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M/V Selendang Ayu Oil Spill
Unalaska, Alaska
Public Health Evaluation of Subsistence Resources Collected During 2005
Final Report

April 18, 2006

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Background

On December 8, 2004, the M/V Selendang Ayu ran aground and broke apart near Unalaska Island between Skan Bay and Spray Cape approximately 25 air miles southwest of Dutch Harbor. An estimated 321,000 gallons of intermediate fuel oil and 14,680 gallons of marine diesel/miscellaneous oils have been released to the environment. In addition, the vessel contained approximately 60 thousand tons of soybeans (1).

Approximately 474 miles of shoreline were evaluated for potential clean up activities. Of those, 70 miles (123 segments) were identified as needing additional treatment (1). Clean up activities commenced during May of 2005 and all but 26 segments (15.54 miles of shoreline) met clean up criteria as of September 2005 (1). The remaining 26 segments located in Skan and Makushin Bay, will be evaluated for clean up in the spring of 2006. The status of the clean up and all other activities associated with the M/V Selendang Ayu grounding and oil spill can be found on the Unified Command web site:
http://www.dec.state.ak.us/spar/perp/response/sum_fy05/041207201/041207201_index.htm.

In March of 2005, the Unified Command of the M/V Selendang Ayu grounding and oil spill requested assistance from the Alaska Division of Public Health (ADPH), Section of Epidemiology to evaluate whether subsistence foods in the Unalaska area were impacted by the spill. The Section of Epidemiology participated in semimonthly conference calls as part of the Selendang Ayu Subsistence Fishery Advisory Group. The group consisted of representatives from the Qawalangin Tribe, the Ounalashka Corporation, Polaris Applied Sciences, the Alaska Department of Environmental Conservation, the Alaska Department of Fish and Game, the U.S. Fish and Wildlife Service, Chumis Cultural Resources, NOAA, the University of Alaska Marine Advisory Program, and the Aleutian Pribilof Islands Association. The group developed a subsistence food sampling plan and a subsistence food consumption questionnaire. Polaris Applied Sciences directed the subsistence food sampling and administration of the subsistence food consumption questionnaire. Their report summarizing the methods and results are attached in Appendix A. This report presents the public health interpretation of the analytical results of the subsistence food sampling.

Methods

Petroleum products can contain a mixture of hundreds of organic compounds. Health concerns of exposure to oil from spills are mainly focused on a group of compounds termed polycyclic aromatic hydrocarbons (PAHs) due to their chemical and toxicological properties (2). Some PAHs are potentially carcinogenic, they are relatively (compared to other compounds in oil) resistant to environmental degradation, and will accumulate in the food chain (2). Therefore, collected subsistence foods were analyzed for PAHs.

Subsistence foods sampling

In April 2005, prior to clean up activities in North and South Skan Bay 2 composite (10 to 20 individuals) blue mussel samples were collected for PAH analysis from North Skan Bay and 3 composite blue mussel samples were collected from South Skan Bay. North and South Skan Bay were the most heavily oil-impacted areas.

The Selendang Ayu Subsistence Fishery Advisory Group developed a subsistence food sampling plan. Fifteen different areas were sampled for a variety of subsistence foods and analyzed for PAHs (Appendix A). During June and July of 2005, composite samples of (10 to 20 individuals) blue mussels, black chitons, and green sea urchins were collected from Unalaska Bay in areas frequented by residents of Unalaska and Dutch Harbor (Figure 1 inset). During August and September of 2005, after oil spill clean up activities were essentially completed for the summer, composite samples of blue mussels, black chitons, and green sea urchins were collected near the Selendang Ayu grounding and spill area (i.e., Anderson, Cannery, Kashega, Kismaliuk, Makushin, and Skan Bays, Figure 1).

Overall, 17 composite black chiton, 30 composite blue mussels, and 12 composite green sea urchin roe samples were collected and analyzed for PAH analysis. In addition, 3 pink salmon were collected from Summer Bay, 3 pink salmon were collected from Skan Bay, and 1 pacific cod was collected from Naginak Cove. Blubber from a harbor seal harvested in Wide Bay was also collected.

In addition, 10 blue mussel composite samples were collected for organoleptic (i.e., inspection of the sample for oil by smell and sight by a panel of certified laboratory technicians) and PSP toxin analysis (Figure 1).

Analytical methodology

PAH concentrations in subsistence samples were determined by modified USEPA 8270c at the Woods Hole Group Analytical Laboratory in Raynham, Massachusetts. Organoleptic and paralytic shellfish poisoning toxin (PSP) testing was conducted at the Alaska Department of Environmental Conservation Laboratory in Palmer, AK.

Subsistence food consumption questionnaire

The Selendang Ayu Subsistence Fishery Advisory Group designed and administered a subsistence food consumption questionnaire (Appendix A). The questionnaire was designed similarly to the Aleutian Pribilof Islands Association *Alaska Traditional Diet Project Nutrition Questionnaire* of August 2003 (3). The questionnaire was presented to the Alaska Area Institutional Review Board. It was concluded IRB approval was not necessary.

Determination of benzo(a)pyrene equivalents

Each subsistence sample analyzed for PAHs was evaluated for its overall carcinogenic potency by calculating benzo(a)pyrene (BaP) equivalents as done previously for the Exxon Valdez, M/V Kuroshima, and New Carissa (Coos Bay, Oregon) oil spills (2,4,5). For each sample, the carcinogenic potency of each PAH compound was expressed relative to BaP and then summed for an overall estimate of BaP-like activity. PAHs that were not detected were assigned a value of zero. USEPA region 9 provides BaP equivalents for six PAHs {Table 1, (6)}.

Table 1. Benzo(a)pyrene equivalents (BaP) for polycyclic aromatic hydrocarbons.

Compound	BaP equivalent
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenzo(a,h)anthracene	1.0
Indeno[1,2,3-cd]pyrene	0.1

Risk-based screening criteria

Risk-based screening criteria (i.e., the concentration that is reasonably considered safe) were calculated for each subsistence food to compare to the concentration of carcinogenic PAHs (i.e, BaP equivalents) detected in each sample. The risk-based screening criteria was calculated using the following formula and the standard assumptions in Table 2, as follows:

Risk-based screening criteria (µg/kg) = $RL \times BW \times AT \times CF_1 \times CF_2/(SF \times ED \times CR)$

Table 2. Input variables for risk-based screening criteria.

RL	Acceptable risk level[a]	1.0×10^{-6}	
BW	Body weight, adult[b]	70	kg
AT	Averaging time[c]	70	years
CF_1	Conversion factor	1000	ug/mg
CF_2	Conversion factor	1000	g/kg
SF	USEPA slope factor for BaP	7.3	(1/mg/kg-day)
ED	Exposure duration[d]	3	years
CR	Consumption rate	see Table 3	g/day

[a] USEPA's risk management range for excess cancer risk above background is one-in-one-million (10^{-6}) to one-in-ten thousand (10^{-4})(6). 10^{-6} excess cancer risk equates to one excess cancer in a population of one million people. This is a theoretical estimate that is based on very conservative mathematical calculations. The true risk could be much lower even zero. To put this in perspective, for the United States it is estimated that men have a 1 in 2 lifetime risk of developing cancer and females have a 1 in 3 lifetime risk (7).

[b] Standard default for adult body weight (6).

[c] Standard default for life expectancy (6).

[d] Estimated maximum residence time for oil (2,5).

Table 3 (see below) presents the calculated risk-based screening criteria.

Results

Subsistence food questionnaire

Twenty-three known frequent subsistence food consumers were interviewed about their seafood consumption in late September and early October of 2005. The upper 95th confidence limit of the mean ingestion rate (g/day) was calculated (the survey results are posted on the United Command web site). Table 3 presents the results of this survey and the results of a survey conducted by the Alaska Department of Fish and Game (ADF&G), Division of Subsistence in 1994 for Unalaska (8). For the ADF&G survey, mean ingestion rates for subsistence resources were based on a random sample of 106 households in Unalaska and were determined as follows. Households were asked how much of a resource they harvested per year. The total yearly harvest for the 106 households was used to estimate the total annual harvest for the Unalaska/Dutch Harbor community. Each interviewed household was also asked if they used the resource, and an estimated total number households using the resource was developed based on these responses. The estimated number of households using a resource was divided into the total estimated harvest amount for that resource to give the amount used per household per year. This value was then divided by the average number of persons in each household to give the amount used by each person per year. This value was divided by 365 to give the amount used per person per day.

Table 3. Upper 95th confidence interval of the mean ingestion rate (g/day) and risk-based screening criteria for the Selendang Ayu oil spill near Unalaska, Alaska.

Resource	Selendang Ayu consumption survey (2005) ingestion rate[a] g/day	Risk-based screening criteria ug/kg	ADF&G (1994) ingestion rate[b] g/day	Risk-based screening criteria ug/kg
black chitons	3.7	60.1	16.3	13.7
sea urchin roe	2.2	99.9	8.3	27.0
blue mussels	1.5	145.3	11.9	18.8
all salmon	65.3	3.4	98.2	2.3
all harbor seal tissues	11.6	19.3	25.8	8.7
pacific cod	11.9	18.9	27.6	8.1

[a]the ingestion rate for blue mussels represents all shellfish (i.e., razor, butter, steamer clams; blue mussels, and cockles)

[b]See text for explanation

Risk-based screening criteria

Based on the ingestion rates for each subsistence food sampled, a risk-based screening value was calculated (Table 3). The ADF&G ingestion rates were greater than the ingestion rates determined from the Selendang Ayu subsistence food questionnaire for all foods sampled; therefore, the calculated risk-based screening criteria were lower. To be conservative, the risk-based screening criteria based on the ADF&G ingestion rates were used to compare to the total BaP equivalents for each sample.

PAH analytical results and comparison to risk-based screening criteria

The PAH analytical results (total PAHs and total BaP equivalents) and calculated risk-based screening criteria are shown in Table 4 for each sample. The raw analytical chemistry data is available upon request from Polaris Applied Sciences, Kirkland, WA. The samples with total BaP equivalents exceeding the risk-based screening criteria are shown in bold print.

Table 4. Total polycyclic aromatic hydrocarbons (PAHs) and total benzo(a)pyrene equivalents for the Selendang Ayu oil spill near Unalaska, Alaska.

Collection Date	Species	Location ID	Sample ID	Total PAHs	Total benzo(a)pyrene equivalents	Risk-based screening concentration
				ug/kg		
Samples collected from Unalaska Bay						
06/25/2005	black chitons	Captains Bay	CH-CBW01-06-25-05-01	36	0.019	13.7
06/23/2005	**black chitons**	**Humpy Cove 1**	**CH-SMB7-062305-01-rep 1***	**836**	**41**	**13.7**
06/23/2005	**black chitons**	**Humpy Cove 1**	**CH-SMB7-062305-01-rep 2***	**791**	**83**	**13.7**
06/23/2005	**black chitons**	**Humpy Cove 1**	**CH-SMB7-062305-01-rep 3***	**1882**	**158**	**13.7**
06/23/2005	black chitons	Humpy Cove 1	CH-SMB7-062305-02	13.8	0.00016	13.7
06/23/2005	black chitons	Humpy Cove 1	CH-SMB7-062305-03	7.5	0.00013	13.7
09/25/2005	black chitons	Humpy Cove 1	CH-SMB-07-9-25-05	8.6	0.0053	13.7
07/20/2005	black chitons	Humpy Cove 2	CH-SMB6/7-7-20-05	48	0	13.7
07/21/2005	black chitons	Iliuliuk Bay 1	CH-SMB1-7-21-05	11	0.019	13.7
07/21/2005	black chitons	Iliuliuk Bay 2	CH-DTE37-7-21-05	16	0.00031	13.7
07/20/2005	black chitons	Morris Cove	CH-SMB10-7-20-05	17	0	13.7
07/21/2005	black chitons	Summer Bay 1	CH-SMB3-7-21-05	16	0.031	13.7
06/25/2005	blue mussels	Captains Bay	MU-CBW01-06-25-05-01	254	0.074	18.8
06/26/2005	blue mussels	Humpy Cove 1	MU-SMB07-06-26-05-01	34	0.054	18.8
09/25/2005	blue mussels	Humpy Cove 1	MU-SMB-07-9-25-05	12	0.04	18.8
07/20/2005	blue mussels	Humpy Cove 2	ML-SMB6/7-7-20-05	29	0.037	18.8
07/21/2005	blue mussels	Iliuliuk Bay 1	ML-SMB1-7-21-05	24	0.045	18.8
07/21/2005	blue mussels	Iliuliuk Bay 2	ML-DTE37-7-21-05	79	0.056	18.8
07/20/2005	blue mussels	Morris Cove	ML-SMB10-7-20-05	9	0.012	18.8
09/25/2005	blue mussels	Morris Cove	MU-SMB-10-9-25-05-01	15	0.029	18.8
07/21/2005	blue mussels	Summer Bay 1	ML-SMB3-7-21-05-rep 1*	108	0.047	18.8
07/21/2005	blue mussels	Summer Bay 1	ML-SMB3-7-21-05-rep 2*	180	0.0021	18.8
09/25/2005	blue mussels	Summer Bay 2	MU-SMB-01-9-25-05-01	13	0.018	18.8

Table 4. (*cont.*)

Collection Date	Species	Location ID	Sample ID	Total PAHs	Total benzo(a)pyrene equivalents	Risk-based screening concentration
					ug/kg	
Samples collected from Unalaska Bay						
06/25/2005	green sea urchin roe	Captains Bay	UR-CBW01-06-25-05-01	116	0	27
06/23/2005	green sea urchin roe	Humpy Cove 1	UR-SMB7-062305-01	120	0	27
07/20/2005	green sea urchin roe	Humpy Cove 2	UR-SMB6/7-7-20-05	14	0.021	27
07/21/2005	green sea urchin roe	Iliuliuk Bay 1	UR-SMB1-7-21-05-rep 1*	52	0	27
07/21/2005	green sea urchin roe	Iliuliuk Bay 1	UR-SMB1-7-21-05-rep 2*	9	0	27
07/21/2005	green sea urchin roe	Iliuliuk Bay 2	UR-DTE37-7-21-05	22	0.029	27
07/20/2005	green sea urchin roe	Morris Cove	UR-SMB10-7-20-05	6	0	27
07/21/2005	green sea urchin roe	Summer Bay 1	UR-SMB3-7-21-05-rep 1*	9	0.00024	27
07/21/2005	green sea urchin roe	Summer Bay 1	UR-SMB3-7-21-05-rep 2*	7	0.00033	27
08/05/2005	harbor seal blubber	Wide Bay	SL-EIDER-8-5-05	18	0	8.7
08/02/2005	pink salmon	Humpy Cove 3	SMB7-PNK-8-02-05-01	17	0.75	2.3
08/02/2005	pink salmon	Humpy Cove 3	SMB7-PNK-8-02-05-02	6.8	0.0021	2.3
08/02/2005	pink salmon	Humpy Cove 3	SMB7-PNK-8-02-05-03	13	0.43	2.3

*"rep" represents a laboratory replicate

Samples collected near the spill site						
08/29/2005	black chitons	Anderson Bay 2	CH-AND3-8-29-05	7.8	0.0035	13.7
08/31/2005	black chitons	Kismaliuk Bay 2	CH-KMK28-8-31-05	36	0.0062	13.7
08/31/2005	black chitons	Kismaliuk Bay 3	CH-KMK32-8-31-05	32	0.0045	13.7
08/28/2005	black chitons	Skan Bay S. 1	CH-SKS06-8-28-05	12	0.057	13.7
08/28/2005	black chitons	Skan Bay S. 3	CH-SKS17-8-28-05	7.1	0.006	13.7
08/29/2005	blue mussels	Anderson Bay 1	MU-AND2-8-29-05-01	7.1	0.0047	18.8
08/29/2005	blue mussels	Cannery Bay	MU-CNB17-8-29-05-01	8.4	0.83	18.8

Table 4. (*cont.*)

Collection Date	Species	Location ID	Sample ID	Total PAHs	Total benzo(a)pyrene equivalents	Risk-based screening concentration
				ug/kg		
Samples collected near the spill site						
09/23/2005	blue mussels	Cannery Bay	MU-CNB-19-9-23-05-01	86	0.54	18.8
09/23/2005	blue mussels	Cannery Bay	MU-CNB-19-9-23-05-02	9.4	0.0031	18.8
08/31/2005	blue mussels	Kashega Bay	MU-KSB7-8-31-05	19	0.0053	18.8
08/31/2005	blue mussels	Kismaliuk Bay 1	MU-KMK7-8-31-05	70	0.14	18.8
08/28/2005	blue mussels	Makushin Bay	MU-MKS11-8-28-05-01	18	0.073	18.8
09/23/2005	blue mussels	Makushin Bay	MU-MKS-11-9-23-05	91	0.037	18.8
04/25/2005	**blue mussels**	**Skan Bay N.**	**SKN-11(North)-rep 1***	**8706**	**35**	**18.8**
04/25/2005	blue mussels	Skan Bay N.	SKN-11(North)-rep 2*	12411	17	18.8
04/25/2005	blue mussels	Skan Bay N.	SKN-11(South)	7759	9.3	18.8
09/23/2005	blue mussels	Skan Bay N. 2	MU-SKN-11-9-23-05	6079	8.6	18.8
04/25/2005	blue mussels	Skan Bay S.	SKS-4(North)	1009	0.59	18.8
04/28/2005	blue mussels	Skan Bay S.	SKS-4N	1692	1.1	18.8
04/25/2005	blue mussels	Skan Bay S.	SKS-4(South)	642	0.53	18.8
08/27/2005	blue mussels	Skan Bay S. 1	MU-SKS06-8-27-05-01	257	0.4	18.8
08/28/2005	blue mussels	Skan Bay S. 3	MU-SKS17-8-28-05-01	537	0.16	18.8
09/23/2005	blue mussels	Skan Bay S. 4	MU-SKS-04-9-23-05-01	479	0.76	18.8
09/23/2005	blue mussels	Skan Bay S. 4	MU-SKS-04-9-23-05-02	800	1.1	18.8
08/29/2005	green sea urchin roe	Cannery Bay	UR-CNB17-8-29-05-01	13	1.2	27
08/29/2005	green sea urchin roe	Cannery Bay	UR-CNB17-8-29-05-02	9.9	0.73	27
08/28/2005	green sea urchin roe	Skan Bay S. 2	UR-SKS10-8-28-05	92	0.15	27
08/28/2005	Pacific cod	Naginak Cove	CD-NGE7-8-28-05	4.9	0.0042	8.1
08/28/2005	pink salmon	Skan Bay N. 1	PNK-SKN4-8-28-05-01	7.3	0.0035	2.3
08/28/2005	pink salmon	Skan Bay N. 1	PNK-SKN4-8-28-05-02	7.1	0.0054	2.3
08/28/2005	pink salmon	Skan Bay N. 1	PNK-SKN4-8-28-05-03	4.8	0.0029	2.3

*"rep" represents a laboratory replicate

Samples collected from Unalaska Bay

One composite black chiton sample (CH-SMB7-062305-01) collected in June 2005 from Humpy Cove had a total BaP equivalents of 41 µg/kg compared to the calculated risk-based screening criteria of 13.7 µg/kg (Table 4). This sample was reanalyzed by the laboratory on two additional occasions and the results were 83 and 158 µg/kg (Table 4). The source of PAHs in this sample was not Selendang Ayu oil (see discussion). Two other composite black chiton samples (CH-SMB7-062305-02 and CH-SMB7-062305-03) were collected at the same time in the same area of Humpy Cove. The results of these samples were significantly lower (0.00016 µg/kg and 0.00013 µg/kg) and not above the risk-based screening criteria. An additional composite black chiton sample was collected in September (CH-SMB7-9-25-05) from the same area in Humpy Cove and this result (0.0053 µg/kg) was lower than the risk-based screening criteria of 13.7 µg/kg.

No other samples from Unalaska Bay exceeded the risk-based screening concentration. Carcinogenic PAHs were not detected in the harbor seal blubber sample, but the laboratory reporting limit for each PAH (9.5 µg/kg) was higher than the calculated risk-based screening criteria of 8.7 µg/kg. However, the estimated detection limit for this sample of 3.4 µg/kg was sufficiently low to detect PAHs present (9). The reporting limit for an analytical method is usually higher than the detection limit and is calculated based on the lowest calibration standard, extract volume, and sample amount. The detection limit is the quantifiable amount that is 3 times the baseline noise level of the instrument (9).

Samples collected near the spill site

The total BaP equivalents for one composite blue mussel sample (35 µg/kg) collected from North Skan Bay in April 2005 (prior to clean up operations) exceeded the calculated risk-based criteria of 18.8 µg/kg. The results of the only composite blue mussel sample collected from North Skan Bay in September (8.6 µg/kg total BaP equivalents) did not exceed the risk-based screening criteria (Table 4).

No other samples collected near the spill site exceeded the risk-based screening criteria.

Organoleptic analysis

Petroleum was not detected in the ten blue mussel samples by organoleptic analysis Table 5.

Table 5. Paralytic Shellfish Poisoning (PSP) toxin and organoleptic results.

Collection Date	Location ID	Sample ID	Species	PSP toxin ug/100g	Organoleptic[1]
08/29/2005	Anderson Bay 1	MU-AND2-8-29-05-02	blue mussels	48	no
08/29/2005	Cannery Bay	MU-CNB17-8-29-05-02	blue mussels	59	no
06/26/2005	Humpy Cove 1	MU-OR-SMB07-06-26-05-01	blue mussels	34	no
06/26/2005	Humpy Cove 1	MU-OR-SMB07-06-26-05-02	blue mussels	33	no
06/26/2005	Humpy Cove 1	MU-OR-SMB07-06-26-05-03	blue mussels	34	no
08/28/2005	Makushin Bay	MU-MKS11-8-28-05-02	blue mussels	40	no
09/25/2005	Morris Cove	MU-SMB-10-9-25-05-02	blue mussels	$\leq$33	no
08/27/2005	S. Skan Bay 1	MU-SKS06-8-27-05-02	blue mussels	137	no
08/28/2005	S. Skan Bay 3	MU-SKS17-8-28-05-02	blue mussels	110	no
09/25/2005	Summer Bay 2	MU-SMB-01-9-25-05-02	blue mussels	$\leq$32	no

[1]Organoleptic results represent the presence of petroleum by inspection and smell.

PSP toxin testing

PSP toxin was detected in 8 of 10 composite blue mussel samples tested. Two samples (MU-SKS06-8-27-05-02 and MU-SKS17-8-28-05-02) collected from Skan Bay had PSP toxin detected above 80 µg/100g, the highest level allowed for commercial sale (Table 5).

Discussion

PAHs are ubiquitous in the environment, and ingestion of food is the main source of PAH exposure for non-smokers of the general population. PAHs are present in cooked and smoked meats and fish, grain products, fruits, and vegetables. For smokers, smoking a pack of cigarettes a day approximately doubles PAH exposure above background levels (10). Following the M/V Selendang Ayu, PAHs were measured in shellfish because they are nonmobile filters feeders with limited capacity to metabolize/excrete PAHs. Therefore, PAHs can accumulate and are good indicators of PAH contamination. Fish, marine mammals, and birds will avoid oiled areas and have the ability to metabolize and excrete PAHs, therefore, they generally do not bioaccumulate PAHs.

Only two samples had concentrations of BaP equivalents that exceeded the risk-based screening criteria. The source of PAHs in the black chiton sample collected from Humpy Cove in June 2005 is unknown. However, a chemical fingerprint analysis of the oil signature indicated that that the source of PAHs detected in the sample was pyrogenic (i.e., sources derived from the combustion of fossil fuels such as wood ash, diesel and bunker fuel soot, and creosote/coal tar treated timbers) in origin and not from the Selendang Ayu oil [(11);Appendix B]. Additionally, PAHs detected in the 3 other black chiton composite samples collected from the same area were very low and not above the risk-based screening criteria.

One composite blue mussel sample collected in April of 2005 (prior to clean up) from North Skan Bay contained BaP equivalents exceeding the risk-based screening criteria. The other samples of blue mussels collected in Skan Bay in April (prior to clean up) and September (post clean up) did not exceed the risk-based criteria, but were elevated compared to all other areas (Table 4). These results are not unexpected since this was the main area impacted by the spill. Additionally, Skan and Makushin Bay had 26 segments of beach that did not meet clean up criteria in 2005.

It must be emphasized that risk-based screening criteria are not thresholds of toxicity. Although concentrations at or below the relevant screening criteria may reasonably be considered safe, it does not automatically follow that any BaP equivalents concentration that exceeds a screening value would be expected to produce adverse health effects. The principle purpose behind protective health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health hazards. The probability that effects will actually occur does not depend on environmental concentrations alone, but on a unique combination of site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure. These values are designed to be conservative for the protection of public health. For example, the risk-based screening criteria developed here used a conservative excess cancer risk estimate of $1x10^{-6}$. However, it is the policy of the State of Alaska to utilize an excess cancer risk estimate of $1x10^{-5}$ in risk assessments. Using an acceptable risk level of $1x10^{-5}$ would increase the calculated risk-based screening criteria by a factor of 10. In addition, the risk-based screening criteria calculated from the ADF&G survey ingestion rates were 2 to 7 times lower (except salmon) than screening criteria calculated from the Spill Task Force survey ingestion rates (Table 3). Also, the upper 95^{th} confidence interval of the mean was used.

Eight of 10 composite blue mussel samples were positive for PSP toxins and two samples from Skan Bay had PSP toxin concentrations greater than the level allowed for commercial sale. Due to PSP concerns, there is currently an ongoing advisory in the state against the gathering and consumption of shellfish except at approved beaches. **There are no approved beaches in the Unalaska/Dutch Harbor area.** We would encourage as soon as possible, the re-posting of areas frequented by shellfish harvesters to warn the public about the dangers of PSP. The ADPH considers the health hazard from PSP to be much more serious than any health hazards associated with PAH exposure at the levels currently found in mussels in the area.

Conclusions

- PAHs in subsistence resources from Unalaska Bay are not present at levels of health concern.
- One chitin sample collected from Summer Bay contained PAHs above risk-based screening criteria; however, PAHs were below risk-based screening criteria in three other composite samples collected from the same area. The source of PAHs was not Selendang Ayu oil.
- As expected, PAHs were highest near the spill site, although, for the samples evaluated, the concentrations were not a health concern.
- The levels of PAHs in subsistence food resources are expected to decline in the future, therefore; any small risk associated with exposure to PAHs through consumption of subsistence resources near the spill zone should either remain constant or decline over time.
- Additional shoreline assessment activities are planned for Skan and Makushin bays during the spring of 2006.
- The health hazards from PSP are much more serious than any health hazards associated with PAH exposure at the levels currently found. Two samples collected from Skan Bay contained PSP toxin at concentrations above the allowable level for commercial sale.

Recommendations:

- To err on the side of safety, consumption advice should be issued similar to that given following the Exxon Valdez oil spill and the M/V Kuroshima oil spill. Specifically, statements that subsistence gatherers should avoid consumption of foods on which oil can be seen, smelled or tasted would be appropriate. These recommendations, developed by the Exxon Valdez oil spill health task force, present a common sense and conservative approach and are appropriate for the protection of public health.
- Re-post beaches to warn the public about the dangers associated with PSP.
- Limited subsistence sampling has been conducted near the spill site. Additional sampling of mussels should be conducted near the spill site this summer to verify the reduction and/or possible fluctuation of PAH levels in the mussels.

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Figure 1. Location of subsistence sample collection.