Arctic Review on Law and Politics, vol. 5, 1/2014 pp. 38–74. ISSN 1891-6252

Oil Spill in Northern Waters: Trial Outcomes and the Long-Term in Case of the *Exxon Valdez*

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Received November 2012, Accepted June 2013

Abstract: This paper examines the natural resource damages litigation that arose from the 1989 *Exxon Valdez* oil spill. The authors compare the outcomes of the federal trial with some evidence, now more than 20 years later, on the long-term impacts of the spill on marine resources and the use of these resources by coastal communities. Because commercial fishermen and Alaska natives were the two main plaintiff groups, this case provides an interesting side-by-side comparison of a market and a nonmarket sector that both utilize the same raw resource base – the fisheries of Prince William Sound and the Gulf of Alaska. The analysis here examines the valuation methodologies from the standpoint of economic theory, regulatory guidelines, the court's numerous decisions concerning what was admissible into evidence, and the respective outcomes – a jury decision and a settlement just prior to trial. The case may have some relevance for other cir-

cumpolar arctic or subarctic regions, such as the North Sea and Arctic Alaska, where expanding oil extraction and development could potentially impact viable commercial fisheries and coastal communities.

Key words: nonmarket valuation, natural resource damage assessment, subsistence, economic values, oil spill.

1. Introduction

On March 24, 1989, the tanker vessel *Exxon Valdez* went aground on Bligh Reef in Prince William Sound, Alaska, and subsequently spilled 11 million gallons of oil into the marine environment. The Exxon oil spill litigation may well be the major environmental case of the 20th century. The September 1994 jury award of $ 5 billion in punitive damages was the largest ever in a pollution case, and the second largest in a civil case in the United States. The defendants appealed the punitive damages which, in a series of rulings at the Court of Appeals and the U.S. Supreme Court were eventually reduced to $ 507.5 million in 2009. Additionally Exxon paid $ 470 million in interest. In phase two of the trial, the jury also awarded substantial compensatory damages of $ 286.8 million to commercial fishermen. The other major plaintiff, the Alaska natives, settled for $ 20 million just prior to going to trial. This paper provides a comparison of the trial outcomes with some evidence, now more than 20 years later, on the long-term impacts of the spill on the natural resources of Prince William Sound and the use of these resources by coastal communities.

This case is of continuing interest for several reasons. For one, the impacts of this oil spill were not only felt on market goods and services, including the commercial fishery, but also impacted subsistence use by Alaska natives. This later nonmarket use is more challenging to value in the context of a natural resource damage assessment. The *Exxon Valdez* case is instructive for the asymmetric treatment of commercial fishers versus subsistence users, which are actually quite parallel market and nonmarket harvests, respectively, of many of the same resources. This paper describes the methods for valuing subsistence use in the context of the case, and in a final section of the paper, provides an update to this work. Secondly, and perhaps most obviously, there continue to be significant oil spills, most recently the British Petroleum oil spill in the Gulf of Mexico which began in April 2010 with the explosion of the *Deepwater Horizon* drilling platform in the Gulf of Mexico. As in the case of the *Exxon Valdez*, the courts will be in a position of needing to reach a judgment on the appropriate compensation for damages, potentially long before the actual injury to the resources and human services in question have run their course.

The *Exxon Valdez* spill, which happened now more than 20 years ago, provides an important data point on the long-term impacts of a spill. Fortunately there has been some continued monitoring of the spill impacts by the *Exxon Valdez* Oil Spill Trustee Council (EVOS) and also some continued subsistence harvest surveys by the Division of Subsistence, Alaska Fish and Game. These findings are contrasted with the much shorter term extrapolation of subsistence damages (three years) allowed by the Court in the *Exxon Valdez* federal trial.

Finally, the *Exxon Valdez* case may also have some relevance for other vulnerable marine environments in the circumpolar arctic and sub-arctic that are at risk for tanker-related oil spills and other impacts of expanded industrialization. The Arctic is experiencing the effects of climate change faster than other parts of the planet, and scientists now predict that the Arctic could be ice-free during summer within 30 years.[1] This expansion of the feasible frontier for oil production and the declining return from existing fields has led to pressure for expansion of oil development into the Arctic. In North America, Shell Oil obtained regulatory authorization for the first oil exploration in Arctic Alaska in decades, and completed top-hole drilling on two wells in the Beaufort and Chukchi Seas. However, problems developed with the drilling vessels and one of these grounded in a pristine area off Kodiak Island after multiple towline failures in near-hurricane conditions.[2] Shell Oil has canceled offshore Alaska drilling for 2013, as has ConocoPhillips for that company's 2014 Arctic drilling plans.[3] ConocoPhillips cites the uncertainties of evolving federal regulatory requirements. However, these developments highlight the challenges of oil development in such an extreme environment. In Norway, the current prime minister supports initiating a study to assess the impacts of proposed oil drilling off the *Lofoten Islands*.[4] While it has been estimated that this area of the Norwegian Shelf may contain as much as two billion barrels of oil, it is also home to the world's largest cod fishery and a long-standing commercial

1. *Ocean Conservancy*, The Arctic: Overview. 2013. Retrieved from http://www.oceanconservancy.org/places/arctic/
2. *Environment News Service*, Shell Oil Offshore Alaska Drilling for 2013, February 27, 2013. Retrieved from http://ens-newswire.com/2013/02/27/shell-oil-cancels-offshore-alaska-drilling-for-2013/
3. *Environment News Service*, ConocoPhillips Puts 2014 Arctic Drilling Plans on Hold, April 11, 2013. Retrieved from http://ens-newswire.com/2013/04/11/conocophillips-puts-2014-arctic-drilling-plans-on-hold/
4. Nilsen, Thomas, Stoltenberg backs Lofoten oil drive, *Barents Observer*. February 3, 2013. Retrieved from http://barentsobserver.com/en/energy/2013/02/stoltenberg-backs-lofoten-oil-drive-03–02

fishing culture.[5] The area is also very scenic and has become a prominent tourism destination. Accordingly, the proposed drilling is very controversial.

By way of a brief comparison, oil production in the North Sea is about 4.5 times production in Alaska, while natural gas production is almost 40 times that in Alaska. In terms of fisheries, the catch in the North Sea proper is about five times that of Alaska, while that of the whole Northwest Atlantic is about 15–20 times that of Alaska. However, the North Sea catch is made up in large part of industrial fisheries, while Alaska fish are usually high-value catches of predatory fish. The North Sea is generally considered to be the safest area in the world in terms of oil spills – a 1300-barrel spill in 2011 from a rig was the "worst in a decade"[6]. A parallel to Alaska, in addition to the presence of a commercial fishery, is that in Norway there is also a substantial indigenous (Sami) population. It appears likely that evaluating the tradeoffs of industrial development in the Arctic and valuing subsistence uses and commercial fishing will be increasingly important issues in the future. This is in part the motivation for revisiting here what can be learned by taking a long-term perspective on the *Exxon Valdez* spill.

The cause of action in the *Exxon Valdez* case was for a public nuisance in a maritime setting; accordingly, the relatively strict standards of *Robins Dry Dock* applied.[7] *Robins Dry Dock* established that in maritime settings, an injured person must have suffered direct physical harm in order to recover economic losses. However, a limited exception to this rule was created for commercial fishermen, who may recover economic damages even though they experienced no physical harm.[8] Accordingly, for example, the commercial fish claim went forward, but the court refused to allow recreational fishermen, cannery workers, processors, and tenderers who were more removed from the physical injury the right to recover under *Oppen*.

With hindsight, perhaps the major legacy of the *Exxon Valdez* in the U.S. was a substantial change in the legal and regulatory framework for assessing oil spill claims. Shortly after the spill, and certainly because of the spill, the United States congress passed the Oil Pollution Act of 1990 (OPA).[9] Due to strong public support to avoid future oil spills, the OPA passed by unanimous voice vote in both the U.S.

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5. Allen, Daniel, Lofoten's troubled waters, Geographical. March 2012. Retrieved from http://www.geographical.co.uk/magazine/lofoten_-_mar_12.html
6. Press Association, Shell finds second oil leak in North Sea. *The Guardian*. August 16, 2011. Retrieved from http://www.guardian.co.uk/environment/2011/aug/16/shell-second-oil-leak?intcmp=239
7. Robins Dry Dock & Repair Co. v. Flint, 275 U.S. 303, 308–09 (1927).
8. Union Oil Co. v. Oppen, 501 F.2d 558, 570 (9th Cir. 1974).
9. Oil Pollution Act of 1990 (33 U.S.C. Section 2701 *et seq.*)

House of Representatives and Senate. OPA provides that the responsible party for a vessel or facility from which oil is discharged is liable for certain specified damages resulting from the discharged oil as well as removal costs.[10] Regulations have been promulgated by the U.S. National Oceanic and Atmospheric Administration (NOAA) that establish a process for a natural resource damage assessment process to support claims under this act.[11]

Oil spill related claims in the Arctic other than U.S. waters would be principally handled under the terms of the Liability and Fund Conventions (the U.S. is not a party). There is significant literature on claims under the International Oil Pollution Compensation Funds, including claims related to the oil tanker *Erika*, which broke up off the coast of Brittany in 1999 and the *Prestige* spill off the coast of Spain in 2002.[12]

Doubtless OPA and the Liability and Fund Conventions make it easier to establish liability for oil spills than under a public nuisance cause of action under maritime law. Nonetheless, the problem remains of establishing an acceptable economic basis for the magnitude of the claim for a given resource or foregone use. There is, unfortunately, not a necessary association of methods of valuation and the cause of action, and most uses will have multiple feasible approaches. One class of methods is cost-based approaches that measure the cost to restore, replace, or acquire the equivalent of the foregone or damaged use or service. The other general approach is to measure the value of the foregone use or service from the standpoint of value to the user. For market goods and services, these perspectives correspond to supply and demand, respectively, and market price provides a convenient valuation parameter. However, for resources that are not exchanged in established markets, price is not available. In this context, the *Exxon Valdez* case is of continued interest as methods from both perspectives were developed for subsistence, an important nonmarket use.

The current paper is based in part on an earlier (1997) paper that drew on the authors' experience participating in the *Exxon Valdez* case on behalf of the plaintiffs.[13] The remainder of this paper is organized as follows. The next section pro-

10. U.S. Environmental Protection Agency, *Oil Pollution Act Overview*. January 28, 2011. Retrieved from http://www.epa.gov/osweroe1/content/lawsregs/opaover.htm on March 21, 2013.
11. U.S. National Oceanic and Atmospheric Administration, Restoration Planning: Guidance Document for Natural Resource Damage Assessment under the Oil Pollution Act of 1990: Appendix A: OPA Regulations. August 1996. Retrieved from http://www.gulfspillrestoration.noaa.gov/wp-content/uploads/2010/10/PPD_AP-A.pdf
12. International Oil Pollution Compensation Funds, 2013. http://www.iopcfunds.org/
13. Duffield, John W. "Nonmarket valuation and the courts: the case of the Exxon Valdez" in *Contemporary Economic Policy* (15) 1997, pp. 98–109.

vides a brief introduction to the economic methods applied in natural resource damage assessment, followed by several sections providing an overview of the *Exxon Valdez* trial,[14] emphasizing commercial fish and subsistence use. A focus of these sections is on the economic methods used from the perspective of four different realities: (i) economic theory ("in principle" the appropriate measure of damages), (ii) legislation and related regulatory guidelines (such as Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] and Oil Pollution Act [OPA] and the U.S. Department of the Interior [DOT] natural resource damage regulations codified at 43 CFR part II), (iii) the court's interpretation of the law (what the presiding judge rules to be legally admissible), and (iv) the jury verdict. Following the discussion of the trial, the paper turns to a longer term perspective, contrasting the trial outcomes with the observed continuing impacts to subsistence harvest.

2. Valuing foregone ecosystem services

Prior to turning to the specific application at hand, the 1989 *Exxon Valdez* oil spill, this section provides an introduction and overview of the methods that have been developed and applied for valuing a broad range of industrial development impacts on natural resources. This general overview provides a context for the specific application of market and nonmarket valuation tools in the *Exxon Valdez* case, as developed in following sections.

Natural resource damage assessment in a litigation setting such as an oil spill is just one application within the general problem of identifying the change in and valuation of human services due to an injury or policy or some other cause. A useful and emerging paradigm in this general area of research is ecosystem service valuation. A recent U.S. National Research Council panel[15] provides a good overview of this area of research and a current panel is evaluating the impacts of the *Deepwater Horizon* spill.[16]

Consistent with these recent National Research Council panels (and the related economics literature) there has been a parallel effort to identify reliable methods for specific application in natural resource damage assessment associated with toxic releases, oil spills and similar environmental disasters. The U.S. Department

14. Exxon Valdez, A89–0095-CV (consolidated), (D. Alaska 1994).
15. National Research Council, *Valuing Ecosystem Services: Toward Better Environmental Decision Making.* Washington, D.C.: National Academy Press. 2005.
16. National Research Council, Approaches for Ecosystem Service Valuation for the Gulf of Mexico after the Deepwater Horizon Oil Spill: Interim Report. Washington, D.C.: National Academy Press. 2012.

of the Interior (DOI) and the National Oceanic and Atmospheric Administration (NOAA) have established regulatory guidelines for implementation of the Clean Water Act and CERCLA[17] and the OPA of 1990.[18] The set of plausible alternative procedures is finite and includes: (i) market prices, (ii) travel cost methods, (iii) hedonic methods, (iv) factor income, and (v) contingent valuation.[19] Contingent valuation has received considerable attention because it is the only method potentially capable of measuring so-called passive use values. In the *Exxon Valdez* public trustees case, plaintiffs used contingent valuation to value injury to Prince William Sound.[20] The defendant's strategy involved funding studies that critically examined the contingent valuation methodology rather than directly estimating potential passive use losses.[21] As a result of the debate initiated by these two sets of studies, a select panel including several Nobel laureates in economics reviewed contingent valuation.[22] While there is now a very substantial literature on contingent valuations,[23] the use of contingent valuation to estimate passive use losses remains controversial.[24]

While much attention has focused on contingent valuation, a long-standing and extensive economics literature examines all of these valuation methodologies.[25]

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17. Comprehensive Environmental Response, Compensation, and Liability Act, Public Law 96–510, 94 Stat. 2767 (1980). 59 Federal Register 14262.
18. Oil Pollution Act of 1990, Public Law 101–380, 104 Stat. 484 (1990). 59 Federal Register 1062.
19. E.g. 59 Federal Register 1182.
20. Carson, Richard T., et al. "A Contingent Valuation Study of Lost Passive Use Values Resulting from the Exxon Valdez Oil Spill," Report to the Attorney General of Alaska, Natural Resource Damage Assessment, Inc., La Jolla, Calif., 1992.
21. Hausman, Jerry A., Report of Professor J. A. Hausman. Presented at the Exxon Valdez consolidated court case, November I, 1993.
22. Arrow, Kenneth J., Robert Solow, Paul R. Portney, Edward E. Leamer, Roy Radner, and Howard Schuman, "Report of the NOAA Panel on Contingent Valuation," 59 Federal Register 4601–4614, January 15, 1993.
23. See for example, Carson, Richard. *Contingent Valuation: A Comprehensive Bibliography and History*, Edward Elgar, Northampton, MA (2011).
24. See Hanemann, W. Michael, "Valuing the Environment through Contingent Valuation" in *The Journal of Economic Perspectives*, 8:4, 1994, 19–44, and Diamond, Peter A., and Jerry A. Hausman, "Contingent Valuation: Is Some Number Better than No Number?" in *The Journal of Economic Perspectives*, 8:4, 1994, pp. 45–64.
25. Overviews include Desvousges, William H., and Venetia A. Skahen, *Techniques to Measure Damages to Natural Resources, Type B Technical Information Document*, U.S. Dept. of Interior, Washington, D.C., 1987; Ward, Kevin M., and John W. Duffield, *Natural Resource Damages: Law and Economics*, John Wiley & Sons, New York, 1992; and Kopp, Raymond J., and V. Kerry Smith, *Valuing Natural Assets: The Economics of Natural Resource Damage Assessment, Resources for the Future*, Washington, D.C., 1993.

But how acceptable are these methods in the courts? Judges and juries provide a very different litmus test than the test of peer review by fellow economists. In a review of several cases, Cummings (1991) concluded that frequently the courts uncritically accept and inappropriately apply economic paradigms. Certainly the court environment is more demanding in terms of whether a given method seems reasonable and is readily communicated. The *Exxon Valdez* trial is of particular interest from this standpoint. One of the major plaintiff groups, the Alaska native class, submitted a claim for lost subsistence use. While subsistence is one of the basic types of services associated with natural resources that was specifically listed in the NOAA Proposed Rules,[26] little work exists on the development of valuation approaches for this type of resource service.[27] Both plaintiffs and defendants in this case implemented a hedonic approach for valuing lost subsistence use.

Because commercial fishermen and Alaska natives were the two main plaintiff groups in Phase II of the Exxon trial, this case provides an interesting side-by-side comparison of a market and a nonmarket sector that both utilize the same raw resource base-the fisheries of Prince William Sound and the Gulf of Alaska. The analysis here examines the valuation methodologies from the standpoint of economic theory, regulatory guidelines, the court's numerous decisions concerning what was admissible into evidence, and the respective outcomes – a jury decision and a settlement just prior to trial.

3. The Exxon Valdez trial

This section describes the *Exxon Valdez* trial itself as context for the economic perspective on the trial and its outcomes in following sections. The *Exxon Valdez* litigation was a many-sided and massive endeavor. The public trustees' case concluded with a settlement for approximately $ 1 billion in damages in 1992. The government settlement also included a criminal fine of $ 150 million, of which $ 125 million was forgiven in recognition of Exxon's reported $ 2 billion in clean-up costs. However, litigation continued for many years for private claims in both state and federal court and at the appellate level. The focus here is on the trial in federal court, the final outcome of which (relating to punitives) was not reached

26. National Oceanic and Atmospheric Administration Proposed Rules. 59 Federal Register 1140.

27. See Brown, Thomas C., and Earnest S. Burch, Jr., "Estimating the Economic Value of Subsistence Harvest of Wildlife in Alaska," in George L. Peterson et al., eds., *Valuing Wildlife Resources in Alaska*, Westview, Boulder, Colo., 1992, pp. 203–254 for a review of this literature.

until June 2009,[28] 20 years after the spill. The latter ruling opens with "This epic punitive damage litigation arising from the 1989 wreck of the *Exxon Valdez* is before us once again".[29]

The federal trial was in four phases that began in May 1994 (see Table 1).

Table 1: Exxon Trial Phases – Federal Court

Phase	Number of Days Jury Deliberated	Date Decided	Award/Settlement
I. Liability	4	June 13, 1994	N/A
II. Compensatory Damages – Classes			
A. Commercial Fishing	23	August 11, 1994	$ 287 million
B. Native Subsistence	Settled just prior to trial	July 22, 1994[a]	$ 20 million[b]
III. Punitive Damages	13	September 16, 1994	$ 5 billion
IV. Compensatory – Individual Claimants	Settled	January 17, 1996	$ 3.5 million

[a] Approximate date.

[b] Additionally, the Native Opt-out group settled for $ 2.55 million on October 12, 1995.

Source: Court records of *Exxon Valdez* consolidated case.

The first phase addressed liability and was decided in the plaintiff's favor on June 13. The finding that Exxon had behaved "recklessly" made the defendants liable for punitive damages in the third phase of the trial. From the plaintiffs' standpoint, at least some parties prior to trial expected that compensatory damages sought for Phase IIA, the commercial fish case, would be on the order of $ 900 million to a $ 1 billion (see Table 2), and that in Phase IIB several hundred million would be sought for native subsistence losses.

28. The U.S. Supreme Court eventually reduced punitive, after many rounds of appeal, by 90 percent to $ 507.5 million compared to the initial trial outcome of $ 5 billion (Exxon Shipping Co. v. Baker 128 S. Ct. 2605,2633 (2008). The final ruling concerned the determination of interest owed by Exxon ($ 470 million) and allocation of appellate costs (In re: the Exxon Valdez, 568 F.3d 7080, 7103).

29. Exxon Valdez, 568 F. 3d at 7083.

Table 2: Jury Decision on Commercial Fishing Losses Caused by the *Exxon Valdez*

Year	Injury Category	Plaintiffs Sought	Exxon Offered	Jury Awarded
1989	Prince William Sound salmon harvest	$ 9.0 million	$ 4.7 million	$ 7.7 million
1989	Upper Cook Inlet salmon harvest	$ 54.0 million	$ 40.4 million	$ 45.9 million
1989	Kodiak salmon harvest	$ 50.6 million	$ 41.7 million	$ 43.0 million
1989	Balboa-Stepovak salmon harvest	$ 0.3 million	0	0
1989	Chignik salmon harvest	$ 5.9 million	$ 3.5 million	$ 5.0 million
1989	Herring harvests	$ 16.7 million	$ 9.2 million	$ 16.6 million
1990–1995	Prince William Sound pink salmon harvest	$ 45.6 million	$ 0–3.6 million	$ 22.4 million
1994–1995	Upper Cook Inlet sockeye harvest	$ 65.8 million	$ 0–9.7 million	0
1994–1995	Kodiak sockeye harvest	$ 6.7 million	0	0
1993–1994	Prince William Sound herring harvest	$ 36.7 million	0	$ 0.7 million
1989	Salmon price depreciation	$ 134.5 million	0	$ 119.7 million
1990–1991	Salmon price depreciation	$ 418.7 million	0	0
1989	Herring price depreciation	$ 10.0 million	0	$ 10.0 million
1990–1991	Herring price depreciation	$ 17.2 million	0	0
1989–1994	Permit sale losses – devaluation	$ 23.3 million	$ 0–0.5 million	$ 9.4 million
TOTALS	$ 895.0 million	$ 99.5–113.5 million	$ 286.8 million	

Source: Court records of *Exxon Valdez* consolidated case.

These sums, while substantial, were a small fraction of the plaintiffs' anticipated claim on punitive damages of $ 15 billion. The structure of the trial probably influenced outcomes, particularly for the native case. The potentially very large scale of the punitive damages and the timing of the native compensatory damages phase, after the commercial fish case and before punitive damages, probably encouraged plaintiffs to settle prior to trial.

The litigation itself was an exercise in free market economics. The defendant was, and remains, one of the world's largest economic entities. Given the scale of the compensatory and punitive damages sought, Exxon had the incentive to commit substantial resources to this litigation. Estimates suggest that Exxon spent about $ 100 million on the science alone in the commercial fish case and spent $ 1 million per day during trial. On the plaintiff side, firms competed for commercial fish and native subsistence clients. The successful firms formed a coalition of approximately 500 lawyers and 60 law firms called the Exxon Plaintiffs' Litigation Joint Venture. Not all firms and clients were unanimous on strategy. A major issue was whether to participate in the respective class. Among the native subsistence claimants, about 700 individuals opted out of the class while 3,620 remained. The trial for compensatory damages for the Alaska native class, the 3,620 claimant group, was scheduled for Phase IIB (Table 1). The compensatory damages trial for the "opt-outs" or individual claimants (both native and commercial fishermen) was Phase IV of the trial. This phase was continually delayed but finally settled in January, 1996. Table 1 summarizes the trial outcomes.

4. Economic structure of the commercial fish and native subsistence sectors

This section introduces an economic perspective on the *Exxon Valdez* case. This entails first describing the economic similarities and differences of the specific economic sectors that were most impacted by the oil spill and evaluated in the course of the legal proceedings: commercial fisheries and subsistence uses. The second section provides an overview of the economic theory and methods relevant to valuing these two sectors. A key feature is that one sector produces marketed products (the commercial fisheries) and the other sector produces goods and services that are not sold but are distributed through customary exchange and are therefore "nonmarket" goods and services.

4.1 Market and Nonmarket Sectors

Table 3 summarizes the primary economic characteristics of the commercial fish and native subsistence sectors affected by the *Exxon Valdez* oil spill.

Table 3: Characterizing Subsistence and Commercial Fish Sectors

Characteristic	Commercial Fishing	Native Subsistence
# of Claimants	10,000[a]	4,000[a]
Natural Resource Inputs	Commercial Fish Species	Fish, marine mammals, birds, eggs, plants
Production Technology	Large Scale, Wide Ranging	Small Scale, Local
Distribution of Product	International Markets	Local Traditional Sharing
Priced Output	Yes	No
Vertical Integration	Not Vertically Integrated	Producer and Consumer are Same Individual

[a] Approximate estimate.

Both groups rely on marine natural resources in Prince William Sound and the Gulf of Alaska. The native subsistence users live in small villages in the sound, on Lower Cook Inlet, on Kodiak, and on the Alaska Peninsula. The path of the oil spill southwest out of Prince William Sound defines the geographic extent of the impacted villages. Commercial fishermen rely on commercial fish species such as salmon and herring. Native subsistence users rely on a broad spectrum of marine and some land resources including the commercial fish species. Based on surveys conducted by the Alaska Division of Subsistence, the pre-spill subsistence harvest of natives in the oiled villages (measured in usable pounds) was approximately 25 % marine mammals (primarily seals), 35 % salmon, 22 % non-salmon fish (herring, halibut, cod, etc.), 13 % land mammals (primarily deer), 3 % marine invertebrates (clams and crabs), and 1 % each birds, eggs, plants, and berries.[30]

The commercial fishermen operate on permits defined by gear type, geographic location, and species targeted. This is a relatively competitive sector typified by small family-owned businesses. Nonetheless, the technology is fairly sophisticated and generally includes a good-sized commercial fishing vessel. By comparison, the Alaska natives also are organized into relatively small family-based groups. Some Alaska natives also may be commercial fisherman or may work on commercial

30. Alaska Department of Fish & Game, Division of Subsistence, Minerals Management Service Data Set, Anchorage, 1993.

fishing vessels. However, native subsistence technology typically is small scale and very local, with each village and family unit using well-defined traditional areas to gather specific resources over the course of an annual cycle. The main economic difference between the two sectors is in distribution. Commercial fishermen sell their products on an international market to processors and distributors. For example, Japan is a primary market for Alaska red salmon. By contrast, Alaska natives do not sell subsistence harvest but instead share it out, based on traditional relationships within the economic unit and the village. The producers and consumers in the subsistence economy essentially are the same individual. From the standpoint of economic valuation, only the commercial fish sector has directly observable market prices for its product. Another important feature of the native subsistence sector is that the village level economies actually are mixed cash-subsistence economies. Residents of the mostly native villages divide their time between participation in wage-earning activity and subsistence activity.

4.2 Concepts for Valuation

The sections below describe the valuation methodologies used to estimate damages to the commercial fish and subsistence sector. The commercial fish damage estimates are based on a market price methodology. The native subsistence losses are based on two approaches. One approach is an equivalence approach aimed at estimating the replacement cost of the foregone subsistence resources. This is approximated using market prices as available in or out of the region for goods similar to the subsistence goods and services impacted (such as salmon, berries, fresh deer carcasses, etc.). A limitation of this supply side approach is that valuing the raw material inputs to the subsistence economy (such as fresh whole fish) undervalues what was lost. This is in part because of substantial value-added activity related to these resources was precluded by the spill in the preparation of the final foods that would actually be distributed and consumed, such as smoked fish or preserved berries and medicinal plants. Additionally, the activity of harvesting and preparing these resources relies on and maintains cultural ecological and technological knowledge that needs to be transmitted to younger generations. A second approach, which in theory could provide a more complete measure, is based on the hedonic method applied to the wage market in these mixed cash-subsistence economies as further developed below in section 6.0.

Fundamental valuation concepts apply to both these approaches. These concepts are articulated in the economics literature and underlie the DOI and NOAA proposed rules for conducting natural resource damage assessments. While the cause of action in Phase II was a public nuisance theory (not CERCLA, OPA, or

the Clean Water Act), the proposed federal guidelines provide a useful statement of fundamental valuation principles. These principles are relevant here as a standard for interpreting the outcomes and decisions of the case.

Injury to a natural resource typically diminishes the services of the resource. Over time (due to natural processes and/or restoration action), the resource may recover to the initial, or baseline, condition. Therefore, two economic valuation problems generally emerge: (i) valuing the lost interim use of the resource prior to recovery, and (ii) estimating the costs of any restoration or replacement actions. The proposed rules formally define these two components as compensable values, and restoration or replacement, respectively. The specific proposed language (in the NOAA rules for example) follows:

Compensable values mean the total diminution in value of the injured natural resources and/or services as a result of the discharge until recovery to baseline or comparable conditions … Replacement means actions that substitute natural resources and/or services for those injured. The natural resources and/or services that are substituted provide the same or comparable resources and/or services as those injured … Restoration means actions that return injured natural resources and/or services to their baseline condition.[31]

Presumably the appropriate measure of damages or compensation under any cause of action is the level that will make the injured party whole. That is exactly what the federal guidelines intend to achieve for cases involving injury to natural resources.

These simple principles imply that resource value is based on the value of the services derived. The definition of compensable values specifically includes the standard economic measure of changes in welfare---that is, "monetized measures in utility, or consumer surplus" and "economic rent"[32] for the impacted users. The D.C. Circuit Court decision on *Ohio* v. *DOI (1989),*[33] which emphasizes concepts of "use values," both direct and passive, explicitly cited the "diminution of value" standard for measuring resource values. Another implication is that the measure of past lost use is the value of foregone services (e.g., compensable values as measured by market methods, travel cost, contingent valuation, hedonic techniques or factor income). As noted, the cost to replace and/or to restore foregone resource inputs after the fact for vertically integrated sectors, such as the subsistence economy of Alaska, will generally not make the injured party whole. One can measure future losses either by compensable values or the cost to restore/replace in a timely way,

31. 59 Federal Register, p.1168.

32. 59 Federal Register, p.1182.

33. Ohio v. United States Department of Interior, 880 F.2d 432,474 (D.C. Cir. 1989).

or a combination.[34] These concepts apply equally in market or nonmarket sectors. However, the court's decisions in Phase IIB were at odds with several of these basic principles.

5. The commercial fish case

This section describes the injury, valuation approach, and outcomes for the commercial fish sector.

5.1 Injury and Valuation Methodology

Damages sought in the commercial fish case in Phase IIA of the federal trial fell into three general categories: reduced harvests, diminished prices, and diminished permit values. All three categories fit readily into the federal guidelines for compensable values since all three lead to changes in economic rent. One can measure the first two categories, reduced harvests and diminished prices, by reductions in past net income. The change in permit values essentially provides a measure of the same thing but for future losses. Changes in the permit values reflect the market's expectation of changes in future net income. The obvious methodology is a market price methodology, and that is what economists on both sides employed. Several publications have addressed in some detail the economics of the commercial fish case.[35]

Because damages were based on observed market prices and quantities, the general valuation approach was not a major issue. Of course, the specific empirical applications were. A major issue was "the science" – establishing the actual impact of the oil spill on the fishery and connecting this to observed changes in price and quantities. As an example, the plaintiffs asserted that observed price reductions for 1989, 1990, and 1991 for salmon and herring were related primarily to the "taint effect" of the spill. The plaintiffs and defendants held considerably different positions on this issue as reflected, almost humorously, in their different characterizations of one of the key resources – red salmon. According to plaintiff's expert Robert Mendelsohn, red salmon is the Japanese "filet mignon." A defense attorney countered that in fact red salmon is the Japanese "spam." Defendants

34. Ward, Kevin M., and John W. Duffield, *Natural Resource Damages: Law and Economics*, John Wiley & Sons, New York, 1992, § 8.7.

35. See Cohen, Maurie J., "Technological Disasters and Natural Resource Damage Assessment: An Evaluation of the Exxon Valdez Oil Spill" in *Land Economics*, 7/1, 1995, pp.6–82, and Owen, Bruce M., David A. Argue, Harold W. Furchtgott-Roth, Gloria J. Hurdle, and Gale Mosteller, *The Economics of a Disaster: The Exxon Valdez Oil Spill*, Quorum Books, Westport, Conn., 1995.

argued that observed price declines were in large part a function of market forces – for example, increased supplies of farmed salmon from Chile and Norway. A major science issue was interpreting the role of the spill compared to other factors in changing salmon and herring harvests.

As noted earlier, the cause of action in the *Exxon Valdez* case was for a public nuisance in a maritime setting. A limited exception to the relatively strict standards of *Robins Dry Dock*[36] was created for commercial fishermen, who may recover economic damages even though they experienced no physical harm.[37] Accordingly, the commercial fish claim went forward to Phase II of the trial, while claims by recreational fishermen, cannery workers, processors, and tenderers did not.

5.2 Outcomes

Table 2 summarizes the outcome of Phase IIA. The plaintiffs sought $ 895 million, the defendants offered $ 99.5 to $ 113.5 million, and the jury awarded $ 286.8 million. Plaintiffs sought a large share of the damages for price depreciation in post-spill years. For example, plaintiffs estimated the loss from depreciation of salmon prices to be $ 419 million in 1990–1991. The jury awarded zero damages for post-spill year price depreciation claims. It is interesting to note that for the more straightforward claims – those for reduced harvest in the spill year and for permit sale losses – the jury awards often are exact averages of the plaintiff and defendant positions. The jury deliberated much longer on the Phase IIA claims than either side had anticipated. Closing arguments occurred on July 11, and the decision came back 23 working days later on August 11.

6. The alaska native subsistence case

This section describes the injury, valuation approaches, and outcomes for the subsistence sector.

6.1 Injury and Valuation Methodology

In principle, the types of injury suffered by the Alaska native class due to the *Exxon Valdez* spill closely paralleled the losses of commercial fishermen working in Prince William Sound and the Gulf of Alaska. Harvests were reduced in the spill year and (to a lesser extent) in all years up to the time of trial, harvests after the spill suffered diminished valuation due to a fear of contamination, and it appeared

36. Robins Dry Dock & Repair Co. v. Flint, 275 U.S. 303, 308–09 (1927).

37. Union Oil Co. v. Oppen, 501 F.2d 558, 570 (9th Cir. 1974).

that future harvests also would be diminished. However, unlike the commercial fishermen, the Alaska natives could not cite prices to indicate the diminished value associated with harvests that were taken, so that category of damages was not quantified. Similarly, Alaska natives suffered a devaluation of their rights to fish and gather marine resources in their traditional places but again had no price signal to measure this loss.

The subsistence damage assessment essentially was limited to observed harvest reductions in 1989–1992 and extrapolated harvest losses for 1993–1995. A measure of the change in this harvest quantity was available due to an ongoing series of subsistence harvest surveys undertaken by the Alaska Division of Subsistence.[38] The specific measure was usable pounds of all resources (e.g., seals, herring, salmon, etc.) per capita. Using pre-spill measures of harvest as a baseline and survey results in 1989–1992 allowed claimants to compute a change in subsistence harvest. Because these data were not available for all villages or all years, imputing some harvest loss estimates became necessary.

The more difficult economic problem for the subsistence damage claim involved placing a unit value on the reduced harvests. Two problems arose – valuing past and future lost use (compensable values), and valuing any restoration or replacement chosen to offset future losses. Because the subsistence resources are not sold, no price exists to reveal the value placed on these resources within the subsistence economy. The prices in external markets, such as Anchorage, are not necessarily relevant measures of lost subsistence use. The supply/demand conditions are unique to the villages, many of which are quite isolated. Native preferences for foods are strongly held and differ from preferences in mainstream society. For example, highly prized foods include seal oil and herring roe on kelp. Additionally, because these are highly vertically integrated economies, substantial value-added may occur before final consumption. In fact, many of the raw resources are processed prior to storage and eventual consumption (e.g., smoked and dried fish and frozen roe on kelp). Contingent valuation could be applied in principle but was not feasible given the timing of the analysis. Two approaches were implemented. One was a hedonic analysis that utilized related wage transactions in the cash sector. For future losses, a second approach might also be considered: either the

38. E.g. Fall, James A., and Charles Utermohle, M.M.S. 11.: An Investigation of the Sociocultural Consequences of Outer Continental Shelf Development in Alaska, Draft Technical Report, Vols. I-IV., Alaska Department of Fish & Game, Division of Subsistence, Anchorage, November 1993.

replacement or restoration cost required to offset reductions in baseline harvest in a timely way so that raw resource inputs are available to the subsistence economy.[39]

The cause of action for the subsistence claim was, as for the commercial fish case, a public nuisance theory. However, the defendants filed a motion for summary judgment on the grounds that the natives did not satisfy the standards of maritime law as set forth in *Robins Dry Dock*. In this same motion, Exxon also argued that the native class members failed and did not intend to provide individualized proof of any loss, but instead intended to rely on the Subsistence Division data. This latter was the anticipated motion that had in part led a number of native class claimants to opt out. The court in Order No. 222[40] denied both elements of Exxon's motion. With regard to the individual proof issue, the plaintiff's offer of individualized proof at the time any award was actually distributed satisfied the court. The court noted that:

The bulk of Exxon's motion is devoted to "nitpicking" the Subsistence Division data to support Exxon's argument that the data does not provide a valid class-wide estimate of pre-spill and post-spill average harvest levels. Plaintiffs, naturally, devote much of their brief to rebutting Exxon's argument regarding the sufficiency of the data.[41]

The court concluded: "These are factual issues which the jury must consider in determining the level of any damages awarded, and cannot be resolved in a motion for summary judgment."[42]

On the *Robins Dry Dock* issue, the court concluded that native subsistence fits within the *Oppen* exception. The following quotation from Order No. 222 provides insight into the court's view of the native claim: "The court need not expand the *Oppen* exception to find that native subsistence harvesters fit within that exception. The native subsistence harvesters 'lawfully and directly make use of a resource of the sea,'" *ibid*. at 570, to a greater extent than do commercial fishermen. Native subsistence harvesters are direct, first users of the sea's aquatic life, and their injuries were more directly foreseeable than injuries to commercial fishermen. Whereas the spill reduced the commercial fishermen's profits because they could not sell

39. A third approach was considered that views subsistence harvest resources as having two components of value; a product value and an activity value (Brown and Burch op cit.). In principle, one could identify these values for every resource and total them. Both of these approaches in principle are feasible for valuing lost use – i.e. compensable values. However, the Brown-Burch model simply rephrases the question, and the problem of identifying the "product" and "activity" values remains.

40. Filed May 31, 1994, *Exxon Valdez* consolidated case.

41. Order No. 222, p. 5.

42. Ibid.

the resource to a third party, it directly reduced the subsistence harvesters' immediate ability to consume that resource. The spill interfered with the subsistence harvesters' ability to "lawfully and directly make use of a resource of the sea … in the ordinary course of their business," *ibid.* at 570, that business being their very livelihoods. Thus where commercial fishermen survive by catching an aquatic resource and selling it, native subsistence harvesters survive by catching an aquatic resource and eating it. The court concludes that the native subsistence harvesters fit within the *Oppen* exception.[43]

6.2 Subsistence Claims Methods

As noted earlier, two methods were applied to value subsistence losses: replacement cost and an hedonic approach. Both of these approaches used the State of Alaska's Subsistence Division data to establish harvest loss.[44]

The concept of replacement cost is relatively straightforward: identify a replacement for what was lost and estimate the cost of that replacement. While conceptually simple, the problem lies in application, since the raw material resources harvested for subsistence resources may not be available in the time, place and condition of what was lost. More importantly, not having the raw material precluded the actual culturally important harvesting, processing and distribution activity that leads to the final good.

The central concept of the hedonic approach is to value the attributes of a commodity or service by examining how the price of the larger commodity varies in response to changes in attributes across a sample.[45] The economic literature on the hedonic or implicit price method is extensive.[46] For example, suppose two otherwise identical homes are sold; one is on a lakeshore property while the other is distant from the lake. If these are otherwise identical properties and the lakeshore home sells for $ 150,000 while the other home sells for $ 100,000, the difference of $ 50,000 is a measure of the implicit price of the lakeshore. Most studies examine a large number of properties and estimate by statistical methods the difference in price due to the attribute of interest, such as proximity to a lake. Similarly, hedonic

43. Ibid, p.7.
44. Fall, James A., "Subsistence Uses of Fish and Wildlife and the Exxon Valdez Oil Spill" in *Arctic Issues Digest*, October 1991, pp. 12–15.
45. Rosen, Sherwin, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition" in *Journal of Political Economy*, 82, 1974, pp. 34–55, and Ward and Duffield, op cit. § 11.2.
46. E.g. Palmquist, Raymond B., "Hedonic Methods," in J. B. Braden and Charles D. Kolstad, eds., *Measuring the Demand for Environmental Quality*, North-Holland, Amsterdam, 1991, pp. 77–120.

studies measure the value of topsoil in farm land, attributes of a worker's place of residence (such as air quality), or of a job (job safety). In addition to applying hedonic methods to final goods markets, hedonic models can also be applied to wage markets where one identifies how wages vary with the attributes of the vocation (danger, technical skill required, etc.)

In the mixed subsistence-wage economies in Alaska native villages, the wage required attracting an individual to a given livelihood or work situation may vary systematically with other attributes of that livelihood, including opportunities for subsistence harvest. This condition supports the economic literature's finding that systematically lower wages are associated with attributes that attract individuals to an area or a job for environmental or safety reasons (air quality, access to sport fishing, job safety).[47] Consistent with this literature, one would expect that lower average income can still attract individuals to a livelihood when offsetting productive subsistence harvest opportunities exist. In short, the hedonic approach that plaintiffs use to value subsistence harvests relies on revealed preference. Individuals choosing to participate in the subsistence livelihood reveal that it has a greater value to them than the wages foregone in a more market-oriented economy. For this particular application, Wolfe and Walker's pre-spill (1987) study using Alaska Subsistence Division data on 98 communities provided an estimate of the trade-off of subsistence harvest (measured in per capita pounds) against income. Their model, which was intended to interpret factors affecting the viability of subsistence economies, indicated a trade-off of about $ 118 per pound of subsistence harvest (1982 dollars). This specific value could have been used as a literature-based estimate and applied to the estimated total pounds of lost subsistence harvest over a given post-spill period. As developed below, the relatively simple statistical model used by Wolfe and Walker (1987) took harvest as exogenous and was re-estimated for purposes of the trial.

6.3 1993 Subsistence Claims Estimates

There were two groups of subsistence claimants, those who chose to join the native class (3,620 individuals) and those who chose to opt out of the class (a total of

47. For a review of hedonic wage studies, see Freeman, A. Myrick Ill, *The Measurement of Environmental and Resource Values, Resources for the Future*, Washington, D.C., 1993, Chapter 12.

700 individuals).[48] The larger group of 3,620 individual native claimants chose to stay with the Alaska native class through Phase IIB (and the eventual settlement of their claims). The discussion here focuses on estimating subsistence losses for this group and the Alaska community subsistence hedonic wage model that was relied on during the federal trial.

As noted, there is a substantial economics literature that utilizes the hedonic wage, or wage compensating differential model. For example, estimates of the trade-off of wages and workplace risk of mortality are the basis of the statistical value of life estimates widely used in regulatory analysis of ambient air and other standards.[49] There is also a literature that relates wages and amenity values as revealed through choice of residence location.[50] These later models are generally applied to intercity data sets, such as across U.S. SMSAs. These models are also used to estimate the benefits and costs of climate change.[51]

The application of a compensating wage model to a cross-section of Alaska villages and towns is consistent with the view that these Alaska cash-subsistence economies are not just a transitory phase in economic development. Rather the village economies represent an equilibrium that is a function of individual choice of where to live and work.[52]

The Wolfe and Walker[53] study provided the first estimate of a statistical relationship between wage income and subsistence livelihoods using harvested usable pounds as a measure of subsistence productivity. Wolfe and Walker were interested in factors that influenced subsistence productivity, including construction of roads, settlement activity and income. The data was based on extensive surveys of

48. The first filing of subsistence claims in the federal trial case occurred in 1993. In March of 1993, a claim was submitted for a group of 411 native claimants. This group of claimants eventually made up the better part of the approximately 700 natives who chose to opt out of the class. Eventually this group relied on the outcomes of the native class case.

49. U.S. Environmental Protection Agency – Science Advisory Board (U.S. EPA-SAB). 2007. SAB Advisory on EPA's Issues in Valuing Mortality Risk Reduction. EPA-SAB-08–001. October. Available on the Internet at http://yosemite.epa.gov/sab/sabproduct.nsf/4128007E7876B8F0852573760058A978/$File/sab-08–001.pdf

50. See Henderson, J. "Evaluating Consumer Amenities and Interregional Welfare Differences" in *Journal of Urban Economics,* 11:32–59, 1982, and Clark, D. and J. Kahn, "The social benefits of urban cultural amenities" in *Journal of Regional Science* (28) 1988, pp. 363–377.

51. See Maddison, D., and A. Bigano, "The Amenity Value of the Italian Climate" in *Journal of Environmental Economics and Management* 45(2):319–332.

52. See Wolfe, Robert J., and Robert J. Walker, "Subsistence Economies in Alaska: Productivity, Geography, and Development Impacts" in *Arctic Anthropology*, 24:2, 1987, pp. 56–81; Kruse, J.A., "Alaska Inupiat subsistence and wage employment patterns: understanding individual choice" in *Human Organizations* (50) 1991, pp. 317–326.

53. Wolf and Walker 1987.

Alaska villages undertaken by the applied anthropology group at Alaska Fish and Game, Division of Subsistence. Duffield[54] used the Wolfe and Walker ninety-eight village dataset in a compensating wage specification to inform subsistence harvest valuation in the context of the Exxon Valdez oil spill litigation. Hausman,[55]who represented the defendant in the case (Exxon) also estimated a compensating wage model using the Wolfe and Walker dataset. Hausman introduced the use of applying an instrumental variable approach to estimating the model, since wages and subsistence harvests are jointly determined.

Hausman's and Duffield's final estimates of the value of subsistence harvests were quite similar at about $ 33. Table 4 reports an estimated wage compensating model from the original 1980s data (column 2).

The estimated wage compensating differential models showed in Table 4 use a two-stage least squares methodology and a linear specification. The two-stage least squares method is used to statistically address the fact that income and harvest levels in the communities are at least partly co-determined. The first stage of the model uses an instrumental variable (the percent of adults in each community with 4 or more years of college education) along with the remaining regional indicator variables to predict adjusted gross income per capita for each community. This predicted income level then was used in the second stage regression. The implied value per pound of subsistence harvest is calculated from the parameter estimate for Adjusted Gross Income Per Capita. The implied value per pound is the negative inverse of the income parameter (–0.05351) times the average cost of living adjustment for the villages compared to Anchorage (1.7598). [(1/-0.0531)*-1 = $ 18.83 *1.7598 = $ 32.89]

In addition to the replacement cost and hedonic estimates developed by the current paper's authors that were the eventual basis of the settlement for the group of 3,620 claimants, several other experts were involved that developed expert reports. This section provides a brief discussion of their work.

54. Duffield, John W. "Nonmarket valuation and the courts: the case of the Exxon Valdez" in *Contemporary Economic Policy* (15) 1997, pp. 98–109.

55. Hauseman, J.A., ed., *Contingent Valuation: A Critical Assessment*, North-Holland, New York, 1993.

Table 4: Estimated Two-Stage Least Squares Wage Compensating Differential Models of Subsistence Harvest in 90 Alaska Communities (Duffield 1997 and updated).

Variable	Original Model: Coefficient (S.E.)	Updated Model
Intercept	1165.956 (161.48)***	936.45 (137.89)***
Income	–0.05351 (0.03002)*	–0.01162 (0.0051)**
Alaska Peninsula	–549.018 (97.51753)***	–174.227 (119.08)
Copper Basin	–622.873 (104.90)***	–522.132 (86.37)***
Kenai Peninsula	–564.685 (177.54)***	–448.975 (120.61)***
Kodiak	–388.762 (108.84)***	–465.551 (111.31)***
North Slope	–401.538 (169.03)**	227.2387 (172.49)
NW Arctic	–108.213 (203.95)	–112.557 (227.61)
N Cook Inlet	–629.667 (203.24)***	–548.580 (230.87)**
Prince William Sound	–565.038 (157.40)***	–248.607 (173.95)
South East	–504.528 (137.88)***	–314.787 (103.27)**
South West	–257.009 (91.53)***	–265.364 (101.56)**
Upper Tanana	–632.759 (117.70)***	–514.022 (130.35)***
Urban	–326.635 (336.98)	–590.972 (169.66)***
West	–201.926 (92.048)**	–22.1552 (105.28)
Observations	90	90
R-Squared	0.704	0.536
Endogenous Variable	Adjusted Gross Income Per Capita (AK DOR 1982)	Adjusted Per Capita personal income (BEA 2010) (adjusted to Anchorage dollars using cost-of-living index)
Instrumental Variable	% of adults with 4 or more years of college	

The development of the claim for this group included analyzing injury from a social and cultural perspective. A key document was Braund & Associates and P. J. Usher Consulting Service (1993)[56], which used methods of social impact assessment and cultural anthropology to examine the effects of the *Exxon Valdez* oil spill on Alutiiq culture. Robert Lind submitted an economic damages report for the class in February 1993. Lind relied on the Braund report and also used a revealed preference-hedonic method to value subsistence losses. He provided estimates of "minimum per capita damage awards given different probabilities of long-term disruption to the Alutiiq way of life".[57] The lowest two estimates reported correspond (for 3,620 class members) to total claims of $ 187 million to $ 336 million and ranged up to around $ 1 billion. Lind additionally indicated that another component of damages was "for losses to the way of life and losses associated with pain and suffering"[58]. Without providing a specific estimate he noted that pain and suffering awards are often based on value-per-statistical-life, which tends to be three to four times greater than the present value of expected future disposable income.

As indicated earlier, defendant's expert Jerry Hausman also provided a subsistence damage report. Hausman also used an implicit price model, essentially taking the Wolfe-Walker data set[59] and re-estimating the parameters. Hausman stated that this revealed preference approach in principle was correct, but could lead to an overestimate due to selection bias. He also noted that the model may be valuing more than just subsistence harvests. Hausman's re-estimation differed from the Wolfe-Walker model in several regards: all indicator variables (regardless of statistical significance) were retained and an instrumental variable approach was used to account for the joint determination of income and subsistence harvest levels by the choice of livelihood. This model resulted in much lower estimated value per pound of subsistence harvest – $ 33.60 in 1982 dollars or $ 38.65 in 1989 dollars, as compared to $ 118 per pound in the original Wolfe-Walker study. Hausman computed harvest loss using Subsistence Division data. His approach involved developing a time series model that included indicator variables for the spill year and post-spill years as a measure of aggregate change. He found that harvests had totally recovered by 1991. His aggregate claim estimates (apparently only applied

56. Stephen R. Braund & Associates and P.L. Usher Consulting Services, "Effects of the Exxon Valdez Oil Spill on Alutiiq Culture and People," 1993.

57. See Lind, Robert C., "The Computation of the Monetary Value of the Damages Suffered by the Alutiiq People Affected by the Exxon Valdez Oil Spill," presented at the Exxon Valdez consolidated court case, February 23, 1993, table 1, p.17.

58. Ibid., p.18.

59. In Duffield 1991.

to the 411 native claimants) were for $ 2.8 million before adjustments. He adjusted these figures by subtracting $ 7.6 million estimated income resulting from working on the oil spill cleanup. He concluded that net damages were minus $ 4.7 million based on the hedonic approach.

Hausman also used a replacement cost estimate for the "product value" of the resources lost. He concluded that since Exxon provided food for native villagers in 1989, "product value losses in 1989 are approximately zero since the lost food was replaced".[60] He noted that since the food provided was not an exact substitute, some remaining small losses may have occurred.

6.4 Motion to Dismiss Noneconomic Claims

This section provides a detailed discussion of the legal arguments that eventually lead the Court to reject the hedonic approach and require only a replacement cost approach. The legal and economic reasoning reported here was central to the subsistence claim outcome.

In early 1994, Exxon moved for summary judgment on the Alaska Native class claims for "non-economic injury".[61] Exxon sought summary judgment on all Alaska Native claims for compensatory damages for injury to "culture" or the "subsistence way of life," arguing *Robins Dry Dock* excluded them. The court granted this motion on March 23, 1994. The defendants thus essentially made the Braund report (and implicitly the economic analysis based on it) inadmissible. This important judgment by the court had considerable implications for economic valuation methodology. The court characterized the motion as follows:

… the motion seeks summary judgment on the Alaska Native non-economic claims for alleged injury to [their] "subsistence way of life," which is said to be a "personal economic, psychological, cultural, communal and religious form of daily living" that is "dependent upon the preservation of uncontaminated natural resources, marine life and wildlife."[62]

The court then added, "The motion is not addressed to claims for damages measured by the economic value of any loss of subsistence harvest which were proximately caused by the *Exxon Valdez* oil spill".[63] Choice of language ("non-economic" claims) may explain why this motion prevailed. But the court's characterization of the motion raises a question that the court does not address: what

60. Hausman op cit., p.17.
61. Order No. 190, Exxon Valdez Consolidated Case at 1.
62. Ibid. p. 2.
63. Ibid.

is a "non-economic" claim and what are claims "measured by the economic value of any loss of subsistence harvest"?

The major part of the reasoning in this order has to do with whether Alaska Natives suffered an injury that was different in kind, not just in degree, from that suffered by the general public. The court concluded:

> The Alaska Natives do not have a viable maritime, public nuisance claim as their claim is only different in degree but not in kind, from that suffered by the general population of Alaska.[64] In the last analysis, what the Alaska Natives seek is a recovery which is not founded upon a legal theory currently recognized by maritime law. They assert that theirs is a non-market economy, and that their damages should not be measured by market economy standards.[65]

The footnote to this sentence reads: "The Alaska Natives tacitly recognize that their cultural damage claim must in the end be converted to dollars. How, they do not say." The court's meaning here remains unclear. At the very least, this statement seems to indicate that the court did not understand or was not even aware of the valuation methods plaintiffs (and, at this point, defendants) were using. Is the judge ruling out any type of so-called "nonmarket valuation" approach? Another interpretation is that the judge is confusing the injury and reduction in lost services (e.g. the use of subsistence resources) with the methods used to value it. This ruling turned the economic question – How does one value lost subsistence use? – into a legal question of – What is an admissible "claim"?.

Order No. 190 was incomplete and raised more questions than it answered by clearly barring "non-economic" claims. But what are "non-economic" claims? By specific reference, the Braund report and claims having to do with pain and suffering apparently would be inadmissible. Order No. 190 was filed on March 23. On March 30, plaintiffs began involving the authors in developing alternative economic estimates of subsistence harvest loss for the Alaska Native class. On April 8, plaintiffs filed exhibits that provided implicit price and replacement cost estimates of the value of the lost subsistence harvest. The implicit price model used the Wolfe-Walker data base with education as an instrumental variable. A parameter of $ 32.46 per pound was estimated resulting in damage claims for the native class of $ 80 to $ 100 million. The replacement cost based claim, using Anchorage market prices plus delivery costs, totaled around $ 20 million.

64. Ibid. p. 7.
65. Ibid. p. 9.

6.5 Defendant Motion to Preclude Evidence

In response to the new plaintiff exhibits, defendants filed a motion on May 12 to preclude evidence, witnesses, and exhibits "offered in violation of Order 190 and expert witness order".[66] The court responded with Order No. 237 on June 30 in large part granting Exxon's motion. The court's reasoning is as follows: The bulk of Exxon's motion is devoted to its efforts to preclude the testimony of two experts, Robert Lind and John Duffield. Both Lind and Duffield are economists who have placed a value on "the economic choices made by Alaska Natives to participate in a subsistence economy as opposed to taking a wage-paying job in the mainstream economy."[67] According to plaintiffs, merely compensating natives for lost subsistence harvests "does not take account of the value placed by the Natives on their subsistence harvest activities, as revealed by their choice to engage in these activities, and is therefore wholly inadequate in assessing the actual economic injury to Alaska Natives resulting from lost subsistence harvests."[68]

As Order No. 237 put the matter:

> The court grants Exxon's motion regarding Lind and Duffield. The value Alaska Natives place on their choice to engage in subsistence activities is a non-economic "way of life" claim which this court has already rejected. In the case of subsistence harvests, to place a value on anything other than the lost harvest itself is to place a value on lifestyle. The court recognizes that lifestyle has a value, but that value is non-economic. Quite simply, the choice to "engage in [subsistence] activities" is a lifestyle choice, and damages to lifestyle were rejected in Order No. 190. The lifestyle choice was made before the spill and was not caused by the spill.[69] [Order No. 237 at 2–3]

The court here appears to interpret erroneously the plaintiff's approach as placing a value on a choice – a choice made prior to the spill and therefore not affected by the spill. This interpretation entirely misses the point that the implicit price method aims at developing a parameter, an implicit price, which one can infer in a baseline situation from observable behavior. This price is not really the value of "the choice" but a unit value for an attribute of the choice-subsistence harvests. In short, the court apparently did not understand the methods being used to value subsistence harvest. The statement from Order 237 is telling: "to place a value on anything other than the lost harvest itself is to place a value on lifestyle." But the fact is that lost harvest 'in itself' has no value. The only value associated with the lost harvest is its use through harvest and consumption. Order 237 seems strangely

66. Clerk's Docket No. 5266.
67. Plaintiffs' opposition, p. 2.
68. Ibid. pp. 2–3.
69. Order No. 237, pp. 2–3.

at odds with the court's earlier insightful description of the impact the spill had on subsistence users:

> [The spill] directly reduced the subsistence harvesters' immediate ability to consume that resource. The spill interfered with the subsistence harvesters' ability to "lawfully and directly make use of a resource of the sea in the ordinary course of their business," that business being their very livelihoods.[70]

Given this view of the subsistence economy, it is odd that the court would not accept the argument that real economic choices natives make about this "livelihood" and "their business" reveal the value they place on subsistence harvests.

Order 237 implied that the court categorically rejected the implicit price approach. The court explicitly noted: "Lest there be any doubt, the claims of the native subsistence harvesters are limited to the economic value of the lost subsistence harvest".[71] In fact, plaintiffs were attempting to do exactly this. Fortunately, the court provided a clarifying footnote: "The court does not see any great difficulty in placing a value on a pound of bear meat, herring roe, or other such foods not normally available in stores. The cost of equivalent foods may be employed".[72] In short, the court unambiguously provided its definition of "economic value" – replacement cost at market prices. Footnote 6 of Order 237 notes, "Exxon requests that the court exclude Duffield's testimony except for that part of the testimony which relates to the replacement cost of subsistence harvest."[73]

The court's view of economics is quite at odds with the fundamental valuation principles discussed above. The court apparently believes that commodities have some inherent and knowable value independent of human use. The court seized on the fact that some of these resources (and certainly some of their potential substitutes) have market prices – somewhere else, in some other context, like an Anchorage supermarket – and insisted that this is the value of subsistence harvests to natives who never pay or receive that price for those commodities and whose preferences and economic situations in many ways are unrelated to the Anchorage supermarket. In short, the court ordered the use of market prices (from another market) and ignored the fact that a market does not exist for the commodities and uses at issue.

Exxon successfully argued, and the judge accepted, the exact opposite of what, in the authors' opinion, is the correct position. On page 1 of their reply brief, defendants state: "Despite plaintiffs' efforts to conceal this issue, this motion presents

70. Order No. 222, p. 7.
71. Order No. 237, p. 4.
72. Ibid.
73. Ibid. p. 3.

no dispute about economic methodology. All the economists agree on methodology. They agree that "revealed preference methods" – which derive economic values from data about people's choices – are a proper way to value goods. The dispute is not among economists, but among lawyers. It is a legal dispute about the "goods" the economists should be instructed to value. Should the economists be instructed, as plaintiffs are doing, to value "subsistence activities" or the "subsistence way of life"? Or should they be instructed, as defendants contend and as Order 190 held, to value "lost subsistence harvest"? This is a purely legal issue that the court must resolve. Indeed, from defendants' point of view it is an issue that the court has *already* resolved, in Order 190.[74] This statement contradicts the facts of the situation. The argument is entirely about economic methodology – the methodology to be used to value subsistence harvests. Defendants recognized that economists agree on using "revealed preference" methods, yet they argued vigorously against the only revealed preference method that all three economic experts proposed and actually applied. Defendants did not explain how replacement cost, based on Anchorage prices, reveals native preferences.

The defendants skillfully used a series of motions that resulted in a very narrow range of admissible economic methods for valuing lost subsistence use. The evaluation of the economic valuation methodology was a jury question that should have met the same fate as the earlier arguments over the use of Subsistence Division data. Instead, defendants successfully presented this issue as a point of law.

6.6 Pre-settlement Damage Estimates

The legal maneuvering on the native subsistence claims at least partially abated with Order No. 237. Having turned the case into an accounting problem, defendants dispensed with Hausman's services and turned to a statistician, Richard Berk, to compute damages using the court-ordered replacement cost approach. Order No. 237 came out on June 30 and totally reconfigured the playing field. Because the court had indicated that Phase IIB would start shortly after the jury came back on the commercial fish case, both sides were under pressure quickly to develop damage estimates consistent with the new order. Table 4 summarizes final pretrial damage estimates that were produced by mid-July.

The defendants estimated the total native claim at $ 8.6 million. Plaintiffs provided a range of $ 19.0 to $ 27.5, depending on the definition of a native household (Table 4). The two parties mainly differed in the estimated total pounds of lost harvest due to ambiguity about per capita harvest levels in villages that were seldom if ever surveyed. Both parties used Anchorage prices plus delivery to villages for

74. Reply Memorandum June 27, 1994. p. 1.

marketed commodities. For some commodities, such as seal and deer, plaintiffs determined that retail markets provide no equivalent foods, and instead priced delivery of fresh whole carcasses from a broker.

6.7 Outcome

The native subsistence case settled around July 22 for $ 20 million. The jury did not come back on the commercial fish case until August 11. The settlement clearly leaned to the plaintiff side and in fact was slightly above their lower range. One possible reason for this is that the defendants may not have wanted the jury to view the native case just prior to considering punitive damages.

7. Long term perspective on subsistence losses

This section provides a long-term perspective on subsistence losses associated with the *Exxon Valdez* spill, and an update of the subsistence valuation model used in the federal trial. According to the Exxon Valdez Oil Spill (EVOS) Trustee Council, as of 2010 twelve of 31 resources impacted by the EVOS had not yet fully recovered to pre-spill levels.[75] As summarized in Table 5, some species dependent on near-shore habitat are not recovering (pigeon guillemots, Pacific herring) and the still recovering resources as of 2010 included intertidal communities, clams, mussels, and sea otters. Consistent with this finding by the trustee council are observed continued suppressed harvest levels for these resources and concerns with food safety on the part of Alaska natives, based on extensive surveys by the Division of Subsistence, Alaska Department of Fish and Game.[76]

75. See EVOS Trustee Council 2010. http://www.evostc.state.ak.us/universal/documents/publications/2010IRSUpdate.pdf

76. For example, see Fall, James A., Rita Miraglia, William Simeone, Charles J. Utermohle, and Robert J. Wolfe. "Long term consequences of the Exxon Valdez oil spill for coastal communities of Southcentral Alaska." Technical paper No. 264. Division of Subsistence, Alaska Department of Fish and Game, Juneau, 328 pp. April 2001.

Table 5: EVOS Trustee Council 2010 Status of Impacted Resources.

Recovery Status	Definition	Resources	
Not Recovering	Continue to show little to no clear improvement from injuries	Killer Whales-AT1 Pacific Herring Pigeon Guillemots	
Recovering	Demonstrating substantive progress towards recovery objectives, but are still adversely affected	Barrow's goldeneye Black Oystercatchers Clams Harlequin Ducks Designated Wilderness	Intertidal Communities Killer Whales-AB Mussels Sea Otters Sediments
Recovered	Recovery objectives met. Current status not related to oil spill.	Archeological Resources Bald Eagles Common Loons Common Murres Cormorants	Dolly Varden Harbor Seals Pink Salmon River Otters Sockeye Salmon
Very Likely Recovered	Incomplete information but prior studies indicate continued impacts unlikely	Cutthroat Trout Rockfish Subtidal Communities	
Recovery Unknown	Data is limited on life history or extent of injury from spill	Kittliz's Murrelets Marbled Murrelets	

Source: EVOS Restoration Plan: 2010 Update, p. 7.

By contrast, as described previously, subsistence harvest damages due to the *Exxon Valdez* spill were limited to the seven year period 1989–1995. The following discussion compares the subsistence settlement with longer term data that shows continuing reduced harvest levels for some subsistence resources.

7.1 Updated Alaska Subsistence Valuation Model

The estimated Hausman and Duffield harvest income models are now based on 30 year-old data. Indexing these results using average Alaska personal income per capita suggests that were this same relationship to hold today, total subsistence harvest NEV would be on the order of $ 75.58 per pound. The 1980s model was updated using the most recently available per capita income,[77] subsistence

77. American Community Survey 5-year averages 2006–2010 (Table B19301) www.census.gov/acs/

harvest,[78] education,[79] and cost of living data[80] for the 90 communities included in both the Hausman and the Duffield models. The updated model (Table 4, column 3) was estimated with community-level income pre-adjusted to Anchorage, AK levels. The estimated implied value per pound of subsistence harvest is therefore simply the negative inverse of the income parameter, or $ 86.06.

One difference between the earlier Hausman and Duffield models and the updated subsistence model is in the per capita income measure used. Hausman and Duffield both used Alaska Department of Revenue data on community level adjusted gross income (AGI). The updated model utilized average community per capita personal income from the most recent U.S. census. This second measure is the more appropriate income measure in that it includes certain amounts (relating in part to the State of Alaska's tax deduction rules) that are deducted from total income in the calculation of AGI. The updated income measure is consistently larger than the Alaska AGI originally used, with the latter being on average an estimated 70 % of the former.[81] The magnitude of the income measure used is directly proportional to the estimated value of subsistence harvest NEV per pound calculated from the estimated model income parameter. A likely range of estimated subsistence harvest values is the estimated $ 86.06 value, based on the updated dataset and specification, and a lower bound estimate of $ 60.24 per pound ($ 86.06*0.70) based on the assumption of consistently using Alaska AGI rather than per capita personal income in the updated model.

Based on both the Hausman[82] and Duffield[83] analyses, the correct in principle way to value subsistence harvests is to use the compensating wage differential approach. By contrast, Table 6 reports a replacement cost estimate (as required by Judge Holland during the federal trial, as discussed earlier) of just product values for subsistence harvests at $ 13.28 per pound.[84] In 2011 dollars, this product value is estimated at $ 19.77 per pound.[85]

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78. Alaska Fish and Game Department of Subsistence, http://www.adfg.alaska.gov/sf/publications/
79. American Community Survey 5-year averages 2006–2010 (Table GCT1502) www.census.gov/acs/
80. McDowell Group, Alaska Geographic Differential Survey: 2008. McDowell Group, Anchorage, AK. www.legis.state.ak.us/basis/get_documents.asp?session=26
81. http://www.irs.gov/uac/SOI-Tax-Stats---Historical-Data-Tables "Table 4. Comparison of Personal Income in the National Income and Product Accounts (NIPA) with Adjusted Gross Income (AGI). For Specified Tax Years, 1990–2005).
82. Hausman 1993.
83. Duffield 1997.
84. This value is the simple average of the replacement cost of lost harvest between two definitions of households in Table 6.
85. It should be noted that a significant component of subsistence harvest in some communities is marine mammals, a resource with a very high market replacement cost.

Table 6: Pre-settlement Compensatory Damage Estimates for Alaska Native Class Lost Subsistence Use

	Defendants	Plaintiffs	
		ADF&G definition of Native[a]	Native Only Households[b]
Number of Claimants	3,620	3,620	3,620
Total Pounds Lost Subsistence Harvest:			
1989–1992	854,682	1,334,472	1,455,919
1993–1995	–	179,391	506,143
Total	854,682	1,513,863	1,962,062
Avg. Replacement Value Per Pound	$ 10.03	$ 12.55[c]	$ 14.01[c]
Total Damages (1994 dollars)	$ 8,567,935	$ 18,992,436	$ 27,495,908

[a] Includes households where at least one head of household is native.

[b] Includes only households where heads of household are all native.

[c] Price differences reflect change in composition of lost harvest (particularly an increased proportion of maritime mammals in years 1992–1995).

Source: Plaintiff and defendant exhibits in *Exxon Valdez* case.

It should be noted that although the value of subsistence harvests per pound of $ 86.06 implied by the wage compensating differential model is large, simply the market replacement cost of these resources is fully 33 % of the lower-bound estimate and 23 % of the upper-bound estimate. As described earlier, in addition to simply procuring the usable pounds of raw subsistence harvest, many of these resources have substantial value-added in the form of processing by drying, smoking, or other preserving, cleaning, or other processing methods. This value-added is captured within the context of the wage compensating differential model.

7.2 Long Term Subsistence Harvest Implications

The $ 20 million settlement for subsistence losses in the Exxon litigation was based on the assumption of seven years of losses allowed by the court. In 2010, after 21 years, 12 of 31 resources impacted by the spill had not fully recovered. Estimates of subsistence losses (compared to the pre-1989 baseline level) in the area impacted, collected by Alaska Fish and Game Department of Subsistence for the period 1989–2003 also show a picture of resources still not fully recovered (Figure 1 and Table 7).

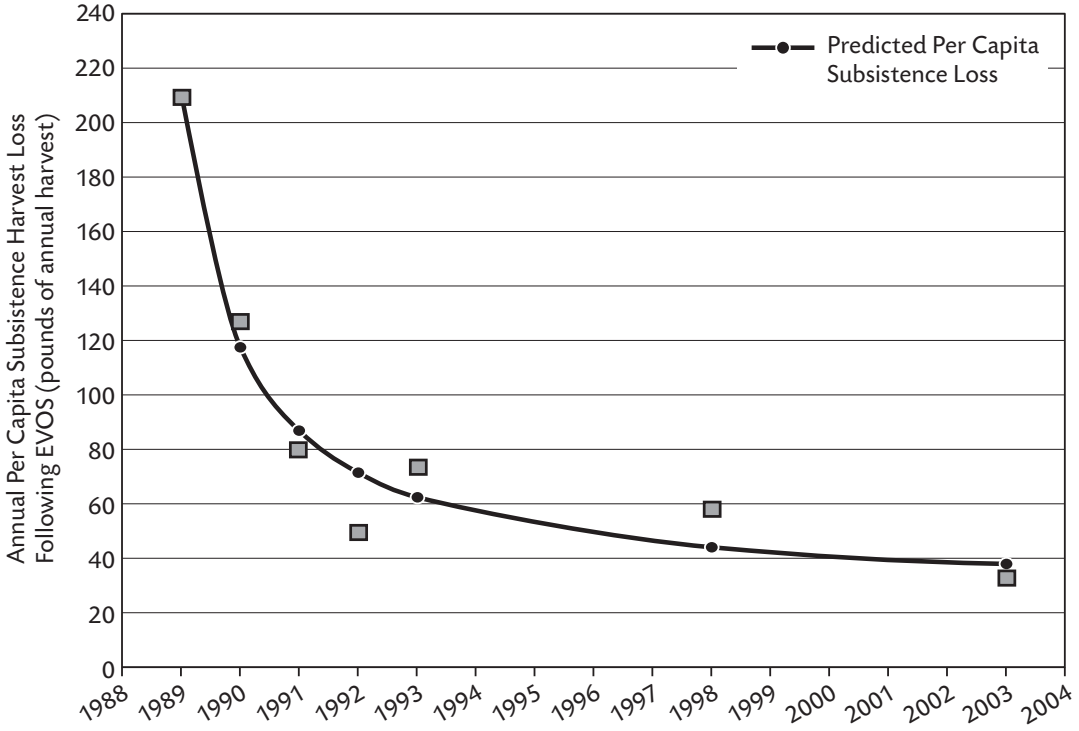

Figure 1: Observed and Predicted Subsistence Loss: 1989–2003.

Table 7: Estimated Subsistence Harvest Loss Model: 1989–2003.

Variable / Statistic	Estimated Parameter (Standard Error)
Intercept	26.05 (7.95)**
1 over Time	183.56 (17.32)***
Sample Size	7
R-square	0.957

A comparison of predicted subsistence losses to the Alaska Native claimants from the Table 7 model, and estimated losses upon which the Exxon settlement was based are shown in Table 8.

Table 8: Comparison of Estimated Long Term Subsistence Harvest Loss: Harvest Loss Model Predictions v. Exxon Litigation Settlement Basis.

Year	Predicted Loss per capita (lbs)	Population	Model Estimated Annual pounds loss	Exxon Case Loss
1989	209.62	3620	758,812	541,864
1990	117.83	3620	426,561	371,859
1991	87.24	3620	315,811	322,218
1992	71.94	3620	260,436	98,531
1993	62.77	3620	227,211	64,531
1994	56.65	3620	205,061	59,796
1995	52.28	3620	189,239	55,049
1989–1995		2,383,131	1,513,848	
1996	49.00	3620	177,373	–
1997	46.45	3620	168,144	–
1998	44.41	3620	160,761	–
1999	42.74	3620	154,720	–
2000	41.35	3620	149,686	–
2001	40.17	3620	145,426	–
2002	39.16	3620	141,775	–
2003	38.29	3620	138,611	–
1989–2003		3,619,625	1,513,848	

The Exxon Subsistence Class settlement was based on observed losses for the period from 1989–1992, and extrapolated losses for 1993–1995. For the observed period, the settlement estimated pounds lost was 1.5 million, and the model predicted loss was 2.38 million pounds. For the period full period of subsistence data (1989–2003) the total predicted loss was 3.6 million pounds harvest, compared to 1.5 million pound in the settlement. The implication of this simple prediction model based on additional subsistence harvest survey data is that long-term reductions in harvest are at least 2.4 times the settlement losses through 2003, the last year for which harvest survey data was collected. The more qualitative data from the trustee council indicates that important subsistence resources still had not fully recovered as of 2010 (see Table 5).

8. Long-term impacts on sport fishing

In addition to subsistence harvest, sport fishing in the Lower Cook Inlet and Prince William Sound was also impacted by the EVOS. As noted earlier, the Court ruled that sport fishing losses did not meet the *Robbins Dry Dock* standard and accordingly these recreational claims were dropped. Although these claims were not litigated, the losses are of interest as an example of how quickly (or slowly) this particular sector recovered. Of course recreational losses would be covered in contemporary U.S. oil spill legislation through an OPA cause of action.

The discussion here focuses just on observed reduction in angler use for Lower Cook Inlet using data supplied by the Alaska Department of Fish and Game Sport Fishing Division as shown in Figure 2. Two points from the figure involve the impact on sport fishing in the spill year (1989), and the duration of sport fishing impacts. In 1989, Figure 2 shows an increase in fishing days over those predicted by a simple trend line. This is attributable to the large number of oil cleanup workers who came to the area and engaged in fishing in non-oiled pockets of water in their time off work.[86] Therefore, fishing impacts were not immediately obvious due to cleanup-related factors.

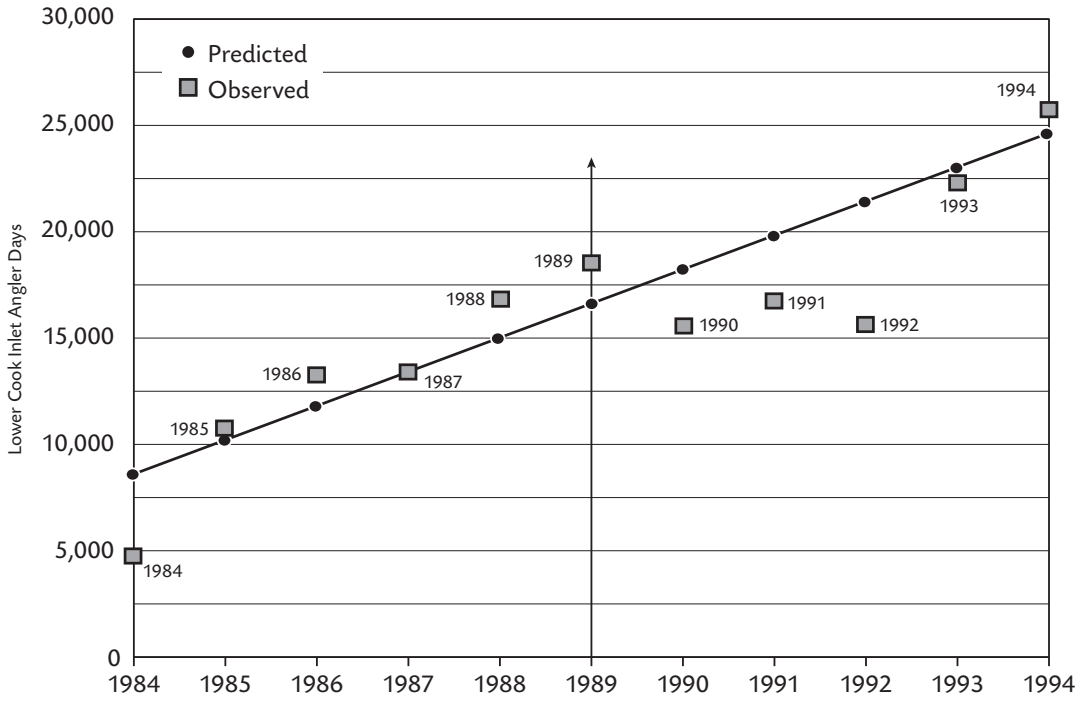

Figure 2: Observed and Predicted Lower Cook Inlet Annual Angler Sport Fishing Days: 1984–1994.

86. See Mills, M.J. "Alaska Sportfishing in the Aftermath of the Exxon Valdez Oil Spill." 1992 Alaska Department of Fish and Game, Division of Sport Fisheries, Special Publication No. 92–5. at p. 3.

Based on this data for Lower Cook Inlet, the negative impacts of the oil spill on fishing use lasted three years post-spill (1990–1992). By 1993 use levels were back on the predicted trend line.

9. Conclusions

The chronology for the native subsistence case suggests that nonmarket valuation has historically been a hard sell. Hopefully, this case will not prove to be typical. The outcome was influenced in part by the skill and resources the defendant brought to bear on the issues. In the authors' opinion, the court made key decisions on economic methodology that were internally inconsistent with its other decisions, and inconsistent with generally-accepted economic principles. These findings are similar to the cases where overly simplistic use of economic paradigms led to "bad" economics and "bad" law.[87] Perhaps in another arena, one where a $ 15 billion punitive claim is not looming, nonmarket valuation issues could get a better hearing and closer scrutiny.

The court's decisions were consistent with the narrow folk definition of economics as the realm of markets and commodity exchange. As Cummings notes,[88] "the essential substance of economic analysis" is tradeoffs. Yet, in this case, the court rejected plaintiff estimates that were based on tradeoffs revealed in market transactions. This case also illustrates the importance of economic rhetoric. While the plaintiffs won the first round in terms of having a claim under *Oppen,* the defendants successfully labeled some claims as "non-economic," repackaged their economics, changed experts, and won the second round on economic methods. The net effect was that, in the authors' view, the unit value of foregone subsistence harvests was underestimated during trial and settlement negotiations.

With hindsight, and based on subsistence harvest data collected through 2003, it appears that the quantity of harvest lost (in addition to the unit value) was also underestimated during trial and settlement negotiations by at least a factor of two. The need to reach closure in a litigation setting, at least in the case of the *Exxon Valdez*, appears to have systematically biased downward the compensation for resources and human services that have long recovery periods.

87. See Cummings, Ronald G., "Legal and Administrative Uses of Economic Paradigms: A Critique," in *Natural Resource Journal,* Winter 1991, pp. 463–473.

88. Cummings op cit., p. 473.