**Preassessment Data Report #2**

**M/V *Selendang Ayu* Oil Spill**

**Surveys of Intertidal, Subtidal, and Anadromous Stream Habitats**

**NOAA**

**Damage Assessment, Remediation, and Restoration Program**

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**Abstract.** On 8 December 2004, the *Selendang Ayu* went aground on Unalaska Island and spilled approximately 321,000 gallons of IFO 380 fuel oil and approximately 15,000 gallons of diesel fuel. About 70 miles of shoreline were within the area of principal oiling, defined as shoreline response segments where some portion required cleanup action. As a preliminary step in the natural resource damage assessment (NRDA) process, NOAA conducted preassessment surveys from December 27, 2004 through February 1, 2005 and from June 2 through 23, 2005. In the winter surveys, NOAA damage assessment teams examined the shoreline for patterns of oil movement and deposition, but daytime high tides were too high to comprehensively examine intertidal habitats for indications of oil impacts on the biota in these habitats. During two extreme low-tide series in June 2005, NOAA and scientists working for the responsible party conducted preassessment surveys of biota in intertidal, subtidal, and stream habitats in the spill area. In visual surveys of the perennial biota (algae and invertebrates) in rocky intertidal habitats, indications of possible adverse impacts of *Selendang Ayu* oil were observed at Spray Cape, but there were no other visible loss of species or reduced abundances of biota observed at other sites that could be attributed to the oil in the time period of 8 December 2004 to 20 June 2005. Shoreline clean-up operations, such as burning of oiled debris, use of heavy equipment, and removal of sand and other material from sections of oiled beaches, very probably killed or removed some beach-wrack biota and infauna to varying degrees. Between 20 and 23 June 2005, the teams observed beach cleaning operations that resulted in the release of oil into surface waters; this release apparently caused bleaching and necrosis of marine algae at HMP-11a. Warm conditions increase both the mobility and toxicity of heavy fuel oil, and these clean up-related oil releases and potential impacts resulting from those releasesmay have continued into the summer months after the field study data collection ended on 23 June 2005. In addition, the U.S. Coast Guard documented more releases of oil from the wrecked *Selendang Ayu* in October and December 2005, some of which stranded on the shoreline. The preassessment-scale surveys were designed to detect gross, acute, readily visible effects, such as acute mass mortality of biota, occurring before 23 June 2005. However, the observations made, as described herein, suggest that injury likely occurred to intertidal and subtidal biota. Additionally, injury to a variety of marine resources can be inferred from experience with similar-sized spills in similar environments and from the scientific literature.

**Introduction**

Preassessment surveys of intertidal, subtidal, and anadromous stream habitats, and associated fauna and flora were conducted in two time periods. In December 2004-January 2005, NOAA staff conducted preliminary field surveys of intertidal shores, subtidal habitats, and freshwater streams on Unalaska Island, in the area affected by the *Selendang Ayu* oil spill. These winter surveys mainly focused on documenting patterns of habitat oiling. Short day lengths, high daytime tides, and adverse weather conditions limited the observations that could be made of biota in these habitats. In June 2005, NOAA teams returned to the spill area during a series of extreme low tides to specifically conduct a second set of preassessment surveys of the biota in intertidal, subtidal, and anadromous stream habitats. Observations made during these surveys are presented below.

**Description of the *Selendang Ayu* Oil Spill**

On 8 December 2004, the *Selendang Ayu* grounded and broke in half on Spray Cape, Unalaska Island, 53o 38’ 04” N, 167o 07’ 30” W (Figure 1). An estimated 335,732 gallons of fuels, mostly Intermediate Fuel Oil (IFO 380), were released following the grounding. Additional information about the incident is available at the Unified Command Website for the *Selendang Ayu* incident:

http://www.dec.state.ak.us/spar/perp/response/sum\_fy05/041207201/041207201\_index.htm.

The Unified Command for the *Selendang Ayu* oil spill divided the 469 miles of shoreline in the potentially spill-affected area into 806 segments (Figure 2). Of these, 123 segments (70 miles) received enough oil somewhere in the segment to require oil clean-up treatment. The sum total of the length of oiled shoreline within all these segments was over 20 miles. One hundred and two of the oiled segments were actually approved for clean-up operations. Primarily because of safety concerns for the cleanup personnel, the remaining 21 segments were not treated.

Beach cleaning operations in the summer of 2005 remobilized unspecified quantities of stranded oil back into surface waters. In October and December 2005, storm waves moved the wrecked sections of the *Selendang Ayu*, causing the release of unknown quantities of additional oil for unknown periods of time. A civilian aircraft reported observing sheen around the vessel on 21 October 2005. The Coast Guard conducted occasional overflights following this report. On 24 October 2005, the Coast Guard conducted two overflights and reported seeing sheen and emulsified oil. This release was thought to have the potential to oil SCAT segments SPR 8, 10, 11, 12 and SKS 1, 2, 3, 4, and 5. The Coast Guard reported seeing a slow rainbow sheen burping up 350 yards from the stern section the following day, and saw a dull sheen the next day. No new oil was observed on the next four overflights conducted from 27 October through 26 November2005, but a thin sheen was observed on 1 December 2005 (information on reports of aerial observations came from a summary compiled by J. Hampton, Coast Guard). Through October 25, 2005, the Unified Command estimated that approximately 1,000 gallons of emulsified oil was released from the *Selendang Ayu* as a result of the storm waves (http://www.dec.state.ak.us/spar/perp/response/sum\_fy05/041207201/sitreps/041207201\_sr\_105.pdf), but this estimate has not been updated and may have missed possible releases occurring before and after October 24, 2005 on days without overflights. There is also no known estimate of the amount of oil that was reportedly released during the December storm.

**Surveys of the Spill Area**

**Winter Surveys: Observations of oil and biota from NOAA field surveys conducted in December 2004 – February 2005.**

*Objectives:* The main objectives of the winter surveys were to document patterns of oiling in habitats and collect ephemeral data (including samples of biota and oil taken from the shore).

*Methods:*NOAA pre-assessment teams conducted field surveys of the spill area on-foot from 27 December 2004 through 1 February 2005, in addition to observations made by Rapid Assessment Technique (RAT) and Shoreline Cleanup Assessment Technique (SCAT) teams. NOAA personnel participating in the pre-assessment field surveys were: Lisa DiPinto, Nick Iadanza, John Cubit, Doug Helton, Ian Zelo, and Daniel Hahn, with assistance from Danielle Savarese (Stratus Consulting). Janis Krukoff and Laresa Syverson (both with Qawalangin Tribe) and USFWS personnel also participated in these surveys. The USFWS vessel M/V *Tiglax* was used as a working platform. Landing on beaches was accomplished using skiffs. The selection of shoreline segments surveyed was determined by the USFWS sampling plan used to survey the segments for bird carcasses. This was a stratified-random design, with the strata being wave-exposed, wave-protected, and accumulation beaches. Segments were randomly selected within these strata. Segment identification codes were the same as was designated for SCAT surveys and is shown in Figure 2.

*Observations and Discussion:* In these winter surveys, days were short and daytime tides were high, so observations were limited to the highest portions of the intertidal zone. However, SCAT surveys documented that most of the oil on the shoreline e had been deposited at higher tide elevations by storm waves in the supratidal zone and in the seaward edge of the terrestrial vegetation. Most of the vegetation is Aleutian rye grass. In the winter, the above-ground portions of this grass were dead, straw-like, and appeared to have an affinity for the oil. In these high locations the oil was beyond the reach of the normal tides. Some of the oil was buried beneath gravel and cobble in storm berms. Evidence of mobile oil in the form of patties (congealed oil mixed with straw from Aleutian rye grass) was also observed. Many of the patties were about the size, shape, and thickness of shoe soles, sporadically stranded on the beaches. In these winter temperatures, any remobilized oil would not be liquid and would not form spreading slicks.

With temperatures around freezing (~32ºF, ~0ºC), most of the oil stranded on the shore was the consistency of thick, cold, sticky peanut butter. To illustrate the consistency of the *Selendang Ayu* oil in winter, the oil could be picked up as a lump with a wooden tongue depressor without losing its shape. When placed in seawater, it did not give off sheen and barely floated (it floated with more than 95% of the lump below the surface of the water). Nick Iadanza observed that the oil appeared less viscous on days with temperatures in the forties (ºF) (~8ºC) and produced sheen when placed in seawater.

Most of the oil we observed was partially emulsified (i.e., had incorporated water and become an oil-water mix). It was a medium brown color instead of black. When pressed with a tongue depressor, the masses of brown oil exuded droplets of water.

Numerous samples of potentially and visibly oiled sediments, the oil itself, and various kinds of biota (mostly mussels) were taken. These samples are being held in frozen storage and could be analyzed if the Trustees determine the information is needed.

In examining the invertebrate fauna of high beaches at Spray Cape (SPR11 and SPR13) on 7 January 2005, Dan Hahn reported amphipods and isopods coated with oil. These oil-coated crustaceans were both live and dead. Some of these appeared to have crawled upwards through the overlying oil. Ty Wyatt (USFWS) made similar observations, including photo-documentation (Wyatt, pers. comm.).

Additional observations of oil movement and deposition were made during the June 2005 surveys described below. Numerous photos illustrating the oiled shorelines and history of the *Selendang Ayu* oil spill are shown on the Incident Command website: http://www.dec.state.ak.us/spar/perp/response/sum\_fy05/041207201/041207201\_ph\_index.htm

**June Surveys: Observations of oil and biota from NOAA field surveys conducted in June 2005**

*Objectives:* The objectives for the June 2005 surveys were the following:

Identify resources at risk; that is, identify fresh, brackish, and marine water biota and habitat in the spill area that could have been injured as a result of the oil spill, including clean-up activities.

Document degree of exposure of natural resources to *Selendang Ayu* oil. (This objective incorporated SCAT data already collected and documented presence of oil in the environment and in/on biota.)

Document indications of possible resource injury caused by the *Selendang Ayu* oil spill and clean-up actions.

Collect ephemeral data (data that would be lost if not recorded by these surveys at this time) regarding potential injury to trust resources.

Collect any additional information necessary for designing or implementing future NRDA and restoration studies.

**Surveys of Intertidal Habitats in June 2005**

*Methods:*The NOAA and responsible party preassessment teamconducted two sets of surveys of intertidal habitats in June 2005, coinciding with the minus low tide series of 2-9 June and 19-23 June. The extreme low tides during these two periods facilitated our access to the lowest intertidal levels of the shores in the spill area.

The primary scientific personnel conducting the intertidal surveys for NOAA are all marine biologists with years of experience surveying intertidal biota in Alaska and/or the Pacific Northwest.

John Cubit (Lead scientist), marine ecologist, NOAA Damage Assessment Center: all June 2005 surveys (2-9 June and 19-23 June)

Allan Fukuyama, marine ecologist, University of Washington: first June surveys (2-9 June 2005)

Sandra Lindstrom, marine phycologist, University of British Columbia: first June surveys (2-9 June 2005)

Carolyn Kurle, marine ecologist specializing in Aleutian Intertidal biota, University of California, Santa Cruz: second June surveys (19-23 June 2005)

Ian Zelo (NOAA Hazmat) was data manager and participated in various field surveys. Nick Iadanza (NOAA DAC) and John Hudson (NMFS Auke Bay Laboratory) also participated in these intertidal field studies, but focused primarily on surveys of anadromous fish streams (see stream section below and their separate reports in the appendices). Jordan Stout (USFWS) conducted the photo-documentation for Cubit’s surveys in the first tide series. Christian Marcotte provided field support for Carolyn Kurle’s surveys. Amy Merten (NOAA Hazmat) also contributed field support. Representatives of the responsible party who participated in the surveys were Gary Mauseth, Bruce Kvan, Greg Challenger (all of Polaris Applied Sciences), and Jon Houghton (Pentec Environmental).

The work platform for these studies was the F/V *Ocean Olympic*, a 155-foot commercial crab fishing vessel whose use was arranged and paid for by the Responsible Party. Shores were accessed by skiffs with experienced skiff operators. In the fjord-like coastline of the spill area, the captain of the F/V *Ocean Olympic* was able to position the vessel near all the study areas for rapid access by skiff. This arrangement allowed the field team to visit any shore at any time of day, weather permitting, and then process data aboard the vessel. High surf prevented landing on some shores on some days, but visits to all shores of interest (as described below) were achieved by adjusting schedules around wave conditions. Thus the choice and number of shoreline locations visited was not restricted by accessibility.

Survey sites were chosen to maximize the following:

Geographic variation in the spatial patterns and degrees of oil exposure (e.g., amount of exposed surface covered with oil, amount of oil buried in beach, amount of oil deposited on high shore, extent of exposure to oil remobilized by beach cleaning operations, etc.). The northern extreme of the geographic range was Volcano Bay; the southern extreme was Chernofski Harbor (see map, Figure 1). The sites at the outer range of the surveys were only exposed to sporadic tar patties, as far as is known.

Ranges of substrate and shore types (e.g., mud, sand, gravel, cobble, boulder, solid bed rock, vertical shore, horizontal platforms, and combinations thereof).

Ranges of wave exposure (ranging from very high energy, wave-exposed, shores to very wave-protected, lake-like, inner inlets, with many intermediate shores within this gradient). The highly indented shoreline of the spill area had many bays and inlets, creating a high diversity of wave-exposure regimes.

Variations in types and diversities of intertidal biological communities (e.g., tidal marsh, algal dominated, invertebrate dominated, high diversity, low diversity, cryptic [under rock], exposed).

Per the methods described in the following, we also chose sites in the field to make matched comparisons of recently oiled and not oiled (“reference”) sites. This was done to scientifically investigate and test hypotheses regarding causality of effects observed during the field surveys.

Shoreline location segments (e.g., “SKN14”) were identified using the alphanumeric system instituted by the *Selendang Ayu* Unified Command (see map in Figure 1).

*Field Methods:*Because the location of the *Selendang Ayu* oil spill was remote and difficult to access, there was little preliminary information regarding possible impacts on which to base our survey designs. Therefore, we used an adaptive survey strategy in which one day’s observations were used to determine the next day’s operations. This strategy included field designation of gradients of oil exposure and designation of unoiled reference sites to test hypotheses that oil exposure caused any apparent adverse effects observed in the field.

In the field, the adaptive survey process was designed to function as follows. If apparent injury to biota was observed in the field, the first step was to determine if this injury was consistent with exposure to oil, as opposed to other factors, such as predation or effects of low tide exposure. Next, the shoreline location having apparently injured biota was compared to a “reference” location, which was the nearest location that had the same shoreline aspect (exposure to wave action, elevation, topography, etc.,) and habitat type, but with little or no exposure to oil. If similar injury also occurred in the reference location, the hypothesis that the injury was likely a result of exposure to oil discharged from the *Selendang Ayu* could be rejected.

As described below, at each site close-up examinations of the biota and substrata were made at all accessible shore levels. This included wading into shallow subtidal areas where shoreline slope and wave conditions permitted. The field surveys were conducted around the daytime low tides. The surveys started at upper tidal levels of the shore during the falling tide and proceeded to the lowest intertidal levels as the tide receded. Most intertidal surveys were conducted on foot after landing from skiffs. Vertical rock faces emerging from deeper water were surveyed from skiffs positioned next to the rock face. Observations of shallow subtidal biota were accomplished by wading into these habitats or floating over them in the skiffs. Deeper subtidal biota were surveyed by divers and video cameras, as described in the subtidal section.

Observations were made directly in the habitat surveyed, not from a distance. Biota were examined within arm’s length.

In the field, biota were examined, the condition, degree and distribution of oiling, and any indications of impacts of oil on the biota were documented. These observations were made by field biologists familiar with the taxonomy, appearance, and ecology of these species, including the effects of natural factors on these biota.

Biota were specifically inspected for visible oiling, abnormal coloration, necrosis, empty shells, abnormal behavior, mortality, and any other indications of possible oil exposure and oil effects. In particular, biota more than seven months old, i.e. preceding the *Selendang Ayu* grounding and oil spill, were carefully examined.

Fronds of large algae were lifted as necessary to view biota and oil, if any, beneath the fronds.

On beaches and boulder shores, boulders and cobble were lifted and gravel excavated, to examine cryptic biota.

Documentation of the observations made during the survey was by field notes and digital photographs, primarily.

Photographs were taken as close as necessary to document the species present, the condition of the biota, and patterns of oiling, if oil was present. Most documentation photos covered an area of about 0.25-1 square meter. Photographs of larger areas were used to document habitat-scale features.

Locations of photographs were recorded using the combined software set of Ozi Explorer (www.oziexplorer.com) and Ozi Photo Tool (oziphototool.alistairdickie.com). This software combination linked the GPS tracks to the digital photographs. GPS waypoints were used to link observations made in field notes to specific shore locations .

9. Voucher specimens were taken as necessary.

Each day when field biologists returned to the F/V *Ocean Olympic*, project data manager Ian Zelo downloaded data from the GPS units and digital camera media using the Ozi Explorer and Ozi Photo Tool programs described above.

*Observations and Discussion:*Portions of 55 shoreline segments (Table 1) were surveyed according to the procedures described above. Photo-documentation was extensive, totaling approximately 13GB of digital photos.

Rocky shore biota On shores with substrata of physically stable bedrock and boulders, an established biota of perennial marine algae and marine invertebrates was found (Table 2). Shores along the northeastern portion of Spray Cape (SPR11-SPR14) are near the wreck of the *Selendang Ayu*. In these segments, splatters of oil remained high on the shore. Here Lindstrom reported that the kelps (*Laminaria longipes* and other species) were reduced to stipes--the main portions of the blades were absent. Also, grazer populations appeared to be reduced. Bedrock at lower tidal elevations and fronds of the perennial algae *Fucus, Mastocarpus, Petrocelis*, and *Laminaria* in the mid-intertidal zone were overgrown by ephemeral green algae (e.g., *Acrosiphonia Ulothrix,* and *Urospora*).

On other shores, both oiled and unoiled, the perennial species were of a size and condition that indicated they had been present before the *Selendang Ayu* oil spill—i.e., they had settled and grown before 8 December 2004. In close and careful examination of the perennial biota there were no indications of visible acute mortality or other adverse effects on these perennial biota, except for Spray Cape and HMP-11a which was exposed to remobilized oil from beach clean-up operations in June, 2005.

Rocky shores were examined for the “green shore phenomena” caused by mortality of herbivores, which has been observed in other spills and in controlled field experiments removing herbivores. At all sites except Spray Cape, no clear indications of blooms of ephemeral algae that exceeded the normal spring blooms of algae found on these kinds of shores in the spring were found. Patterns of grazing marks, grazing patches, and herbivore distribution in these habitats indicated that *Littorina* *sitkana* and limpets (Lottiidae) were consuming the bloom-forming algae, forming cleared areas in the stands of the ephemeral algae. However, Lindstrom believes that the extent of growth of ephemeral green algae (*Acrosiphonia, Urospora, and Ulothrix)* at Spray Cape exceeded normal seasonal growth, especially where these green algae were growing as epiphytes on perennial algae in the mid-intertidal zone and on bedrock at lower tidal elevations. Lindstrom attributed the extent of this bloom to a general lack of grazers at these tidal elevations at this site. The cause for the observed lack of grazers cannot be attributed to oil exposure with the available information.

Beaches of cobble, gravel, sand. An abundant and diverse assemblage of cryptic beach invertebrates was observed beneath cobble, drift seaweeds and other beach wrack. These included talitrid amphipods (“beach hoppers”), centipedes, arachnids, and kelp flies. The talitrids were at densities of 1 to 10 per 100 cm2. In some cases, beach biota were within 10 cm of mats of buried oil, but no oil was found on the biota. In addition, on 19 June 2005, oiled wrack (accumulations of dead plant material) harboring amphipods living in direct contact with oil was observed on the beach at SKN-6. Although the amphipods did not appear oiled or to be experiencing acute effects from the oil, amphipods living in such close proximity to oil could serve as potential vectors of oil to higher trophic levels. Foxes were seen overturning rocks and wrack on beaches, apparently feeding on the beach invertebrates found there.

In the course of the surveys, large amounts of beach material were observed being removed from heavily oiled sections of beaches for disposal at waste sites. This material probably contained beach biota. For example, the excavating machinery at SKN-11 was removing the oiled cobble and gravel, placing it in “Super Sacks” for transport out of the area. Any biota in the beach material would have also been removed. Excavating machinery could have also crushed beach biota. In addition, oily debris was moved into piles and burned on some beaches which would have killed beach-wrack fauna and infauna in the vicinity of the fires. Many of the areas where burning of debris was conducted were in high wave energy areas with cobble and pebble sediments that are unstable and dynamic and may have less interstitial biota than areas with lower wave energy and finer sediments.

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the summer. At Spray Cape, there appears to have been a lack of herbivores, possibly a result of the spill, and resulting bloom of ephemeral green algae. There were also observations of dead eulachon, which could potentially be a result of exposure to oil from the *Selendang Ayu*.

Much of the most apparent and likely injury appears to be the result of response actions taken during warmer weather at some of the most heavily oiled areas. Biota in these areas and those nearby were exposed to remobilized oil, and some injury is likely to have resulted from that exposure- such as the apparent oil-related injuries to some algal species. While not observable in our surveys, there is also likely to have been sub-lethal effects to some biota within the areas most affected by the spill. However, the magnitude of likely injury resulting from the *Selendang Ayu* incident is relatively moderate, except perhaps at the most heavily oiled areas and those in the vicinity of oil remobilized during the cleanup operations in the spring and summer of 2005. The total length of shoreline where oil was observed to be present is approximately twenty miles, so some degree of injury to these habitats and biota likely occurred over a large area. The observations made during the winter and June surveys, together with information obtained from the response efforts, and what can be reasonably inferred from experience with the effects of similarly-sized spills in similar environments and the scientific literature indicate that an as yet undetermined amount of restoration will be needed to address the injury to natural resources and services in the intertidal, subtidal, and anadromous stream habitats.

Contact John Kern at john.kern@noaa.gov for more information

**Figure 1. SCAT survey map showing most of the area surveyed in the studies described in this report.** Chernofski Harbor is about 20 km southwest of “ALM” (Alimuda Bay) at lower left.



**Figure 2. Detailed map of SCAT segments (1 of 6)**



**Figure 2. Detailed map of SCAT segments (2 of 6)**



**Figure 2. Detailed map of SCAT segments (3 of 6)**



**Figure 2. Detailed map of SCAT segments (4 of 6)**



**Figure 2. Detailed map of SCAT segments (5 of 6)**



**Figure 2. Detailed map of SCAT segments (6 of 6)**



**Table 1**. *Selendang Ayu* oil spill segments surveyed in June 2005.

|  |  |  |  |
| --- | --- | --- | --- |
| **Date** | **Segment** | **Date** | **Segment** |
| 6/2/2005 | ALM 8 | 6/9/052 | UDE3 |
|  | ALM 7 |  | UDE1 |
|  | ALM 6 |  | VLC9 |
|  | ALM10 |  | VLC10 |
|  | CFS 19 |  |  |
|  | CFS 20 | 6/19/2005 | SKN 3 |
| 6/3/2005 | KMK 30 |  | SKN 4 |
|  | PMS 7 |  | SKN 7 |
|  | PMS 10 |  | SKN 6 |
| 6/4/2005 | SPR 11 |  | PMS 16 |
|  | SPR12 | 6/20/2005 | HMP 12 |
|  | SKS 4 |  | HMP 9 |
|  | SKS 6 |  | PTN 3 |
| 6/5/2005 | CNB9 |  | PTS 11 |
|  | CNB10 | 6/21/2005 | MKS 4 |
|  | PTN2 |  | MKS 5 |
|  | PTN3 |  | MKS 6 |
| 6/6/2005 | HMP7 |  | SPR 2 |
|  | HMP6 |  | SPR 3 |
|  | HMP10 |  | UDW 1 |
|  | HMP11 | 6/22/2005 | SKN 14 |
|  | HMP5 |  | SKN 10 |
| 6/7/2005 | SKN8 |  | SKN 11 |
|  | SKN9 |  | SKN 7 |
|  | SKN11 |  | PMS 20 |
|  | SKN12 | 6/23/2005 | HMP 11 |
|  | SKN14 |  | HMP 13 |
|  | SKN15 |  |  |
| 6/8/2005 | SKS 18 |  |  |
|  | SKS 14 |  |  |
|  | SKS 15 |  |  |
|  | SKS 16 |  |  |
|  | SKS 17 |  |  |

**Table 2.** Examples of mature perennial biota found on rocky shores in the spill area, June 2005.

|  |  |
| --- | --- |
| **Invertebrates** | **Common name category** |
| *Henricia* | starfish |
| *Katharina* | chiton |
| *Littorina* *sitkana* | snail |
| *Lottia digitalis* | limpet |
| *Lottia pelta* | limpet |
| *Nucella emarginata* | snail |
| *Calliostoma ligatum.* | snail |
| *Balanus glandula* | barnacle |
| *Semibalanus cariosus* | barnacle |
| *Mytilus trossulus* | mussel |
|  |  |
| **Marine algae** |  |
| *Laminaria* | kelp |
| *Alaria* | kelp |
| *Cymathere* | kelp |
| *Fucus* | rockweed |
| *Hedophyllum* | kelp |
| *Neorhodomela larix* | red alga |
| *Petrocelis* | tar-spot alga |
| *Agarum (or* possibly *Thalassiophyllum)* | kelp |
| The individuals of these species were large enough that they were probably present in the spill area before 8 December 2004, when the *Selendang Ayu* wrecked at Spray Cape. | |

**Table 3.** Summary of clean up methods by segment. Segments in bold type were locations not treated due to safety concerns. Does not include segments which had no observable oil (NOO) in winter (2004-2005) and which had a No Further Treatment (NFT) recommendation in spring (2005). When more than one oiling category is used for a segment, the highest was put in this table.

| **SEGMENT NAME** | **WINTER OILING CAT.** | **SPRING OILING CAT.** | **SPRING**  **CLEAN-UP?** | **MANUAL CLEAN-UP** | **MECH. REMOVAL** | **MECH. TILL** | **BERM RELOC-ATION** | **OPEN BURN** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ALM03 | NOO | MODERATE | YES | X |  |  |  |  |
| ALM09 | NOO | MODERATE |  |  |  |  |  |  |
| AND01 | LIGHT | LIGHT | NFT |  |  |  |  |  |
| AND06 | LIGHT | LIGHT | YES | X |  |  |  |  |
| AND07 | NOO | HEAVY | NFT |  |  |  |  |  |
| AND08 | NOO | HEAVY | YES | X |  |  |  |  |
| ASP07 | NOO | LIGHT | YES | X |  |  |  |  |
| ASP14 | NOO | MODERATE | YES | X |  |  |  |  |
| ASP15 | NOO | LIGHT | YES | X |  |  |  |  |
| ASP16 | NOO | LIGHT | YES | X |  |  |  |  |
| BCK07 | NOO | HEAVY | YES | X |  |  |  |  |
| BCK09 | HEAVY | MODERATE | YES | X |  |  |  |  |
| BCK11 |  | HEAVY | YES | X |  |  |  |  |
| CBE21 | HEAVY | NOO | NFT |  |  |  |  |  |
| CNB01 | NOO | MODERATE | YES | X |  |  |  |  |
| CNB10 | NOO | LIGHT | YES | X |  |  |  |  |
| CNB11 | NOO | LIGHT | YES | X |  |  |  |  |
| CNB14 | NOO | LIGHT | YES | X |  |  |  |  |
| CNB15 | NOO | LIGHT | YES | X |  |  |  |  |
| CNB17 | NOO | MODERATE | YES | X |  |  |  |  |
| CNB19 | MODERATE | LIGHT | NFT |  |  |  |  |  |
| CNB20 | MODERATE | HEAVY | YES | X |  |  |  |  |
| CNB21 | HEAVY | HEAVY | YES | X |  |  |  |  |
| HMP02 | NOO | HEAVY | YES |  |  |  |  |  |
| HMP03 | NOO | HEAVY | YES |  |  |  |  |  |
| HMP05 | HEAVY | HEAVY | YES | X |  |  |  |  |
| HMP06 | HEAVY | HEAVY | YES | X |  |  |  |  |
| HMP07 | HEAVY | HEAVY | YES | X | X | X |  |  |
| HMP08 | HEAVY | LIGHT | YES | X |  |  |  |  |
| HMP10 | HEAVY | HEAVY | YES | X |  |  |  |  |
| HMP11 | HEAVY | HEAVY | YES | X | X | X |  | X |
| HMP12 | HEAVY | HEAVY | YES | X | X | X | X |  |
| HMP13 | HEAVY | HEAVY | YES | X |  |  |  |  |
| KFP01 | NOO | HEAVY | YES | X |  |  |  |  |
| KFP02 | NOO | HEAVY | YES | X |  |  |  |  |
| KFP03 | NOO | HEAVY | YES | X |  |  |  |  |
| KFP04 | NOO | VERY LIGHT | X | X |  |  |  |  |
| KFP05 | LIGHT | VERY LIGHT | NFT |  |  |  |  |  |
| KFP07 | LIGHT | VERY LIGHT | NFT |  |  |  |  |  |
| KFP08 | NOO | HEAVY | YES | X |  |  |  | X |
| KFP09 | MODERATE | HEAVY | YES | X |  |  |  |  |
| KFP10 | NOO | HEAVY | YES | X |  |  |  |  |
| KMK02 | NOO | HEAVY | YES | X |  |  |  |  |
| KMK06 | MODERATE | MODERATE |  |  |  |  |  |  |
| KMK07 | MODERATE | HEAVY | YES | X |  | X |  |  |
| KMK08 | HEAVY | NOO | NO |  |  |  |  |  |
| KMK09 | HEAVY | HEAVY | YES | X |  |  |  |  |
| KMK11 | HEAVY | LIGHT | YES | X |  |  |  |  |
| KMK15 | NOO | LIGHT | YES | X |  |  |  |  |
| KMK26 | NOO | HEAVY | YES | X |  |  |  |  |
| KMK27 | MODERATE | HEAVY | YES | X |  |  |  |  |
| KMK28 | HEAVY | HEAVY | YES | X |  |  |  |  |
| KMK29 | HEAVY | LIGHT | NFT |  |  |  |  |  |
| KMK30 | HEAVY | HEAVY | YES | X |  |  |  |  |
| KMK32 | NOO | MODERATE | YES | X |  |  |  |  |
| KSB01 | NOO | MODERATE | YES | X |  |  |  |  |
| KSB02 | MODERATE | HEAVY | YES | X |  |  |  |  |
| KSB03 | NOO | HEAVY | YES | X |  |  |  |  |
| KSB08 | MODERATE | MODERATE | YES | X |  |  |  |  |
| KSB10 | HEAVY | MODERATE | YES | X |  |  |  |  |
| KSB15 | NOO | LIGHT | YES | X |  |  |  |  |
| KTS19 |  | LIGHT | YES | X |  |  |  |  |
| MKS01 | HEAVY | HEAVY | YES | X | X | X |  | X |
| MKS02 | HEAVY | HEAVY | YES | X | X | X |  |  |
| MKS03 | HEAVY | LIGHT | YES | X |  |  |  |  |
| MKS04 | HEAVY | NOO | NFT |  |  |  |  |  |
| MKS05 | HEAVY | HEAVY | YES | X |  |  |  |  |
| MKS06 | HEAVY | HEAVY | YES | X |  |  |  |  |
| MKS07 | LIGHT | HEAVY | YES | X |  |  |  |  |
| MKS08 | LIGHT | NOO | NFT |  |  |  |  |  |
| MKS09 | HEAVY | HEAVY | YES | X |  |  |  |  |
| MKS10 | HEAVY | NOO | NFT |  |  |  |  |  |
| MKS11 | HEAVY | HEAVY | YES | X |  |  |  |  |
| MKS12 | NOO | HEAVY | YES | X |  |  |  |  |
| **MKS13** | NOO | HEAVY | NFT |  |  |  |  |  |
| **MKS14** | NOO | HEAVY | NFT |  |  |  |  |  |
| **MKS15** | NOO | HEAVY | NFT |  |  |  |  |  |
| **MKS16** | NOO | HEAVY | NFT |  |  |  |  |  |
| **MKS17** | NOO | HEAVY | NFT |  |  |  |  |  |
| **MKS18** | NOO | HEAVY | NFT |  |  |  |  |  |
| NGE07 | LIGHT | LIGHT | YES | X |  |  |  |  |
| NGW01 | LIGHT | LIGHT | NFT |  |  |  |  |  |
| NGW02 | MODERATE | LIGHT | YES | X |  |  |  |  |
| NGW03 | MODERATE | LIGHT | YES | X |  |  |  |  |
| NGW04 | LIGHT | LIGHT | NFT |  |  |  |  |  |
| NGW05 | LIGHT | LIGHT | NFT |  |  |  |  |  |
| NGW06 | LIGHT | LIGHT | NFT |  |  |  |  |  |
| NGW07 | LIGHT | LIGHT |  |  |  |  |  |  |
| PMN02 | HEAVY | NOO | NFT |  |  |  |  |  |
| PMN10 | LIGHT | NOO | NFT |  |  |  |  |  |
| PMN12 | LIGHT | LIGHT | NFT |  |  |  |  |  |
| PMN13 | NOO | VERY LIGHT | NFT |  |  |  |  |  |
| PMN15 | NOO | MODERATE | YES | X |  |  |  |  |
| PMN16 | NOO | MODERATE | YES | X |  |  |  |  |
| PMN24 | LIGHT | NOO | NFT |  |  |  |  |  |
| PMN25 | LIGHT | NOO | NFT |  |  |  |  |  |
| PMN28 | NOO | HEAVY | YES | X |  |  |  |  |
| PMS05 | LIGHT | LIGHT |  |  |  |  |  |  |
| PMS06 | LIGHT | MODERATE | YES | X |  |  |  |  |
| PMS10 | MODERATE | MODERATE | YES | X |  |  |  |  |
| PMS11 | LIGHT | LIGHT |  |  |  |  |  |  |
| PTN01 | MODERATE | LIGHT | NFT |  |  |  |  |  |
| PTN02 | NOO | HEAVY | YES | X |  |  |  |  |
| PTN03 | HEAVY | HEAVY | YES | X |  |  |  |  |
| PTN04 | HEAVY | HEAVY | YES | X |  |  |  |  |
| PTN10 | LIGHT | HEAVY | YES | X |  |  |  |  |
| PTS01 | LIGHT | HEAVY | YES | X |  |  |  |  |
| PTS03 | LIGHT | NOO | NFT |  |  |  |  |  |
| PTS04 | LIGHT | NOO | NFT |  |  |  |  |  |
| PTS05 | MODERATE | MODERATE | NFT |  |  |  |  |  |
| PTS06 | NOO | NOO | NO |  |  |  |  |  |
| PTS07 | MODERATE | LIGHT | NFT |  |  |  |  |  |
| PTS08 | MODERATE | NOO | NFT |  |  |  |  |  |
| PTS10 |  | MODERATE | NFT |  |  |  |  |  |
| SKN04 | NOO | LIGHT | YES | X |  |  |  |  |
| SKN05 | HEAVY | HEAVY | YES | X |  | X | X | X |
| SKN06 | NOO | MODERATE | YES | X |  |  | X |  |
| SKN08 | HEAVY | MODERATE | YES | X |  |  |  | X |
| SKN11 | HEAVY | HEAVY | YES | X | X | X |  | X |
| SKN12 | LIGHT | HEAVY | YES | X |  |  |  |  |
| SKN13 | HEAVY | MODERATE | YES | X |  |  |  |  |
| SKN14 | HEAVY | HEAVY | YES | X |  |  |  |  |
| SKN15 | HEAVY | HEAVY | YES | X |  |  |  | X |
| SKS01 | NOO | HEAVY | YES | X |  |  |  |  |
| SKS02 | NOO | HEAVY | YES | X |  |  |  |  |
| SKS03 | NOO | HEAVY | YES | X |  |  |  |  |
| SKS04 | MODERATE | HEAVY | YES | X | X | X | X |  |
| SKS06 | HEAVY | HEAVY | YES | X |  |  |  |  |
| SKS10 | NOO | HEAVY | YES | X |  |  |  |  |
| SKS11 | NOO | HEAVY | YES | X |  |  |  |  |
| SKS12 | NOO | LIGHT | YES | X |  |  |  |  |
| SKS13 | NOO | MODERATE | YES | X |  |  |  |  |
| SKS14 | NOO | MODERATE | YES | X |  |  |  |  |
| SKS15 | NOO | HEAVY | YES | X |  |  |  |  |
| SKS16 | NOO | HEAVY | YES | X |  |  |  |  |
| SKS17 | NOO | MODERATE | YES | X |  |  |  |  |
| SKS18 | HEAVY | HEAVY | YES | X | X | X |  |  |
| SMB06 |  | HEAVY | YES | X |  |  |  |  |
| SPR01 | NOO | MODERATE | YES | X |  |  |  |  |
| SPR02 | HEAVY | MODERATE | YES | X |  |  |  |  |
| SPR03 | NOO | LIGHT | YES | X |  |  |  |  |
| SPR04 | HEAVY | MODERATE | YES | X |  |  |  |  |
| SPR05 | HEAVY | NOO | NFT |  |  |  |  |  |
| SPR07 |  | MODERATE | YES | X |  |  |  |  |
| SPR09 |  | MODERATE | YES | X |  |  |  |  |
| SPR10 |  | LIGHT | YES | X |  |  |  |  |
| SPR11 | LIGHT | HEAVY | YES | X |  |  |  |  |
| SPR12 |  | HEAVY | YES | X |  |  |  |  |
| UDE16 | LIGHT | LIGHT | YES | X |  |  |  |  |
| WDE03 | MODERATE |  |  |  |  |  |  |  |
| UDW01 | NOO | HEAVY | YES | X |  |  |  |  |
| UDW04 | NOO | LIGHT | YES | X |  |  |  |  |
| UNK03 |  | LIGHT | YES | X |  |  |  |  |
| VLC01 |  | HEAVY | YES | X |  |  |  |  |
| VLC10a |  | LIGHT | YES | X |  |  |  |  |

**Table 4.** Summary of observations pertinent to oil remobilization made in the Selendang Ayu spill area from June 2005 onwards.

|  |  |
| --- | --- |
| **DATES** | **OBSERVATIONS** |
| 20-23 June 2005: | NOAA survey teams documented remobilized oil from beach cleaning operations in Skan Bay (SKN10-11) and probably from beach cleaning operations in Hump Back Bay (~HMP10-12). |
| August-September 2005 | Scott Arnold, Alaska Department of Health and Social Services, reported elevated levels of total PAHs in blue mussels from various locations in Skan Bay, but not in other nearby bays |
| ~September 2005: | Mark Carls reported increase of oil in PEMD samplers at Skan Bay (SKN-14). |
| 21 October 2005 | Unnamed observer in civilian aircraft reported what appeared to be a sheen around thevessel. Coast Guard reported oil from Selendang in water and onshore around wreck (Spray Cape) and Skan Bay. |
| 24 October 2005 | Coast Guard reported seeing sheen and emulsified oil coming from the stern of the *Selendang Ayu*. |
| 25 October 2005 | Coast Guard observed a rainbow sheen burping up from around 350 yards from the vessel. |
| 1 December 2005: | Coast Guard/ADEC reported sheening from the vessel (POLREP 104). |
| 1 December 2005 | Dan Magone reported oil on about 200 feet of shoreline near the Selendang; “grass has distinctive droopy look….” |
| 3 December 2005 | Dan Magone reported “ribbon of oil sheen” in inner bay of “Lower Skan Bay”. |
| Feb or March 2006(?) | Seaduck crews reported sticky oil blobs on beach and oiled scaup. |

**Table 5.** Final Status of 2005 Non-End Point Segments

| **SEGMENT** | **SEGMENT LENGTH (km)** | **OILED LENGTH (km)** | **FINAL STATUS** | **DATE of STATUS DETERMINATION** |
| --- | --- | --- | --- | --- |
| BCK11 | 0.951 | 0.08 | End Point Reached | 6/8/06 |
| HMP06 | 0.463 | 0.08 | Natural Recovery | 6/6/06 |
| HMP11b | 0.300 | 0.12 | End Point Reached | 6/6/06 |
| KFP01 | 1.494 | 0.635 | Natural Recovery | 6/13/06 |
| KFP02 | 0.536 | 0.38 | End Point Reached | 6/12/06 |
| KFP03 | 0.239 | 0.03 | End Point Reached | 6/12/06 |
| KFP10a | 1.102 | 0.36 | End Point Reached | 6/12/06 |
| KMK26 | 0.265 | 0.02 | End Point Reached | 6/4/06 |
| KMK30 | 1.839 | 0.04 | End Point Reached | 6/4/06 |
| MKS13 | 1.507 | 0.02 | End Point Reached | 6/4/06 |
| MKS14 | 0.688 | 0.14 | Natural Recovery | 6/4/06 |
| MKS16 | 0.681 | 0.265 | Natural Recovery | 6/4/06 |
| MKS17 | 1.294 | 0.08 | End Point Reached | 6/4/06 |
| SKN05 | 0.676 | 0.6 | End Point Reached | 6/5/06 |
| SKN06 | 1.854 | 0.02 | End Point Reached | 6/5/06 |
| SKN08 | 0.128 | 0.082 | End Point Reached | 6/5/06 |
| SKN11 | 0.210 | 0.24 | End Point Reached | 6/5/06q |
| SKN12 | 1.172 | 0.025 | End Point Reached | 6/5/06 |
| SKN15 | 2.610 | 2.073 | Natural Recovery | 6/12/06 |
| SKS03 | 0.865 | 0.122 | Natural Recovery | 6/8/06 |
| SKS04 | 0.235 | 0.235 | End Point Reached | 6/8/06 |
| SKS06 | 0.439 | 0.04 | End Point Reached | 6/8/06 |
| SKS11c | 0.045 | 0.08 | End Point Reached | 6/12/06 |
| SKS18d,e,g | 3.610 | 0.354 | End Point Reached | 6/12/06 |
| SPR11a | 1.210 | 0.1 | Natural Recovery | 6/8/06 |
| SPR12 | 0.593 | 0.2 | End Point Reached | 6/8/06 |

**Table 6.** Locations of anadromous fish streams surveyed in June 2005.

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Incident Command Segment Code** | **General Location Name** | **Site of Auke Bay Hydrocarbon Monitoring Stations** |
| 1. | MKS 5 | Makushin Bay South (Glacier Valley Creek) | X |
| 2. | HMP 9 | Humpback Bay |  |
| 3. | HMP12 | Humpback Bay |  |
| 4. | PTN 3 | Portage Bay North |  |
| 5. | PTS 10 | Portage Bay South |  |
| 6. | SKN 4 | Skan North | X |
| 7. | SKN 14 | Skan North | X |
| 8. | SPR 3 | Spray Cape |  |
| 9. | PMN 20/21 | Pumicestone North | X |
| 10. | PMS 16 | Pumicestone South | X |

**Photo of Dry Tilling to Expose Buried Oil at HMP-12 (2 December 2005)**



(photo taken by ADEC)