sea otter in the western Sound.

Recovery Objective

Sea otters will have recovered when the population in oiled areas returns to its prespill abundance and distribution. An increasing population trend and normal reproduction and age structure in western Prince William Sound will indicate that recovery is underway.

SEDIMENTS

Injury and Recovery

Exxon Valdez oil penetrated deeply into cobble and boulder beaches that are common on shorelines throughout the spill area, especially in sheltered habitats. Cleaning and natural degradation removed much of the oil from the intertidal zone, but visually identifiable surface and subsurface oil persists at many locations.

The last comprehensive survey of shorelines in Prince William Sound, conducted in 1993, included 45 areas of shoreline known to have had the most significant oiling. Based on that survey, it was estimated that heavy subsurface oil had decreased by 65 percent since 1991 and that surface oil had decreased by 50 percent over the same time period. Surveys also have indicated that remaining shoreline oil in the Sound is relatively stable and, by this time, is likely to decrease only slowly. Oil also persists under armored rock settings on the Kenai and Alaska peninsulas, and this oil has undergone little chemical change since 1989.

In 1995, a shoreline survey team visited 30 sites in the Kodiak Archipelago that had measurable or reported oiling in 1990 and 1991. The survey team found no oil or only trace amounts at these sites. The oiling in the Kodiak area is not persisting as it is at sites in Prince William Sound due to the higher energy settings in the Kodiak area, the state of the oil when it came ashore, and the smaller concentrations of initial oiling relative to the Sound.

Following the oil spill, chemical analyses of oil in subtidal sediments were conducted at a small number of index sites in Prince William Sound. At these sites, oil in subtidal sediments reached its greatest concentrations at water depths of 20 meters below mean low tide, although elevated levels of hydrocarbon-degrading bacteria (associated with elevated hydrocarbons) were detected at depths of 40 and 100 meters in 1990 in Prince William Sound. By 1993, however, there was little evidence of *Exxon Valdez* oil and related microbial activity at most index sites in Prince William Sound, except at those associated with sheltered beaches that were heavily oiled in 1989. These index sites--at Herring, Northwest, and Sleepy bays--are among the few sites at which subtidal oiling is still known to occur.

Recovery Objective

Sediments will have recovered when there are no longer residues of *Exxon Valdez* oil on shorelines (both tidal and subtidal) in the oil-spill area. Declining oil residues and diminishing toxicity are indications that recovery is underway.

SOCKEYE SALMON

Injury and Recovery

Commercial salmon fishing was closed in Prince William Sound and in portions of Cook Inlet and near Kodiak in 1989 to avoid any possibility of contaminated salmon being sent to market. As a result, there were higher-than-desirable numbers (i.e., overescapement) of spawning sockeye salmon entering the Kenai River, Red and Akalura lakes on Kodiak Island, and other lakes on Afognak Island and the Alaska Peninsula. Initially these high escapements may have produced an overabundance of juvenile sockeye that overgrazed the zooplankton, thus altering planktonic food webs in the nursery lakes. Although the exact mechanism is unclear, the result was lost sockeye production as shown by declines in the returns of adults per spawning sockeye.

The effects of the 1989 overescapement of sockeye salmon have persisted in the Kenai River system through 1995. Although the overall escapement goal for that system was met in 1995, there is concern that the initial overescapement will continue to affect post-spill year-classes.

Production of zooplankton in both Red and Akalura lakes on Kodiak Island has rebounded from the effects of the overescapement at the time of the oil spill. There continues to be some problem in the rate of production of sockeye fry in Red and Akalura lakes. This problem may or may not be linked to the overescapement, and possible additional factors include low egg-to-fry survival, competition from other freshwater fishes, and the interception of adults in the mixed-stock fishery harvest offshore.

Recovery Objective

Sockeye salmon in the Kenai River system and Red and Akalura lakes will have recovered when adult returns-per-spawner are within normal bounds.

SUBTIDAL COMMUNITIES

Injury and Recovery

Oil that was transported down to subtidal habitats apparently caused changes in the abundance and species composition of plant and animal populations below lower tides. Different habitats, including eelgrass beds, kelp beds, and adjacent nearshore waters (depths less than 20 meters), were compared at oiled and unoiled sites. Biologically, the greatest differences were detected at oiled sites with sandy sea bottoms in the vicinity of eelgrass beds, at which there were reduced abundances of eelgrass shoots and flowers and helmet crabs. The abundance and diversity of worms, clams, snails, and oil-sensitive amphipods (sand fleas) also were reduced. Organisms living in sediment at depths of 3-20 meters were especially affected. Some opportunistic (i.e., stress-tolerant) invertebrates within the substrate, mussels and worms on the eelgrass, and juvenile cod, were greater in numbers at oiled sites.

By 1993, oil concentrations in sediments had dropped considerably, so that there was little difference between oiled and unoiled sites. The eelgrass habitat, the only habitat examined in 1993, revealed fewer differences in abundances of plants and animals. As was true in 1990, however, some opportunistic species still were more abundant at oiled sites. These included the opportunistic worms and snails, mussels and worms on the eelgrass, and juvenile cod.

Preliminary results from eelgrass habitats visited in 1995 revealed that natural recovery had occurred. No difference was detected in abundance of eelgrass shoots and flowers, mussels on eelgrass, amphipods, helmet crabs, and dominant sea stars between oiled and unoiled sites. The abundance of small green sea urchins, however, was more than 10 times greater at oiled sites. The possibility that urchins increased due to a reduction in numbers of sea otters, which prey on urchins, is being examined in the Nearshore Vertebrate Predator Project. Analyses of the recent oil concentrations in sediments and organisms that live within the substrate are not yet complete.

Recovery Objective

Subtidal communities will have recovered when community composition in oiled areas, especially in association with eelgrass beds, is similar to that in unoiled areas. Indications of recovery are the return of oil-sensitive species, such as amphipods, and the reduction of opportunistic species at oiled sites.

SERVICES

COMMERCIAL FISHING

Injury and Recovery

Commercial fishing is a service that was reduced through injury to commercial fish species (see individual resources) and also through fishing closures. In 1989, closures affected fisheries in Prince William Sound, lower Cook Inlet, upper Cook Inlet, the outer Kenai coast, Kodiak, and Chignik. Most of these fisheries opened again in 1990. Since then, there have been no spill-related district-wide closures, except for the Prince William Sound herring fishery, which was closed in 1993 and has remained closed since then due to the collapse of the herring population and poor fishery recruitment since 1989. These closures, including the on-going closure of the herring fishery in Prince William Sound, harmed the livelihoods of persons who fish for a living and the communities in which they live. To the extent that the oil spill continues to be a factor that reduces opportunities to catch fish, there is on-going injury to commercial fishing as a service.

On this basis, the Trustee Council continues to make major investments in projects to understand and restore commercially important fish species that were injured by the oil spill. These projects include: supplementation work, such as fertilizing Coghill Lake to enhance its sockeye salmon run and construction of a barrier bypass at Little Waterfall Creek; development of tools that have almost immediate benefit for fisheries management, such as otolith mass marking of pink salmon in Prince William Sound and in-season genetic stock identification for sockeye salmon in Cook Inlet; and research such as the SEA Project and genetic mapping which will enhance the ability to predict and manage fisheries over the long-term.

Recovery Objective

Commercial fishing will have recovered when the commercially important fish species have recovered and opportunities to catch these species are not lost or reduced because of the effects of the oil spill.

Passive Use

Injury and Recovery
Passive use of resources includes the appreciation of the aesthetic and intrinsic values of undisturbed areas, the value derived from simply knowing that a resource exists, and other nonuse values. Injuries to passive uses are tied to public perceptions of injured resources. Contingent valuation studies conducted by the State of Alaska for the *Exxon Valdez* oil spill litigation measured substantial losses of passive use values resulting from the oil spill.

Recovery Objective
Passive uses will have recovered when people perceive that aesthetic and intrinsic values associated with the spill area are no longer diminished by the oil spill.

Recreation and Tourism

Injury and Recovery
The spill disrupted use of the spill area for recreation and tourism. Resources important for wildlife viewing and which still are injured by the spill include killer whale, sea otter, harbor seal, and various seabirds. Residual oil exists on some beaches with high value for recreation, and its presence may decrease the quality of recreational experiences and discourage recreational use of these beaches.

Closures of sport hunting and fishing also affected use of the spill area for recreation and tourism. Sport fishing resources include salmon, rockfish, Dolly Varden, and cutthroat trout. Since 1992, the Alaska Board of Fisheries has imposed special restrictions on sport fishing in parts of Prince William Sound to protect cutthroat trout populations. Harlequin ducks are hunted in the spill area. The Alaska Board of Game restricted sport harvest of harlequin ducks in Prince William Sound in 1991, and those restrictions remain in place.

Recreation was also affected by changes in human use in response to the spill. For example, displacement of use from oiled areas to unoiled areas increased management problems and facility use in unoiled areas. Some facilities, such as the Green Island cabin and the Fleming Spit camp area, were injured by clean-up workers.

In the years since the oil spill, there has been a general, marked increase in visitation to the spill area. However, there are still locations within the oil-spill area which are avoided by recreational users because of the presence of residual oil.

Recovery Objective
Recreation and tourism will have recovered, in large part, when the fish and wildlife resources on which they depend have recovered, recreation use of oiled beaches is no longer impaired, and facilities and management capabilities can accommodate changes in human use.

SUBSISTENCE

Injury and Recovery

Fifteen predominantly Alaskan Native communities (numbering about 2,200 people) in the oil-spill area rely heavily on harvests of subsistence resources, such as fish, shellfish, seals, deer, ducks, and geese. Many families in other communities, both in and beyond the oil-spill area, also rely on the subsistence resources of the spill area.

Subsistence harvests of fish and wildlife in most of these villages declined substantially following the oil spill. The reasons for the declines include reduced availability of fish and wildlife to harvest, concern about possible health effects of eating contaminated or injured fish and wildlife, and disruption of lifestyles due to clean-up and other activities.

Subsistence foods were tested for evidence of hydrocarbon contamination from 1989-94. No or very low concentrations of petroleum hydrocarbons were found in most subsistence foods. The U.S. Food and Drug Administration determined that eating foods with such low levels of hydrocarbons posed no significant additional risk to human health. Because shellfish can continue to accumulate hydrocarbons, however, the Oil Spill Health Task Force advised subsistence users not to eat shellfish from beaches where oil can be seen or smelled on the surface or subsurface. Residual oil exists on some beaches near subsistence communities. In general, subsistence users remain concerned and uncertain about the safety of fish and other wildlife resources.

The estimated size of the subsistence harvest in pounds per person now appears to have returned to prespill levels in some communities, according to subsistence users through household interviews conducted by the Alaska Department of Fish and Game. These interviews also indicated that the total subsistence harvest began to rebound first in the communities of the Alaska Peninsula, Kodiak Island, and the lower Kenai Peninsula, but that the harvest has lagged behind a year or more in the Prince William Sound villages. The interviews also showed that the relative contributions of certain important subsistence resources remains unusually low. The scarcity of seals, for example, has caused people in Chenega Bay to harvest fewer seals and more salmon than has been customary. Herring have been very scarce throughout Prince William Sound since 1993. Different types of resources have varied cultural and nutritional importance, and the changes in diet composition remain a serious concern to subsistence users. Subsistence users also report that they have to travel farther and expend more time and effort to harvest the same amount as they did before the spill, especially in Prince William Sound.

Subsistence users also point out that the value of subsistence cannot be measured in pounds alone. This conventional measure does not include the cultural value of traditional and customary use of natural resources. Subsistence users say that maintaining their subsistence culture depends on uninterrupted use of fish and wildlife resources. The more time users spend away from subsistence activities, the less likely that they will return to these practices. Continuing injury to natural resources used for subsistence may affect ways of life of entire communities. There is particular concern that the oil spill disrupted opportunities for young people to learn subsistence culture, and that this knowledge may be lost to them in the future.

Recovery Objective

Subsistence will have recovered when injured resources used for subsistence are healthy and productive and exist at prespill levels. In addition, there is recognition that people must be confident that the resources are safe to eat and that the cultural values provided by gathering, preparing, and sharing food need to be reintegrated into community life.

[*Note: This table is modified from p. 32 of the* Restoration Plan.]

Table 2. Resources and Services Injured by the Spill

INJURED RESOURCES				LOST or REDUCED SERVICES
Recovered Bald eagle	**Recovering** Archaeological resources* Common murres Intertidal communities** Mussels Pink salmon Sediments Sockeye salmon Subtidal communities ---------------------- *Archaeological resources are not renewable in the same way that biological resources are, but there has been significant progress toward the recovery objective. **Status of intertidal communities based largely on monitoring in sheltered rocky habitats in Prince William Sound; status of other intertidal habitats is less certain or unknown, though some recovery can be anticipated.	**Not Recovered** Cormorants (3 species) Harbor seal Harlequin duck Killer whale (AB pod) Marbled murrelet Pacific herring Pigeon guillemot Sea otter (in oiled west. PWS)	**Recovery Unknown** Black oystercatcher Clams Common loon Cutthroat trout Designated Wilderness areas Dolly Varden Kittlitz's murrelet River otter Rockfish	Commercial fishing Passive uses Recreation and Tourism including sport fishing, sport hunting, and other recreation uses Subsistence

Amending the List of Injured Resources and Services. The list of injured resources and services will be reviewed as new information is obtained through research, monitoring, and other studies sponsored by the Trustee Council. In addition, information may be submitted to add to or otherwise change this list. This information can include research results, assessment of population trends, ethnographic and historical data, and supportive rationale. Information that has been through an appropriate scientific review process is preferable. If data have not been peer reviewed, they should be presented in a format that permits and facilitates peer review. Information to change the list will be reviewed through the Trustee Council's scientific review process.