6.0 QUANTIFICATION AND SCALING OF RESOURCE SERVICES

The DOI regulations define a resource service as "the physical and biological functions performed by the resources including the human uses of those functions" (43 CFR §11.14(nn)). The quantification phase of the damage assessment must "establish the extent of the injury to the resource in terms of the loss of services that the injured resource would have provided had the discharge or release not occurred" (43 CFR §11.13(2)).

Present day uses of the Commencement Bay watershed include marine transportation; heavy industry; limited tribal commercial and subsistence fishing; various recreational activities, including boating and recreational fishing; and non-tribal subsistence fishing. Over the period of industrialization, from the turn of the century to the present, development and use of the bay and surrounding land area has been accompanied by increasing levels of contamination as well as the physical loss of aquatic habitat. The point- and nonpoint-source discharges throughout the 1900s have resulted in the accumulation of hazardous substances in the sediment and have caused injuries to the natural resources of Commencement Bay, including water, sediments, birds, fish, shellfish, and benthic and epibenthic populations. Exposure to SOCs may also have detrimentally affected the plants, aquatic birds, and fisheries in Commencement Bay and, subsequently, the use of these resources for commercial, recreational, and tribal activities. For example, health advisories have warned against the consumption of fish and crabs from the waters of Commencement Bay.

The surface waters of Commencement Bay provide habitat and support for a host of biological resources, as well as aesthetic, recreational, commercial, and tribal services to society, while sediments provide habitat to benthic and epibenthic communities which, in turn, are key nutritional sources in the food chain for both aquatic birds (e.g., the great blue heron) and fish species (e.g., juvenile salmonids, flatfish, rock fish).

Non-commercial fishing, including recreational fishing for salmon, steelhead, and resident fish, and subsistence fishing by tribal and non-tribal individuals, occurs throughout Commencement Bay. Moreover, the anadromous fish originating within the estuary are caught elsewhere in the Pacific Northwest and Pacific Ocean. In addition, a total of 130 species of birds are found regularly in Commencement Bay, including diving birds (loons,

grebes, and cormorants), ducks and geese, shorebirds (herons and rails), and raptors (peregrine falcons and bald eagles).

This section identifies services potentially affected by releases of the SOCs. Studies that directly address services (both ecological and human-based) provided by Commencement Bay resources are limited; thus, additional studies will be needed to fully quantify the loss of services associated with these exposures. In addition, this section provides potential approaches to quantifying resource injuries. The resource services have been grouped into two service flows: support of the ecological community and support of human activities (tribal activities, recreational/commercial activities, and passive uses).

6.1 NATURAL RESOURCE SERVICES

6.1.1 Services to Ecosystem

Commencement Bay (primarily the soft-bottom sediment habitat of the bay) provides services, either directly or indirectly, to a wide range of biological resources. Section 4.0 highlights some of the relationships that exist in Commencement Bay between the soft-bottom substrate and existing biological communities. Figure 4-2 presents a conceptual model for the Commencement Bay ecosystem that serves to illustrate these relationships. The benthic substrate provides habitat and serves as a food source for a wide range of benthic and epibenthic organisms. These organisms, in turn, serve as food to other benthic species, as well as serving as food directly to fish and larger invertebrates. The inter-relationships between species at higher trophic levels and soft- bottom sediments are also evident. For example, birds, such as the great blue heron, feed on flatfish and invertebrates, which in turn feed on the organisms that inhabit soft-bottom sediments.

Other aquatic habitat types in Commencement Bay may also have been injured by the release of SOCs, although injuries to these other habitats have not been documented at this time. While the extent of these habitats in Commencement Bay is now substantially less than that of soft-bottom habitats, primarily due to the extensive physical alterations that have occurred during development (see DEA [1991] for a discussion of habitat losses due to development), they provide critical services to key resources that are present in Commencement Bay. For example, juvenile salmon rely on the epibenthic invertebrates found in intertidal habitats as

a food source. Evidence of injury to resources using intertidal habitats is presented by Varanasi et al. (1993), who found that juvenile chinook salmon exhibit suppressed immune competence when exposed to PAHs and chlorinated hydrocarbons. Likely routes of exposure to PAHs and chlorinated hydrocarbons of juvenile salmon in the Injury Study Area include sediment and prey items. The reduction in services associated with natural resource injuries to habitats other than soft-bottom communities, although representing only a relatively small portion of the aquatic habitat present in the Commencement Bay ecosystem, should be quantified because of their overall importance to key Commencement Bay resources.

6.1.2 Services to Humans

This section identifies the major types of services provided to humans by natural resources that may have been injured within the Commencement Bay area.

6.1.2.1 Recreational Services

The City of Tacoma is the metropolitan focal point of southern Puget Sound, attracting visitors by both land and water. With the extensive revitalization and development of the Commencement Bay waterfront in the last 5 years, this area has regained its reputation as a prime recreational area for the entire Tacoma and Pierce County region. The following recreational activities are currently ongoing in and around Commencement Bay:

- Charter/party boat fishing
- Scuba/skin diving
- Private boat fishing
- Wildlife viewing
- Pier/shoreline fishing
- Swimming
- Recreational boating
- Picnicking

The quality and/or quantity of these activities, however, with the possible exceptions of recreational boating, swimming, and picnicking, may still be reduced relative to activities under baseline conditions because of releases of SOCs.

Fishing

Fishing occurs from a number of locations in Commencement Bay. Three of the main types of fishing are charter/party boat fishing, private boat fishing, and pier/shoreline fishing.

- ***Charter/Party Boat Fishing***—Charter/party boat sport fishing occurs in Commencement Bay on boats that originate from within Commencement Bay and on boats that travel into the bay from other areas. This type of fishing is directed toward both salmon and bottom-fish, depending on the season. Within Commencement Bay, boat operators leave from the Tacoma City Center area.

- ***Private Boat Fishing***—Private boat fishing occurs from boats launched, moored, or docked within Commencement Bay, or from boats that travel into Commencement Bay from outside locations. A number of launch sites are available around Commencement Bay including:

  - Browns Point Park (private ramp)
  - Tacoma Waterways Industrial Area (public ramp, hoist)
  - Tacoma City Center (public hoist)
  - Commencement Bay Parks (public handcarry, small boats)
  - Point Defiance Boathouse (public ramp, hoist)
  - Days Island (public ramp)
  - River Marina

  In addition, a number of marinas are located in the waterways and along the shore of Commencement Bay.

- ***Pier/Shoreline Fishing***—Public piers available for fishing are located at Old Town Dock, The Boathouse at Point Defiance Park, and Les Davis Pier. Beaches at Point Defiance, Browns Point, and the Ruston Way Parks allow fishermen a convenient access point for fishing from shore.

Non-consumptive Uses

In addition to fishing and boating activities, a number of other non-consumptive recreational activities occur within Commencement Bay. Non-consumptive use refers to the use of a resource that does not involve harvesting of the resource (e.g., birdwatching, swimming), while consumptive use refers to those uses of a resource that involve harvesting of the resource (e.g., hunting and fishing). These non-consumptive activities, swimming, sport diving, picnicking, and wildlife viewing, occur at a number of sites around Commencement Bay, but primarily in the Point Defiance and Ruston Way areas. In addition to wildlife

viewing on Commencement Bay, the 9.5-acre Gog-le-hi-te wetland is used for wildlife preservation and viewing.

6.1.2.2 Tribal Services

Natural resource services provided to the Puyallup and Muckleshoot Tribes are those that stem from a host of tribal practices largely related to the continued viability of their resource-based society, including subsistence. The existence of these services is revealed by the fact that tribal members expend time and money to retain their cultural heritage and identity through fishing and tribal programs to restore and maintain natural resources.

For the natural resource damage assessment, an understanding of Puyallup and Muckleshoot Tribes' reliance upon the natural resources of Commencement Bay and the Puyallup River system can be based on ethnographic and ethnohistorical research.

6.1.2.3 Passive Use Services

The passive use component of value is unrelated to an individual's actual visit to Commencement Bay. Passive use values are the values individuals place on resources that are not linked to direct use of a resource by the individual. Passive use values include: the value of knowing the resource is available for use of family, friends, or the general public; the value derived from protecting the resource for its own sake; and the value of knowing that future generations will be able to use the resource. Passive use values may pertain to the provision of, improvement to, or prevention of injury to natural resources.

Resources at Commencement Bay that might be expected to generate substantial passive use values include the following:

- Spring-run chinook salmon because they are being considered for federal listing as threatened or endangered
- Other salmon, steelhead, and fish species
- Shellfish (e.g., shrimps, crabs, clams)
- Bald eagle, peregrine falcon, and marbled murrelet because they are federally listed as threatened or endangered

- Other bird species (e.g., great blue heron, other waterfowl)
- Marine mammals

Members of the general population may hold substantial passive use values for these resources based on a variety of motives, including altruism, environmental stewardship, and concern for future generations. Members of tribal groups may have stronger or more compelling motives to generate passive use values for these resources because of their spiritual/religious practices associated with the resources. Additional motivation would derive from a strong dependence on the resources for tribal lifestyle and cultural activity. Information can be developed to show that, because tribal religious and cultural practices are observable, the resources arguably provide direct as well as passive use values.

6.2 INJURY QUANTIFICATION

Injury quantification involves both identifying resource injuries in quantifiable terms and determining the reduction in services (relative to baseline conditions) associated with the resource injuries. Information developed during the injury quantification phase of a damage assessment will be used during the damage determination phase to establish the amount of money to be sought in compensation for injuries to natural resources. 43 CFR § 11.80(b) of the DOI regulations (revised rule dated March 25, 1994) states:

> The measure of damages is the cost of restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the injured natural resources and services those services provide. Damages may also include, at the discretion of the authorized official, the compensable value of all or a portion of the services lost to the public for the time period from the discharge or release until attainment of the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources and their services to baseline.

For Commencement Bay, injury quantification will serve two basic purposes in the damage assessment process:

- Provide information required to establish damages that are related to the losses of services caused by the releases

- Provide sufficient detail to allow for the determination of the compensable value associated with the loss of services provided by injured resources prior to restoration to baseline services

The DOI regulations provide general guidance on the process of quantifying the reduction in resource services, which includes the following steps (43 CFR § 11.71 (b)1-(b)5):

1. Measure the extent to which the demonstrated injury has occurred in the assessment area

2. Measure the extent to which the injured resource differs from the baseline conditions to determine the change attributable to the release

3. Determine the services normally produced by the injured resource, which are considered the baseline services

4. Identify interdependent services to avoid double-counting and to discover significant secondary services that may have been disrupted by the injury

5. Measure the disruption of services resulting from the discharge or release

In addition to defining baseline conditions, injury quantification will require determining the extent to which resources have been injured and reduced. For sediment resources, injuries and services can be quantified by determining the total area of sediment surface that contains SOCs that exceed the SMS concentrations (see 43 CFR § 11.71(h)). Injury quantification of biological resources should be made at the population, habitat, or ecosystem level of organization (see 43 CFR § 11.71(l)). Considering the lack of sufficient historical data concerning population levels of species in Commencement Bay, it is likely that the approach to be used in quantifying injuries will be either at the habitat or ecosystem level.

This section identifies some of the approaches that can be used to quantify reductions in services provided by injured Commencement Bay natural resources. Inadequacies of the current data do not suggest either that no human service losses have resulted from resource injuries or that measurement of these injuries is not possible. Complete quantification of all substantial resource service reductions will require additional focused comprehensive studies.

6.2.1 Baseline Level of Services

An important step in the estimation of damages associated with reduced use of Commencement Bay resources—recreational activity, for example, or tribal reliance on the harvested resources—is the establishment of baseline conditions from which to quantify injuries.

Procedures for developing of a baseline condition are provided in 43 CFR § 11.70 to 11.73. The procedures require that the quantification phase determine "the effect of the discharge or release in terms of the reduction from the baseline condition in the quantity and quality of services" (43 CFR § 11.70a).

Baseline conditions are defined in 43 CFR § 11.72(b)(1) as follows:

> "Baseline data should reflect conditions that would have been expected at the assessment area had the discharge ... not occurred, taking into account both natural processes and those that are the result of human activity."

In addition, it is stated that quantification must "measure the extent to which the injured resource differs from baseline conditions ... to determine the change attributable to the discharge or release."

Under the following conditions, the procedures allow for the use of historical and/or control area data:

- "If available and applicable, historical data for the assessment area or injured resource should be used to establish the baseline" (43 CFR § 11.72(c))
- "Where historical data are not available ... or do not meet the requirements ... baseline data should be collected from control areas" (43 CFR § 11.72(d))

Because of the historical nature of past human activities (and impacts) in Commencement Bay and the varied history of resource uses, direct application of historical data to define baseline conditions may not be practical. Two specific baseline issues that need to be addressed in quantifying Commencement Bay injuries include:

1. Resources of Commencement Bay may have been affected by a number of factors, including exposure to SOCs both within and beyond the Commencement Bay Injury Study Area, habitat loss, habitat loss outside of the Commencement Bay Injury Study Area, and over harvest

2. Demands for resource services have decreased over the decades during which contamination has accumulated in Commencement Bay; the observed demand for services post-1980 could be lower because of adjustments related to the contamination of resources in the bay

The first issue deals with the scientific problem of unraveling causative variables affecting resource services, and thereby the supply of natural resource services. The second issue calls attention to the presence of a resource quality variable in the demand for natural resource services and suggests that observed behavior post-1980 would include a response to lowered resource quality due to identified contamination.

6.2.2 Loss of Services to Ecosystem

6.2.2.1 Quantification of Services Provided by Sediment

43 CFR § 11.71(h) provides recommended methods for quantifying injuries to surface water resources, including establishing the areal extent of SOCs present in sediment relative to baseline conditions. For Commencement Bay, quantifying injuries to sediment can be accomplished using one of two methods:

- Using biological data that demonstrate resource injuries (e.g., sediment toxicity data) to establish areas of Commencement Bay in which SOCs in the sediments are causing injuries and loss of services

- Using sediment standards promulgated by the SMS draft or the recently published U.S. EPA sediment quality guideline concentrations

Although both methods could be used to quantify injuries to sediment, for the purposes of this planning document, injury to Commencement Bay sediment can be quantified by determining the areal extent to which substances of concern are present in concentrations that exceed the SQS. Section 2.0 of this report provides a partial analysis of the areas in which selected SOCs are present at concentrations that exceed the SQS concentrations. Further studies, however, will need to be conducted to verify that the concentrations of SOCs present in the sediments do result in injuries to other resources. Not all SOCs that may be present at

concentrations that result in injuries to sediment have published SQS concentrations. For these substances of concern, only the first method of delineating injured sediments will be used.

6.2.2.2 Quantification of Services Provided by Biological Resources

43 CFR § 11.71 (1) states that the extent to which injured biological resources differ from baseline conditions should be determined by analysis at the population, habitat, or ecosystem level. Choosing the appropriate level of biological organization to use in the quantification process should be based on an analysis of population, habitat, or ecosystem changes that meet one or more of the following categories (43 CFR § 11.71 (1)(2)):

- Species or habitats that can represent broad components of the ecosystem, as representatives of a particular ecological type, a particular food chain, or a particular service
- Species, habitats, or ecosystems that are especially sensitive to the identified SOCs and for which recovery will provide a useful indicator of successful restoration
- Species, habitats, or ecosystems that provide especially significant services, even though they may not be designated as special resources

Given the widespread distribution of substances of concern in Commencement Bay sediment (see Section 2.0), and the likelihood of substantial injuries to biological resources at all trophic levels, the appropriate level of biological organization to use in quantifying injuries is either the habitat or the ecosystem level. The primary habitat-type potentially injured by releases of the SOCs is the soft-bottom habitat.

As discussed in Section 6.1, the soft-bottom substrate of Commencement Bay provides services, either directly or indirectly, to a wide number of biological resources. Quantifying resource injuries can be accomplished by evaluating each habitat type separately, or by evaluating impacts to the aquatic ecosystem as a whole. Quantifying injuries at the habitat level is recommended because it avoids double-counting of resource injuries. Quantification of injuries to biological resources at the habitat level does not require a complete examination of the entire Commencement Bay food web, or establishing injuries to all

ecosystem components. The primary habitat type potentially affected by the substances of concern is the soft-bottom habitat, although other habitat types may also have been injured.

As discussed previously, 43 CFR § 11.71(1)(2) states that biological injuries can be quantified at the habitat level by selecting "species or habitats that can represent broad components of the ecosystem, either as representatives of a particular ecological type, of a particular food chain, or a particular service." Injuries to biological resources in Commencement Bay can be quantified at the habitat level by establishing and quantifying injury to the following resources:

- Benthic species
- Macroinvertebrates, such as selected crab or shrimp species
- Bottom fish, such as selected species of flatfish
- Pelagic fish, such as juvenile stages of salmon
- Top-level consumers, such as the great blue heron

6.2.2.3 Baseline Services

As discussed in Section 6.2.1, the historical nature of human activities in Commencement Bay makes establishing the baseline level of resource services difficult. Activities such as extensive dredging and port development have affected biological resources in the bay, including the loss of more than 95 percent of the original mudflat and marsh habitats (see DEA, 1991). The result of these activities has been to severely modify the complexity of Commencement Bay habitats, creating primarily a mono-habitat of shallow subtidal, soft-bottom sediments. Intertidal areas still exist, but unlike the intertidal mudflats historically present in Commencement Bay, the intertidal habitat of present day Commencement Bay is dominated by the rip-rapped, steep-sloped sides of the maintained waterways. Because of these extensive alterations, baseline services provided by many of the resources of the Commencement Bay soft-bottom habitat cannot be determined by comparing the current habitat conditions with the habitat as it was before substantial human activity occurred.

The DOI regulations provide an alternative approach to establishing baseline resource conditions and services using suitable control areas (43 CFR § 11.729(d)). Control areas are selected based on their similarity to the assessment area and lack of exposure to the SOCs (43 CFR § 11.72(d)). Selected control areas for biological resources need to be comparable, but not necessarily identical, to the habitat of the assessment area in terms of habitat

distribution, type, quantity, and relationship to other habitats, as well as species composition (43 CFR § 11.72(A)(3)(i)(A)). If injuries exist to multiple resources, then multiple control areas can be identified for the purpose of quantifying the injuries to each resource (43 CFR § 11.72(K)(3)(i)(K)).

Commencement Bay offers unique challenges in identifying suitable control areas for quantifying natural resource injuries. A review of the Puget Sound region indicates that there are few embayments with similar size and shape, and with the riverine input of Commencement Bay. The few that do exist, however, have also been altered by human activities, including releases of hazardous substances (e.g., Elliott Bay and Bellingham Bay), making them unsuitable as control areas for many injuries.

Despite the challenges to finding a suitable location to serve as a single control area for establishing baseline conditions for all resource injuries, identifying suitable control areas to serve as a measure of baseline conditions for each potential injury is a more straightforward process. Control areas must be comparable to the assessment area for those factors that will affect injury quantification. Many of the potential natural resource injuries identified in Commencement Bay are associated with components of the ecosystem that are relatively common in Puget Sound and for which suitable control areas can be found. For example, the extent to which exposure to substances of concern compromise the immune system of juvenile salmon can be quantified by comparing the percentage of the sampled population in Commencement Bay having a suppressed immune system to the percentage in populations of juvenile salmon from other systems showing a similar response. Because a majority of the juvenile salmon present in Commencement Bay are hatchery-released, a suitable control area would be one in which hatchery-released juvenile salmon dominate the population. Such control areas exist throughout Puget Sound, including the nearby Nisqually Delta.

One of the more difficult resource services to quantify is that associated with injuries to the benthic community. As discussed by Simenstad et al. (1993), it is not possible using the historical data available from Commencement Bay to temporally differentiate between the impacts to benthic communities caused by physical changes and those caused by the release of SOCs. Benthic communities in Commencement Bay are theoretically affected by a number of factors other than substances of concern, including dredging activities and occasional boat traffic.

When considering the services provided by benthic communities or the populations of selected community members, it is important to note that the primary services provided are associated with the nutritional well-being of other species in the Commencement Bay ecosystem. Nutritional well-being is related to both the quantity and quality of food provided by the benthic community. Quantity of food is related to the abundance of benthic species over a given area, as well as the presence or absence of key prey species. Quality of food, on the other hand, is related to the nutritional composition (e.g., percent lipid and polyunsaturated fatty acids) and the presence of hazardous substances in the tissues that could affect predator species.

In selecting a control area for quantifying injuries to the benthic community associated with the quantity of food provided to other aquatic species, two factors become apparent:

- There is no other single, uncontaminated embayment in Puget Sound that is comparable to Commencement Bay in attributes that might affect the abundance of benthic populations

- There is no other area in Puget Sound in which dredging has occurred for the purposes of maintaining navigational depth where navigation or other commercial activities have not and do not continue to occur, and that is free of SOCs

An alternative approach to selecting a single control area for quantifying injuries to benthic communities is to select multiple areas and to use benthic community data to construct a "statistical" benthic community that is representative of baseline conditions. Areas selected would represent a range of conditions and factors that are thought to affect the benthic community abundance in Commencement Bay. Examples of Puget Sound areas that could be used as control areas in establishing the composite benthic community include:

- The Nisqually Delta, which represents a near pristine complex habitat environment, similar to the environment that may have existed in Commencement Bay prior to human activities

- Carr Inlet, which represents a typical southern Puget Sound soft-bottom environment

- Oak Harbor, which represents an area that has undergone dredging and development activities related to water uses and contains only low-to-moderate concentrations of some SOCs

- The north shoreline of Commencement Bay, which represents a largely undeveloped area within the ecosystem that may have been only minimally contaminated by the release of hazardous substances

- Blair Waterway, which represents a developed area within the ecosystem that has been only marginally contaminated by the release of hazardous substances

Quantifying the differences in quality of food provided to other aquatic species can be accomplished using a more direct comparison to uncontaminated control areas. For example, a major pathway for substances of concern to affect the immune system in juvenile salmon may be related to the ingestion of prey items contaminated with PAHs and chlorinated hydrocarbons (Varanasi et al., 1993). Comparing concentrations of the substances of concern in benthic species from areas from which fish were collected that exhibit immune suppression to the concentrations in benthic species in areas from which fish do not exhibit immune suppression provides a means by which this loss of service can be quantified.

6.2.3 Loss of Services to Recreation

Available data for determining the loss of services are divided into two main categories: recreation data and resource data. Recreation data focus on the levels and locations of the various recreational activities occurring within the Commencement Bay area, such as the number of salmon anglers and the quantity of their catches. Resource data are focused on the levels of resources (e.g., abundance of catchable species) present in the Commencement Bay area, such as salmon or shellfish populations.

There are two main sources of data available for boat-based fishing within Commencement Bay: WDF Statistical Reports and Washington State Department of Fish and Wildlife (WDFW) Sport Catch Reports. The WDF Statistical Reports contain information on both sport and commercial catches of anadromous fish, marine fish, and shellfish in the state of Washington by region, in addition to catches of salmon by Indian tribes. These reports provide estimates on the catch of fish, not the amount of effort (i.e., number of anglers or boats) necessary to achieve this catch. Table 6-1 shows the sport catches for chinook salmon for the years 1946 through 1988 for the entire Puget Sound as reported in WDF Statistical Reports. Tribal subsistence catch is excluded.

Table 6-1. Number of Sport Catches of Chinook Salmon by Major Catch Area

Year	Numbers of Chinook Salmon Caught by Area							Total
	Inner Puget Sound	San Juan Islands	Neah Bay and Strait of Juan de Fuca	LaPush	Ocean Shores Westport	Columbia River	Fresh-water	
1946	51,400	1,000	8,600	0	0	23,400	0	84,400
1947	69,500	1,400	11,500	0	0	12,800	0	95,200
1949	75,500	1,000	16,000	0	0	11,200	0	103,700
1950	73,100	900	24,100	0	0	16,600	0	114,700
1951	90,800	1,100	39,800	0	0	7,200	0	138,900
1952	108,600	500	38,700	0	54,000	11,000	0	212,800
1953	88,000	1,100	32,300	2,500	10,000	14,700	0	148,600
1954	131,400	1,700	46,300	3,600	23,000	12,500	0	218,500
1955	127,100	2,500	33,800	3,000	49,000	12,900	0	228,300
1956	174,600	1,200	31,900	7,000	69,000	34,400	0	318,100
1957	207,900	3,700	39,400	5,200	56,000	18,700	0	330,900
1958	119,700	2,400	43,000	4,000	36,000	25,000	0	230,100
1959	73,600	2,600	46,400	1,800	41,000	23,400	0	188,800
1960	82,100	1,300	21,800	3,400	43,000	37,700	0	189,300
1961	89,600	3,700	38,700	1,200	45,000	20,500	0	198,700
1962	93,600	14,500	18,400	2,500	50,000	29,900	0	211,600
1963	124,000	29,200	22,100	3,500	52,000	32,600	0	263,400
1964	53,439	8,958	46,014	1,913	49,908	22,069	0	182,301
1965	71,839	6,930	38,830	5,822	68,591	48,680	0	240,692
1966	74,566	9,439	52,213	2,002	70,113	59,313	0	267,646
1967	56,059	13,916	49,775	6,401	84,084	63,761	0	273,996
1968	53,483	21,069	52,109	6,368	91,750	37,870	0	262,649
1969	48,203	16,034	60,965	6,138	102,270	33,490	0	267,100
1970	78,666	19,822	48,179	7,708	79,660	66,033	0	300,068
1971	88,162	19,108	55,088	4,052	106,829	40,160	0	313,399
1972	87,141	24,928	91,632	7,069	123,300	67,339	0	401,409
1973	126,470	11,168	73,502	9,664	101,681	77,607	34,951	435,043
1974	145,440	23,960	102,872	16,484	92,427	88,781	21,070	491,034

Table 6-1. continued

Year	Numbers of Chinook Salmon Caught by Area							Total
	Inner Puget Sound	San Juan Islands	Neah Bay And Strait of Juan de Fuca	LaPush	Ocean Shores Westport	Columbia River	Fresh-water	
1975	203,990	31,988	111,800	18,558	89,075	140,191	21,373	616,976
1976	161,483	55,248	101,781	6,946	91,479	60,974	25,966	503,877
1977	106,332	25,763	71,242	2,734	100,953	63,999	27,471	398,494
1978	128,649	25,203	82,022	2,674	64,785	21,768	31,552	356,653
1979	169,254	35,827	84,488	1,944	48,654	27,621	21,442	389,230
1980	154,704	22,031	70,529	931	28,274	15,660	19,161	311,290
1981	96,535	16,546	54,559	75	57,472	23,897	16,892	265,976
1982	77,311	13,004	33,022	998	83,091	19,483	21,836	248,745
1983	112,444	23,963	60,512	139	35,773	10,414	21,733	264,978
1984	90,037	36,578	48,232	10	6,028	8,827	23,750	213,462
1985	80,515	22,489	46,319	300	18,148	8,510	19,851	196,132
1986	71,158	30,208	71,848	339	15,289	12,689	30,292	231,823
1987	56,472	13,877	55,344	214	29,733	37,105	39,917	232,662
1988	59,574	9,412	43,049	574	13,442	22,108	39,604	187,764

Source: Washington Department of Fisheries Statistical Reports.

The WDFW Sport Catch Reports are detailed reports on the locations and levels of recreational fishing for salmon, sturgeon, shellfish, and marine fish. Their primary focus is on sport-caught salmon. These reports contain both the numbers of sport-caught fish and the numbers of fishing trips. For purposes of collecting data on salmon fishing, the WDFW has divided the state of Washington into 13 primary reporting or Salmon Punch Card Areas (PCAs). Commencement Bay is located in PCA 11[1]. Table 6-2 shows historical numbers of recreationally caught salmon in the 13 PCAs. Table 6-3 lists the number of anglers and associated catches for PCA 11 for the period 1970 through 1990. As Table 6-3 demonstrates, there are, on average, 44,318 salmon caught and 139,925 angler trips each year in PCA 11. Table 6-4 shows the total 1990 sport salmon catch by location[2]. In Puget Sound, the most popular mode of sport fishing is by private/rental boat, accounting for approximately 80 percent of all recreational sport trips, with charter boat and shore fishing accounting equally for the other 20 percent (State of Washington, 1988).

Traditionally, Pacific salmon have been the target catch of most marine angling trips, and bottom-fish have been caught incidentally within Puget Sound. However, during recent years, a greater interest in halibut, lingcod, and rock fish has resulted in anglers taking more trips to fish for bottom-fish. The greater interest in bottom-fishing may have resulted from reduced salmon stocks and restricted fishing seasons, the increase in the number of anglers, and a greater popularity for catching and eating bottom-fish.

Unlike the salmon fishing data, the bottom-fish data are reported in a much less systematic manner. No annual statistical reports directed toward sport bottom-fishing are prepared by WDFW, although WDFW does estimate the number of anglers and catch. Additionally, those data that are reported are aggregated for the entire southern Puget Sound area (combined PCAs 11 and 13). Table 6-5 shows bottom-fish catches and angler trips in the southern Puget Sound area for the period 1970 to 1985.

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[1] In 1976, several area boundary lines were changed resulting in 13 PCAs instead of 12. PCA 11 originally contained all of the southern end of Puget Sound from the northern tip of Vashon Island. The change in boundary lines resulted in a division of this area into two sections: the new PCA 11 covers the northern tip of Vashon Island to the Tacoma Narrows Bridge, and the new PCA 13 covers the area south of the Tacoma Narrows Bridge.

[2] In 1981, WDFW determined that a bias existed in the salmon punch card data that resulted in an overestimation of the sport catch in the Puget Sound area. Consequently, the sport salmon catch estimates are adjusted, beginning in 1981, by multiplying the original punch card estimate by 0.833.

Table 6-2. Annual Sport Salmon Catches from 1964 to 1990

Year	Total	Freshwater	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8	Area 9	Area 10	Area 11	Area 12	Area 13[a]
1964	475,662	28,988	111,385	103,094	11,055	45,051	46,309	13,912	16,186	5,528	40,289	21,466	24,476	7,923	–
1965	940,223	54,509	279,225	275,457	23,694	57,606	53,620	23,477	18,803	10,253	58,004	28,368	43,077	14,130	–
1966	756,896	52,948	203,806	176,447	28,262	78,016	33,887	23,748	23,575	5,729	60,135	22,533	24,235	23,575	–
1967	1,063,096	135,250	315,594	214,661	53,325	84,871	55,401	32,601	29,878	6,125	61,662	18,564	20,861	34,303	–
1968	877,276	61,663	210,693	284,923	23,075	73,556	67,734	36,245	25,489	3,621	45,511	17,785	19,135	7,846	–
1969	876,648	79,905	200,379	270,777	21,054	80,945	75,902	46,227	23,748	3,695	28,059	16,589	19,976	9,392	–
1970	978,395	135,974	269,232	303,372	36,894	46,659	30,579	26,027	21,842	5,690	43,648	23,200	24,265	11,013	–
1971	1,344,818	145,904	342,928	446,738	39,682	87,184	71,947	39,573	28,355	5,189	54,920	35,225	27,332	19,841	–
1972	1,138,926	121,432	307,938	353,113	31,278	61,704	45,446	45,058	29,536	3,097	42,968	32,942	35,962	28,452	–
1973	1,095,360	147,554	236,385	348,406	49,900	48,645	33,347	40,308	14,852	3,966	52,935	42,574	61,919	14,569	–
1974	1,320,420	88,048	334,664	320,467	74,832	80,362	50,319	53,222	36,318	5,491	76,518	69,341	105,110	25,728	–
1975	1,399,375	101,531	308,475	331,565	57,356	59,451	48,975	74,336	37,626	7,726	100,089	78,832	162,072	31,341	–
1976	1,749,560	100,601	433,026	543,295	70,133	68,670	63,966	102,639	55,396	21,688	88,737	62,607	61,562	24,405	52,835
1977	1,191,414	96,843	248,518	321,888	38,359	86,186	73,106	61,568	31,709	17,792	64,651	39,372	44,657	22,020	44,745
1978	1,107,852	86,845	220,548	269,338	24,439	52,270	59,400	68,849	36,293	13,229	73,187	56,479	48,018	26,801	72,156
1979	1,123,809	88,659	167,478	174,365	24,160	53,840	134,354	70,839	48,101	33,835	104,619	71,167	71,495	20,006	60,891
1980	852,879	105,461	158,883	163,748	19,146	29,500	39,587	52,663	24,457	18,432	60,072	52,128	57,751	17,138	53,913
1981	760,115	58,139	142,879	151,301	1,734	36,883	55,900	56,318	21,826	16,986	67,838	42,602	42,175	14,989	50,545
1982	736,926	91,849	102,769	158,005	9,857	42,716	67,611	33,870	12,947	9,940	49,853	49,727	51,975	8,672	47,135
1983	860,623	108,783	98,599	100,791	7,318	58,469	62,486	74,311	29,844	23,268	98,485	54,228	72,772	11,756	59,513
1984	561,428	142,170	79,792	16,631	167	6,604	39,276	67,246	29,985	17,442	79,526	24,130	28,781	5,158	24,520
1985	686,333	107,734	93,927	93,620	2,062	26,878	101,920	45,342	23,798	25,427	75,193	33,019	38,157	4,897	14,359
1986	830,644	115,469	156,275	98,421	2,553	25,027	138,951	71,544	27,550	26,822	79,730	33,686	33,891	3,460	17,265
1987	782,834	110,636	123,441	71,458	3,005	29,418	107,138	82,377	27,152	31,421	86,270	42,179	32,753	8,947	26,639
1988	701,755	168,594	141,646	62,001	3,341	19,576	107,935	47,483	22,225	16,514	47,109	28,020	22,202	2,420	12,689
1989	831,960	121,417	155,235	100,000	2,405	44,600	164,580	64,766	19,078	23,165	63,724	36,748	24,561	4,588	7,093
1990	824,171	107,934	114,722	102,984	5,809	48,329	223,012	54,848	12,797	14,865	57,875	47,519	25,555	1,618	6,304

Source: Washington State Department of Fisheries Sport Catch Reports.

[a] In 1976, several Punch Card Area (PCA) boundary lines were changed resulting in 13 PCAs instead of 12. The changes were mostly reflected in PCAs 8, 9, 10, and the new area 13.

Table 6-3. Salmon Catches In and Angler Trips to Punch Card Area 11

YEAR	SALMON	ANGLERS[a]
1970	28,750	94,137
1971	26,817	69,829
1972	33,388	74,796
1973	33,522	91,570
1974	56,430	118,078
1975	87,011	132,378
1976	61,562	153,575
1977	44,657	139,636
1978	56,479	203,030
1979	71,495	189,423
1980	57,751	194,682
1981	42,175	126,313
1982	51,975	171,396
1983	72,772	161,589
1984	28,781	95,659
1985	38,157	151,032
1986	33,891	171,323
1987	32,753	191,836
1988	22,202	117,449
1989	24,561	141,392
1990	25,555	149,309
Average	**44,318**	**139,925**

Source: Washington State Department of Fish and Wildlife Sport Catch Reports.

[a] Pre-1976 catch and angler trips were reported for the total South Sound, Punch Card Areas (PCAs) 11 and 13. Pre-1976 numbers reported here are estimates of PCA 11 catch and trips.

Table 6-4. Total 1990 Sport Salmon Catches and Number of Angler Trips by Location

Marine Area	Number of Salmon					Total Salmon	Marine Angler Trips	Salmon Per Trip
	Chinook	Coho	Chum	Pink	Sockeye			
Ilwaco-Ocean (Area 1)	9,897	87,898	23	0	26	97,844	67,832	1.44
Ilwaco-Buoy (Area 1)	3,612	13,266	0	0	0	16,878	51,025	0.33
Westport-Ocean Shores (Area 2)	16,829	86,102	50	0	3	102,984	69,309	1.49
LaPush (Area 3)	600	5,207	0	0	2	5,809	4,190	1.39
Neah Bay (Area 4)	2,674	45,642	0	3	10	48,329	32,165	1.50
Subtotal Coast	33,612	238,115	73	3	41	271,844	224,521	1.21
Sekiu-Pillar Point (Area 5)	37,752 [a]	185,118 [a]	0 [a]	23 [a]	119 [a]	223,012 [a]	208,729	1.07
East Juan de Fuca (Area 6)	12,735 [a]	42,080 [a]	23 [a]	10 [a]	0 [a]	54,848 [a]	87,436	0.63
San Juan Islands (Area 7)	7,390 [a]	5,166 [a]	24 [a]	6 [a]	217 [a]	12,803 [a]	52,812	0.24
Deception Pass, Hope, Camano Island (Area 8)	7,661 [a]	7,105 [a]	0 [a]	0 [a]	93 [a]	148,590 [a] 0	100,115	0.15
Admiralty Inlet (Area 9)	22,538 [a]	35,264 [a]	68 [a]	0 [a]	5 [a]	57,875 [a]	187,649	0.31
Seattle-Bremerton (Area 10)	17,574	29,745	112	0	88	47,519	148,186	0.32
Tacoma-Vashon Island (Area 11)	15,729 [a]	9,793 [a]	33 [a]	0 [a]	0 [a]	25,555 [a]	149,309	0.17
Hood Canal (Area 12)	679 [a]	411 [a]	528 [a]	0 [a]	0 [a]	1,618 [a]	9,341	0.17
South Puget Sound (Area 13)	3,446 [a]	2,497 [a]	361 [a]	0 [a]	0 [a]	6,304 [a]	72,644	0.09
Subtotal Puget Sound	125,504	317,179	1,149	39	522	444,393	1,016,221	0.44
Marine Area Totals	159,116	555,294	1,222	42	563	716,237	1,240,742	0.58
Freshwater Totals	41,871	19,125	4,328	270	6,800	107,934 [b]	—	—
TOTALS	200,987	574,419	5,550	312	7,363	824,171	—	—

Source: Washington State Department of Fish and Wildlife Sport Catch Report.

[a] Due to the lack of sampling data, some salmon were recorded, but unidentified. An average from recent years was used to determine species composition of these salmon and per trip value.

[b] Total includes an additional 35,492 males and 48 other unidentified salmon.

Table 6-5. Bottom-Fish Angler Trips and Catches From Southern Puget Sound

YEAR	ANGLER TRIPS	CATCH
1970	2,967	11,368
1971	4,562	8,185
1972	4,465	14,954
1973	22,149	70,280
1974	30,752	103,874
1975	33,517	111,062
1976	51,917	248,013
1977	55,367	286,564
1978	42,470	285,083
1979	69,030	432,493
1980	73,242	345,000
1981	95,515	474,032
1982	129,275	541,790
1983	135,537	507,943
1984	65,145	265,442
1985	62,228	159,540

Source: Palsson (personal communication 1993).

The most comprehensive report on bottom-fishing was prepared by WDFW (1985). WDFW (1985) reports, for the period 1973 to 1985, an average of 66,626 angler trips, from both boats and piers/shorelines, yielding an average of 294,701 bottom-fish annually in the southern Puget Sound area.

Table 6-6 shows the estimated number of salmon and bottom-fish angling trips in PCA 11, and the estimated number of trips that occur within the Commencement Bay area.

Table 6-6. Estimated Salmon and Bottom-fish Angling Trips in PCA 11

ACTIVITY	ESTIMATED NO. OF ANNUAL TRIPS IN PCA 11	ESTIMATED NO. OF ANNUAL TRIPS IN COMMENCEMENT BAY
Boat-based salmon fishing	125,933	12,593[a]
Boat-based bottom-fishing	117,880[b]	11,788[a]
Shore-based fishing	42063	6,309[c]

[a] Estimated as 10 percent of trips to PCA 11 (Palsson, personal communication 1992).

[b] PCA 11 is approximately 50 percent of PCAs 11 and 13 combined.

[c] Landolt et al. (1985) estimated that Commencement Bay contains approximately 15 percent of the fishing structures in PCA 11.

In January 1981, the Tacoma-Pierce County Health Department first issued health advisories for the consumption of fish and shellfish caught within the Commencement Bay nearshore area. In 1982, the CB/NT area was listed as a national Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 1985, the Tacoma-Pierce County Health Department began posting signs warning against the consumption of fish from these areas of Commencement Bay.

It is probable that the official warnings have affected the types and levels of recreational activities occurring within Commencement Bay. It is also likely that the impacts of SOCs occurred before the advisories were issued because of local knowledge of conditions within the bay. Moreover, conditions in the bay may have lowered the overall abundance of the species and reduced catch rates from what they would have been in the absence of SOCs.

Recreational users can respond to conditions within the bay in four primary ways:

- Lessen the frequency with which they participate in recreational activities in an attempt to lessen exposure to SOCs
- Change the location of their recreation to a site that is not affected by SOCs
- Cease recreational activities altogether
- Recreate as frequently, but experience reduced satisfaction due to reduced quantity and/or quality of resources of interest

The actual response an individual will take as a result of the conditions depends on the individual's preferences, the amount of contamination at the site, and the availability of other uncontaminated locations appropriate for their chosen recreational activities. If concentrations of SOCs are high, and substitute sites do not exist, then the likely response is to stop participating. However, if many other uncontaminated sites exist, the likely response would be to substitute the clean sites for the contaminated ones.

In Commencement Bay, recreational activities most impacted by the substances of concern can be divided into two categories:

- Those relying on natural resources injured by substances of concern, such as fishing and wildlife viewing
- Those requiring direct contact with the water, such as scuba/skin diving and swimming

To determine the reduction in recreational activities within Commencement Bay as a result of the SOCs, two questions must be answered:

- What types and levels of recreational activities would have occurred in Commencement Bay if long-term contamination by the SOCs had not been present?
- How did people adjust their recreational activities as a result of that contamination?

Two approaches can be employed to answer these questions. The first approach uses historical data on recreational activities to determine a baseline level of recreation in the absence of contamination problems. This baseline level could then be adjusted for population growth trends, and changes in the popularity of specific activities, to determine what would have been the present-day levels of these activities. The calculated level of activity would then be compared to actual present-day recreational levels to determine the amount of recreation lost in Commencement Bay. This lost recreation in the bay would be adjusted to account for substitution away from the bay to other recreation sites, in order to develop a net loss to individuals as a result of contamination within Commencement Bay.

The second approach uses estimates of the current levels of recreational activities occurring in Commencement Bay, along with estimates of the reduction in natural resources these

activities rely on, to determine the potential activity levels in the absence of contamination. As opposed to the first method, which measures recreational activity directly, this method relies on a "production function" theory of recreation to determine the potential levels of recreation that could occur in the bay in the absence of contamination. Using the "production function" theory, natural resources (e.g., healthy, bountiful fish populations; clean water) are used as inputs to the production of recreational activities. Thus, the greater the availability of inputs, the greater the level of output, in this case recreation (Bergstrom and Stohl, 1993).

Selection of the most appropriate method to determine impacts from contamination depends primarily upon the availability of adequate data. If adequate data exist to estimate pre-contamination baseline conditions, and changes from this baseline can be attributed to increased contamination levels, the first approach would most likely be appropriate. If pre-contamination data are not available or are inadequate, then measurement of current activity levels can be used in conjunction with knowledge of resource depletion to develop an estimate of potential recreational levels in the absence of contamination. This method develops the baseline levels for comparison from the measurement of current levels of activities and resource depletion.

6.2.4 Loss of Services to Tribal Economies

The Puyallup and Muckleshoot Indian Tribes have experienced economic losses at Commencement Bay associated with:

1. The loss of access to and the reduction of the salmon runs in streams and rivers and in Commencement Bay

2. The loss of access to, and abundance of, the shellfish, bottom-fish, other fish, wildlife, and plant species along and within Commencement Bay

Injury quantification for SOC-related reductions in natural resource services to the Puyallup and Muckleshoot Indian Tribes is complicated because of the changes in those services resulting from physical alteration of the ecosystem.

Postulating a baseline demand, which includes all non-SOC-related reductions to tribal resource services, to determine the value of reduced resource services related to contaminants

will entail the determination of some intermediate tribal social condition between the pristine condition and condition for the tribes as affected by the injuries.

Because of the difficulty in establishing an intermediate baseline condition that includes all factors but the presence of SOCs, damage estimates may be more easily understood by comparing the resource services provided during the pristine and historical conditions to those provided post-1980. Total damages could be allocated among the injurious factors.

6.3 VALUATION OF NATURAL RESOURCE SERVICES

Natural resources have value because they provide satisfaction to people. This satisfaction may stem from directly observable services provided by the resources or from people's satisfaction derived simply from knowing that the natural resources are sustained in a healthy condition.

Societal values for resources reflect the quality and quantity of the service flows provided and conditions that affect access to the services of the resources, notably the presence and attributes of substitutes. Service flows typically refer to commercial, recreational, or other opportunities to enhance an individual's quality of life provided by the resource. The values for these service flows often are not observed in a market context because people cannot buy or sell access to the resources (i.e., they are not traded in markets). Economists label these values non-market values and have created specialized tools to measure them.

DOI regulations define the compensable value (or interim lost value) of the services lost to the public as "the value of lost public use of the services provided by the injured resources plus lost non-use values such as existence and bequest values" (43 CFR §11.83(c)(1)). Two categories of non-market values are defined in the regulations governing natural resource damage claims:

1. Direct use values, or the values people have for the onsite services of a resource. These typically can be measured by observing people's behavior. These services might be consumptive, such as fishing, or non-consumptive, such as wildlife viewing.

2. Passive use values, which are not related to current uses but stem from the existence of a resource attribute. These typically cannot be inferred from a person's behavior. Passive use values are considered to be higher in relation to resource uniqueness and in relation to the degree to which an injury is irreversible.

Total compensable value for injured resources includes both the direct use and passive use resource values. Further, total compensable value is added to restoration costs to determine total compensable damages related to injuries to natural resources. Compensable values accrue from the onset of the injury to the recovery of the baseline condition. Some general examples of uses people make of natural resources in Commencement Bay are provided in Table 6-7. Fishing, swimming, and boating are meant to illustrate typical non-tribal uses made of the resources. Tribal activities, including harvests of natural resources and cultural activities, are a broad second group of uses. Tribal harvest is the largest part of the local commercial catch. Wildlife viewing is meant to encompass hiking, bird watching, and general recreational activities that occur around Commencement Bay.

Table 6-7. Compensable Values for Commencement Bay Natural Resource Services

COMPENSABLE VALUE	
Direct Use Values	**Passive Use Values**
Recreational fishing, swimming, boating	Existence (spiritual)
Non-tribal subsistence and commercial fishing (economic rent)	Bequest (altruism)
Tribal harvests (commercial/subsistence)	
Tribal way of life/culture	
Wildlife viewing	

For the purposes of the natural resources damage claim, services related primarily to anadromous fish runs have been partitioned between non-tribal catch and tribal harvests because the services provided by salmon encompass several subcomponents that yield additive compensable values. The fisheries subcomponents include:

- Tribal subsistence harvest of salmon
- Tribal subsistence harvest of shellfish
- Incidental catch of other fin fish by tribal members for subsistence (e.g., smelt)

- Commercial and other exchange values for salmon by tribal members
- Recreational catch of salmon and other fin fish by non-tribal members
- Commercial catch by non-tribal members
- Subsistence catch by non-tribal members

In addition to direct use values, Table 6-7 identifies four possible passive use values. Other passive use values not listed in Table 6-7 include stewardship of the resources, vicarious protection of the resources, and protection of the ecosystem (or species) for intrinsic values. Table 6-7 lists spiritual values as a passive use category, although it can be argued that tribal spiritual practices related to natural resources constitute a direct use because the ceremonies related to these beliefs are observable. For the purposes of this planning document, tribal spiritual practices will be considered a passive use value.

Whether direct use or passive use values, a majority of the Commencement Bay resource services are not traded in any market from which values can be established. Moreover, standard direct use methods of valuation are unlikely to provide useful information about the values tribal members hold for their religious and cultural practices associated with natural resources. Consequently, a survey approach will be necessary to elicit total values—both direct and passive use—associated with spiritual or cultural reliance on the resource. Although the application of contingent valuation surveys to tribal populations has not been done extensively, there has been research applying this valuation method to elicit direct and passive use values from the general population. However, limited evidence exists to infer general levels of direct and passive use values held by the people of the Pacific Northwest in relation to their anadromous fisheries. In conjunction with the Northwest Power Planning Council's agenda to double the size of salmon and steelhead fish runs by the year 2000, Olsen et al. (1991) undertook a contingent valuation method survey of people's willingness to pay for existence of the resource and the sport fishery services for the anadromous fisheries of the Columbia River basin. The study provides estimates of direct use values for sports fishermen and passive use values for Pacific Northwest residents related to doubling the Columbia River run size. These values were estimated at $26.52 annually for passive use values reported by non-angler households and $74.16 annually for total values reported for angler households (in 1989 dollars). These values were attached explicitly to doubling the run size (i.e., adding 2.5 million fish to the returning fish run). These household values resulted in annual regional values for doubling the size of the fish runs in the range of $170 million for 3.4 million households. The study team divided the regional value by the management goal (i.e., adding 2.5 million returning fish by the year 2000) concluding that

the combined direct and passive use values per fish were in the range of $68.00 annually (Olsen et al., 1991).

The Olsen et al. (1991) values for specific salmon and steelhead enhancement policies are not reported in a "benefits transfer" context (i.e., benefits estimated in one or more situations similar to another situation). None of the appropriate steps to "borrow-in" these numbers have been undertaken. Rather, these values are reported simply because the Olsen et al. (1991) study is the only directly relevant study found in the literature survey. Nonetheless, one can assume that these estimates provide some indication of the level of value that might be found by competent contingent valuation research associated with restoring the health of the runs in Commencement Bay. Original research will be required to determine passive use and other direct use values people may hold for resources of Commencement Bay.