Exxon Valdez Oil Spill
Restoration Project Annual Report

Harbor Seals and EVOS:
Blubber and Lipids as Indices of Food Limitation

Restoration Project 95117-BAA
Annual Report

This annual report has been prepared for peer review as part of the *Exxon Valdez* Oil Spill Trustee Council restoration program for the purpose of assessing project progress. Peer review comments have not been addressed in this annual report. It has also been prepared for NOAA review as a final report.

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Study History: This project began in FY95 as a Broad Agency Announcement award (95117-BAA) with NOAA as part of the EVOS restoration program. It was rolled over in FY96 as part of project 96001. Work on blubber chemistry continued in 96001 and is currently in progress under 97001. The NOAA sponsorship ceases with this report and thus this document serves as a Final report for that agency. However, it is an Annual report for EVOS since the work continues.

Abstract: The hypothesis presented for testing in Broad Agency Announcement (BAA) 52ABNF400104 was that food limitation could have a multi-level impact on marine mammals, affecting their reproductive success, juvenile survival, and adult body condition. We proposed to approach the request from a unique perspective: *If food limitation does indeed impact reproductive success, juvenile survival or adult body condition, then it follows that there should be differences in body condition of adult harbor seals before and after EVOS and within and outside of the EVOS area.* This BAA/NOAA study utilized blubber analysis methods to test body condition status of harbor seals. Blubber provides insulation and is also a critical fuel source for marine mammals. Therefore, its quality and energy density are prime descriptive characteristics of the energy available to the animal. The project was designed with two major components: the analysis of contemporary blubber samples from animals inside and outside of Prince William Sound and the study of archived blubber samples collected before the EVOS event. Simultaneous work on body condition and health status of harbor seals continues under project 97001.

Key Words: blubber chemistry, body condition, *Exxon Valdez*, harbor seals, health, *Phoca vitulina*, Prince William Sound, Southeast Alaska, traditional knowledge.

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INTRODUCTION

This work considers the theoretical impact of food limitation as a potential factor in the non-recovery of harbor seals (Phoca vitulina) in Prince William Sound (PWS) and northern Gulf of Alaska regions after the *Exxon Valdez* Oil Spill (EVOS) event of 1989. The Broad Agency Announcement of FY1995 (BAA) 52ABNF400104 presented the hypothesis that food limitation could have a multi-level impact on marine mammals, affecting their reproductive success, juvenile survival, and adult body condition. In response to that request, this study utilized blubber analysis to examine the nutritional status of harbor seals. Blubber provides both insulation and critical fuel source for marine mammals. Therefore, its quality and energy density are prime descriptive characteristics of the energy available to the animal. The project was designed with two major components: the analysis of contemporary blubber samples from animals inside and outside of Prince William Sound and the study of archived blubber samples collected before the EVOS event. Both sections of the study have been extremely successful.

As part of a NOAA/EVOS agreement on this project, the work on blubber was continued under EVOS projects 96001 and 97001. Therefore, this report is an ANNUAL report for EVOS, but functions as a FINAL report to NOAA. However, the work itself is not completed and many of the studies discussed in this report continue.

OBJECTIVES

The essential elements of this proposal are contained in three tasks:

1. Obtain and analyze blubber from contemporary samples.
2. Obtain and analyze blubber from historical samples.
3. Model changes in blubber with independent data on body condition and change over time relative to EVOS through data gathered within project 95001-97001 (continuing).

METHODS

1. Sample collection

We have been working with the Alaska Native Harbor Seal Commission, the Alaska Department of Fish and Game and the National Marine Fisheries Service in a collaborative project to obtain blubber samples from Native hunters throughout Alaska, including PWS. This has been extremely successful for all groups.

Under direct support of 95117-BAA, we have been collaborated with project /064 (Frost) and collected samples from live animals via biopsy techniques. However, these samples are much smaller than those provided by the hunters, and we have them in cryogenic storage while we perfect our techniques for conducting micro-scale analysis of samples.

DISCUSSION

The gross composition of the subsistence samples are listed in Table 4 and raw data for all samples are contained in Appendices 1-3. There were no significant differences in energy density or water content in blubber samples from various sites on the body, but the lipid content of any individual sample was directly and inversely related to water content. This relationship has been reported previously and the comparable results from our work confirm both the method and the general quality of harbor seal blubber from the EVOS area. However, we did find a sub-group of samples with significantly less lipid content, but have not been able to find other parameters that set those seals apart.

Within the samples from southeast Alaska, there were no patterns in blubber quality with gender or month of year, however, some differences in fat-free water content (hydration state of the cellular matrix of blubber) were found between males and females.

Blubber quality was higher in seals collected in April 1996 from Prince William Sound than from seals collected in the fall/winter in southeast Alaska suggesting either regional and/or seasonal differences (Table 5). Current sampling regimes should be able to distinguish these possibilities. While seals from PWS had much less blubber at key sites on the body, there was no relationship between blubber quality and absolute blubber thickness. However, when relative blubber thickness (ratio of blubber thickness to total radius) was analyzed, there were clear patterns suggesting a "threshold" ratio beyond which only a few seals crossed (Figs 7-10). This threshold may be a valuable indicator of nutrition status and is currently being examined more completely.

The quality of the 20 year old archived samples were extremely high and able to be completely analyzed. More samples are being brought into the laboratory for further analysis. They showed no difference in the energy density on a dry-mass basis indicating no significant change in the energy quality of the blubber between 1976 and 1996. The older samples were less hydrated however and we are using a variety of tests to determine if the freezing process removed some of the water. However, the overall results show that the archived and current samples are very close in quality.

Overall, the results from this study demonstrate that the quality of harbor seal blubber is similar to that seen at other locations around the world suggesting there has not been an major alteration in blubber chemistry in our study animals. However, we do show regional differences that suggest that seals in the area are responding to differences in their local environments. We have also shown that there have not been significant changes in the quality of blubber collected over 20 years ago from the same regions.

We conclude that the evidence suggests the overall quality of blubber in harbor seals has NOT been compromised either across time or across regions.

INTRODUCTION

A key issue surrounding the decline of harbor seal populations in Alaska has been the role of food limitation and nutritional stress (Alaska Sea Grant 1993). Seal body composition, or relative amounts of fat, varies with levels of energy intake (Nordøy and Blix 1985; Markussen 1995), and is reflected by changes in subcutaneous blubber, which comprises up to 90 % of the lipid stores of a seal (Beck et al. 1993). However, blubber quality has also been shown to vary in response to energy status, and can vary seasonally reflecting reproductive or foraging demands (Bowen et al. 1992; Beck et al. 1993). By describing both the quantity and quality (i.e. lipid content) of blubber, a more complete understanding of seal condition can be obtained.

This study was designed ultimately to compare the quality of blubber from harbor seals sampled recently to those sampled in the late 1970's, prior to or at the beginning of detected population declines (Pitcher 1990; Small 1996). We also sought to determine whether compositional or quantitative differences existed in blubber from seals among regions exhibiting different population dynamics around the Gulf of Alaska.

OBJECTIVES

The essential elements of this project were contained in three parts:

i. Obtain and analyze blubber from contemporary samples.
ii. Obtain and analyze blubber from historical samples.
iii. Model changes in blubber with independent data on body condition and change over time relative to the *Exxon Valdez* oil spill through data gathered within Project 95001-97001 (continuing).

METHODS

Sample Collection

Harbor seal (*Phoca vitulina*) blubber samples were collected from three sources; through a subsistence harvest biosampling program, by biopsy of live animals, and from samples collected in 1976-77 and archived by Alaska Department of Fish and Game (ADFG). Seal hunters and trained assistants removed blubber samples (approximately 100 - 200 g) from the 'hip' region (about 60 - 70 % of standard length from the nose) of seals collected during subsistence harvests. Measurements of body mass, standard length, curvilinear length, axillary girth, hip girth, xiphosternal and dorsal hip blubber thickness were also collected when possible. Blubber collected from the seal was placed in a storage bag (Ziploc) and frozen at -5°C. Blubber samples were kept frozen for transport to the University of Alaska, Fairbanks (UAF) Museum, where they were recorded into a chain of custody database and redistributed to our laboratory. If a blubber sample had not been included for a particular seal, blubber from the head (also shipped to the museum) was collected at that time. Blubber samples were double or triple bagged in freezer storage bags (Ziploc) and frozen at -80°C.

Biopsies of blubber were collected during spring and fall season seal-tagging projects in Prince William Sound and around Kodiak Island. Capture and handling techniques have been detailed in Fadely and Castellini (1996), Frost et al. (1995) and Swain (1996). In the field, blubber biopsies were taken from anesthetized seals using 6 mm biopsy punches (Acuderm Inc.), placed directly into 1.2 or 2.0 ml cryovials, and frozen immediately at -196°C in a liquid-nitrogen Dewar-type dry shipper (Taylor-

To better understand the results of our harbor seal work, we have also been collecting blubber samples from northern fur seals (*Callorhinus ursinus*), ringed seals (*Phoca hispida*) and Steller sea lions (*Eumetopias jubatus*) via collaborative work with other investigators. To date we have performed some bomb calorimetry on Steller sea lion samples.

Percentages were transformed using the arcsine angular transformation (Sokal and Rohlf 1973) prior to statistical testing. All statistical procedures were conducted using the Statistix® software package. Results are presented as $x \pm 1sd$.

RESULTS

Sample Collection

Blubber samples obtained from the subsistence harvest tissue program were collected during October 1995 to January 1996 from southeast Alaska ($n = 23$), and during March-April 1996 from Prince William Sound ($n = 18$; Table 1). Subsamples of frozen blubber archived by ADFG were taken from seals collected at Kodiak Island during April 1976 ($n = 2$) and southeast Alaska during January-February 1977 ($n = 7$; Table 2). There were no archived Prince William Sound blubber tissues. Tissue biopsies were collected from live seals during 1995-96 Prince William Sound and Kodiak Island capturing trips in association with Projects 95/96001, 95/96064 and with ADFG (Table 3). Because of the small size of tissue biopsies (generally < 2 g), analyzes of these were delayed until techniques were finalized with larger samples. Results of these analyzes have been moved to 96001 and 97001, and will not be dealt with in this report.

Proximate Blubber Composition

Gross composition of subsistence harvest blubber samples, combining both southeast Alaska and Prince William Sound are listed in Table 4, and individual data are summarized for all samples analyzed in Appendices 1-3. The protein component of blubber samples was not determined, but subtraction of the sum of other components from 100% left a mean of 1.8 %, inclusive of both protein content and any measurement error. No significant differences were found in energy density ($t = 0.48$; $P = 0.6499$; df = 6) or water content ($t = 1.95$; $P = 0.1909$; df = 2) among blubber samples derived from the head or hip areas, thus head blubber values were utilized for comparison if hip samples were unavailable.

Blubber lipid content was directly and inversely related to water content ($r^2 = 0.9537$, $P < 0.0001$, $n = 34$; Figure 1). Likewise, energy density decreased with increasing water content (Figure 2), and increased with increasing lipid content (Figure 3). For 1995-96 samples, this relationship was energy density (in cal/g) = 3637.0 + 5558.3*(wet-mass basis lipid content) ($r^2 = 0.5127$, $P < 0.0001$, $n = 26$). There were no significant relationships between blubber density and water content ($r^2 = 0.1835$, $P = 0.2897$, $n = 8$ for all comparisons), or wet or dry-mass basis lipid content ($r^2 = 0.1641$, $P = 0.3194$ and $r^2 = 0.0790$, $P = 0.5001$, respectively). There was a significant linear relationship between density and energy density ($r^2 = 0.5742$, $P = 0.0294$; Figure 4). Lipid content (wet-mass basis) was independent of the fat-free basis water content, though this plot separated seals into two groups, a group with blubber of greater than about 92% lipid content, and a smaller group of 5 males and 1 female with lower than 90% blubber lipid content (Figure 5).

changed abruptly as the ratio decreased. This pattern was not evident in a plot of fat-free basis water content against relative hip blubber thickness, which showed no pattern over the range of ratios (Figure 10). In a frequency histogram plot of 107 relative dorsal hip blubber thicknesses measured during related Projects 95001 and 96001 (Figure 11), mean relative blubber thickness was 0.214 ± 0.075 and the mode was 0.182, similar to the range of greatest energy density, lipid and water variability (Figures 7-9).

Southeast Alaska Interannual Comparisons

Archived blubber samples collected during 1977 were significantly higher in lipid (wet-mass basis) content (x = 94.2 ± 1.0 %, n = 7) than 1995-96 season samples (x = 90.8 ± 2.5 %, n = 12; t = 4.04, P = 0.0011, t-test for unequal variances), but not in dry-mass basis lipid content (t = 2.02, P = 0.0615; t-test for unequal variances). There was no difference between the two periods in the relationship between lipid content and water content ($F_{1,16}$ = 0.10, P = 0.7541; ANOVA on linear regression standardized residuals; Figure 1). Energy densities (wet-mass basis) of archived blubber (x = 8935 ± 66, n = 7) were also significantly higher than of recently collected blubber (x = 8632 ± 206, n = 13; t = 4.86, P = 0.0002 for unequal variances), and conversely archived blubber water content (x = 4.6 ± 0.8 %, n = 7) was significantly lower than the 1995-96 blubber samples (x = 7.4 ± 2.3 %, n = 13; t = 17.6, P = -4.15; t-test for unequal variances). Energy densities expressed on a dry-mass basis were not significantly different between the two periods ($F_{1,18}$ = 0.34, P = 0.5694). There were no significant differences in how energy density (wet-mass basis) varied with water content ($F_{1,18}$ = 1.79, P = 0.1970; Figure 2) or with lipid content ($F_{1,16}$ = 0.90, P = 0.3556; Figure 3). There were also no significant differences between periods in fat-free basis water content for males ($F_{1,7}$ = 3.35; P = 0.1097) or females ($F_{1,6}$ = 2.67; P = 0.1536).

energy density varies by at least 10 %. As Gales et al. (1994) suggest, estimates of the energy content (and therefore condition) of these seals can be erroneous if blubber quality is unknown.

We found a small (about 3.5 %) decrease in energy density of seal blubber from southeast Alaska when compared to archived samples collected during 1976-77. Because of the duration these samples have been archived, the quality of this 20 year old blubber was a foremost concern. We have found that these archived blubber samples appear to be adequate for comparative purposes. By carefully trimming away clearly rancid, oxidized or desiccated tissue, there was no evidence of lipid oxidation in the analyzed portions, as the dry-mass basis lipid content was not significantly different between the two periods. Slight desiccation of the blubber samples would artificially increase wet-mass lipid content and produce the results found here. However, water content expressed on a fat-free basis were not different between the two periods, suggesting desiccation had not occurred. None of the measured values were out of the range of values measured from present day samples, so if desiccation had occurred, it was very minor. Finally, there was no relationship between visual determinations of sample condition and resultant water and lipid content, or with energy density. Because the archived samples are of adequate quality, we will analyze many more during the second project year. Additionally, we will analyze visually poor samples without removing the clearly oxidized or desiccated portions to determine whether our techniques are sensitive to these effects.

We conclude that the quality of harbor seal blubber from animals collected in this program does not show obvious changes either over time (1976-1996) or over region that would severely compromise the energy budget of these animals. However, there are clear thresholds in the relationships between quality and relative quantity of blubber that may be indicators of body condition. We were able to show minor regional differences in blubber quality that could be reflective of energetic demand differences.

ACKNOWLEDGEMENTS

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Table 1 continued. Harbor seal (*Phoca vitulina*) blubber samples from the Gulf of Alaska provided by the subsistence harvest biological tissue program.

AF Number	Date	Sex	Mass (kg)	SL on belly (cm)	SL on back (cm)	AxG (cm)	Sampler's Name	Village	Harvest Location
13879	09-Apr-96	F		96	148	100	Daniel Vlasoff	Tatitlek	Rocky Bay
13880	10-Apr-96	M	43.4	127	130	86	Daniel Vlasoff	Tatitlek	Seal Island
13882	09-Apr-96	M		142	148	101	Daniel Vlasoff	Tatitlek	Rocky Bay
13883	09-Apr-96	M		105	105	74	Daniel Vlasoff	Tatitlek	Rocky Bay
13884	10-Apr-96	M	27.1	105	106	74	Daniel Vlasoff	Tatitlek	Seal Island
13885	10-Apr-96	F	45.2	134	134	87	Daniel Vlasoff	Tatitlek	Seal Island
13886	11-Apr-96	M		130	131	90	Daniel Vlasoff	Tatitlek	Green Island
13887	11-Apr-96	M		141	144	93	Daniel Vlasoff	Tatitlek	Green Island
13888	11-Apr-96	M		104	103	86	Daniel Vlasoff	Tatitlek	Green Island
13889	11-Apr-96	F		144	149	113	Daniel Vlasoff	Tatitlek	Green Island
13890	11-Apr-96	M		162	164	113	Daniel Vlasoff	Tatitlek	Green Island
13891	11-Apr-96	F		105	108	70	Daniel Vlasoff	Tatitlek	Green Island
13892	11-Apr-96	M		96	97	68	Daniel Vlasoff	Tatitlek	Green Island
13893	11-Apr-96	F		96	97	67	Daniel Vlasoff	Tatitlek	Green Island
13894	11-Apr-96	F		92	101	76	Daniel Vlasoff	Tatitlek	Green Island
13895	11-Apr-96	F		139	154	112	Daniel Vlasoff	Tatitlek	Green Island

Table 3. Harbor seal (*Phoca vitulina*) blubber tissue biopsies collected from Prince William Sound and Kodiak Island during 1995-96.

ID	LTag	RTag	Date	Sex	Location
PV95PW01	B24	B25	09-May-95	M	Dutch Group
PV95PW02	B92	B91	09-May-95	M	Lone Island, North end
PV95PW03	B96	B95	09-May-95	M	Dutch Group
PV95PW04	B97	B98	09-May-95	M	Dutch Group
PV95PW05	B99	B100	09-May-95	M	Dutch Group
PV95PW06	Y202	Y201	11-May-95	F	Olsen Bay, Port Gravina
PV95PW07	Y204	Y203	11-May-95	M	Olsen Bay, Port Gravina
PV95PW08	Y206	Y205	11-May-95	F	Pt.Chalmers, Montague Is.
PV95PW09	Y212	Y211	11-May-95	F	Channel Is, Montague Strait
PV95PW10	Y210	Y209	11-May-95	M	Channel Is, Montague Strait
PV95PW11	Y208	Y207	11-May-95	F	Channel Is, Montague Strait
PV95PW12	Y214	Y213	11-May-95	M	Channel Is, Montague Strait
PV95PW13	Y215	Y216	11-May-95	F	Channel Is, Montague Strait
PV95PW14	Y218	Y217	11-May-95	M	Channel Is, Montague Strait
PV95PW15	Y219	Y220	12-May-95	M	Stockdale Harbor, Montague
PV95PW16	Y226	Y225	12-May-95	M	Stockdale Harbor, Montague
PV95PW17	Y228	Y227	12-May-95	F	Stockdale Harbor, Montague
PV95PW18	Y221	Y222	12-May-95	M	Stockdale Harbor, Montague
PV95PW19	Y224	Y223	12-May-95	F	Stockdale Harbor, Montague
PV95PW20	Y230	Y229	14-May-95	F	Pt.Chalmers, Montague Is.
PV95PW21	Y232	Y231	14-May-95	F	Pt.Chalmers, Montague Is.
PV95PW22	Y233	Y234	14-May-95	M	Pt.Chalmers, Montague Is.
PV95PW23	B301	B302	25-Sep-95	F	Gravina Is.
PV95PW24	303	304	25-Sep-95	F	Gravina Is.
PV95PW25	308	309	26-Sep-95	F	Pt.Chalmers, Montague Is.
PV95PW26	B310	B313	26-Sep-95	F	Pt.Chalmers, Montague Is.
PV95PW27	B305	B306	26-Sep-95	F	Pt.Chalmers, Montague Is.
PV95PW28	B314	B316	26-Sep-95	M	Little Green Is., Montague
PV95PW29	B323	B317	26-Sep-95	M	Little Green Is., Montague
PV95PW30	Y251	Y252	26-Sep-95	F	Little Green Is., Montague
PV95PW31	Y253	Y254	26-Sep-95	M	Little Green Is., Montague
PV95PW32	Y255	Y256	26-Sep-95	M	Little Green Is., Montague
PV95PW33	Y257	Y258	26-Sep-95	F	Little Green Is., Montague
PV95PW34	Y235	Y236	26-Sep-95	F	Little Green Is., Montague
PV95PW35	Y238	Y237	26-Sep-95	F	Little Green Is., Montague
PV95PW36	Y240	Y239	26-Sep-95	F	Little Green Is., Montague
PV95PW37	Y243	Y248	27-Sep-95	M	Channel Is, Montague Strait
PV95PW38	Y263	Y264	27-Sep-95	F	Pt.Chalmers, Montague Is.
PV95PW39	Y262	R260	27-Sep-95	F	Pt.Chalmers, Montague Is.
PV95PW40	Y241	Y242	27-Sep-95	M	Pt.Chalmers, Montague Is.
PV95PW41	Y249	Y250	28-Sep-95	M	Applegate Rocks, Montague
PV95PW42	Y267	Y266	28-Sep-95	M	Applegate Rocks, Montague

Table 4. Comparison of proximate blubber composition measured for pinnipeds.

Species	Energy Density (kcal/g)	Water (%)	Lipid (%)	Protein (%)	Ash (%)	Density (g/cm3)	Reference
Grey seal	9.25 ± 0.02	7.4 ± 1.1				0.90	Nordøy and Blix 1985
Harbor seal	8.73 ± 0.21	6.53 ± 2.30	91.8 ± 2.8		0.03 ± 0.01	0.954 ± 0.009	This study
Adult		5 - 15	77 - 92.1	2 - 5			Bowen et al. 1992
Pup		7 - 17	75.8 - 90	2 - 5.5			Bowen et al. 1992
Harp seal		9.52 ± 3.14	87.7 ± 4.1	2.0 ± 1.0	0.01 ± 0.04		Gales et al. 1994
						0.937 ± 0.028	Gales and Renouf 1994
Southern elephant seal						0.95	Gales and Burton 1987
Steller sea lion	8.23 ± 0.13						This study

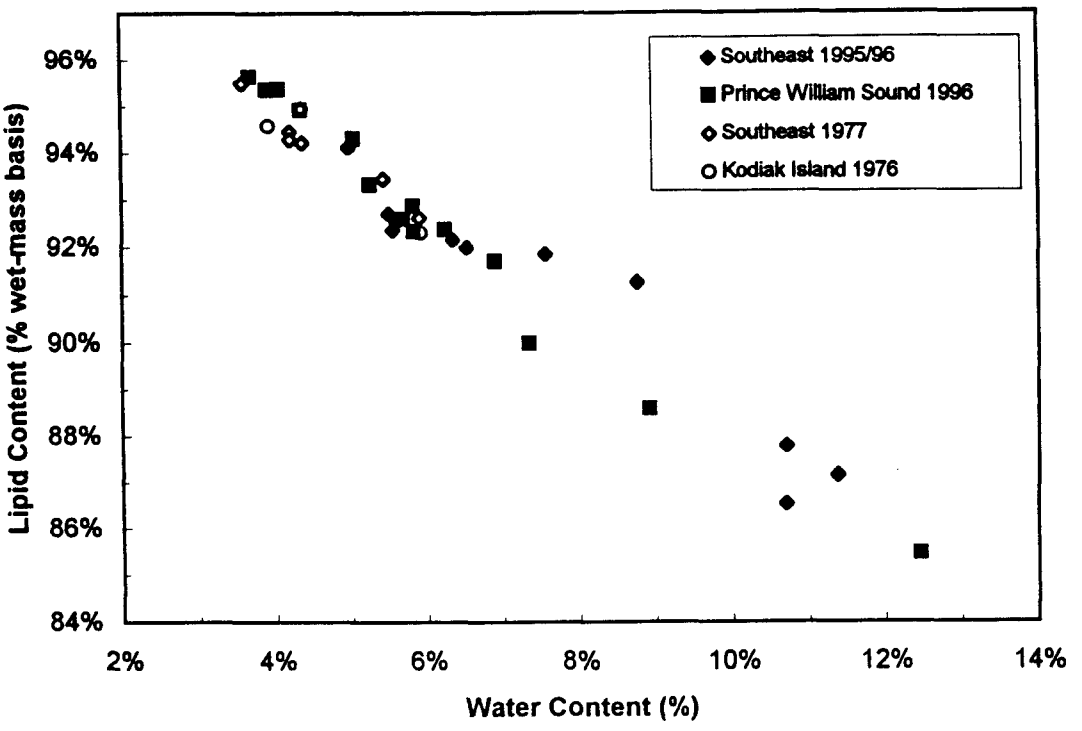

Figure 1. Relationship between lipid (wet-mass basis) and water content for harbor seal (*Phoca vitulina*) blubber from seals collected in southeast Alaska, Prince William Sound, and Kodiak Island.

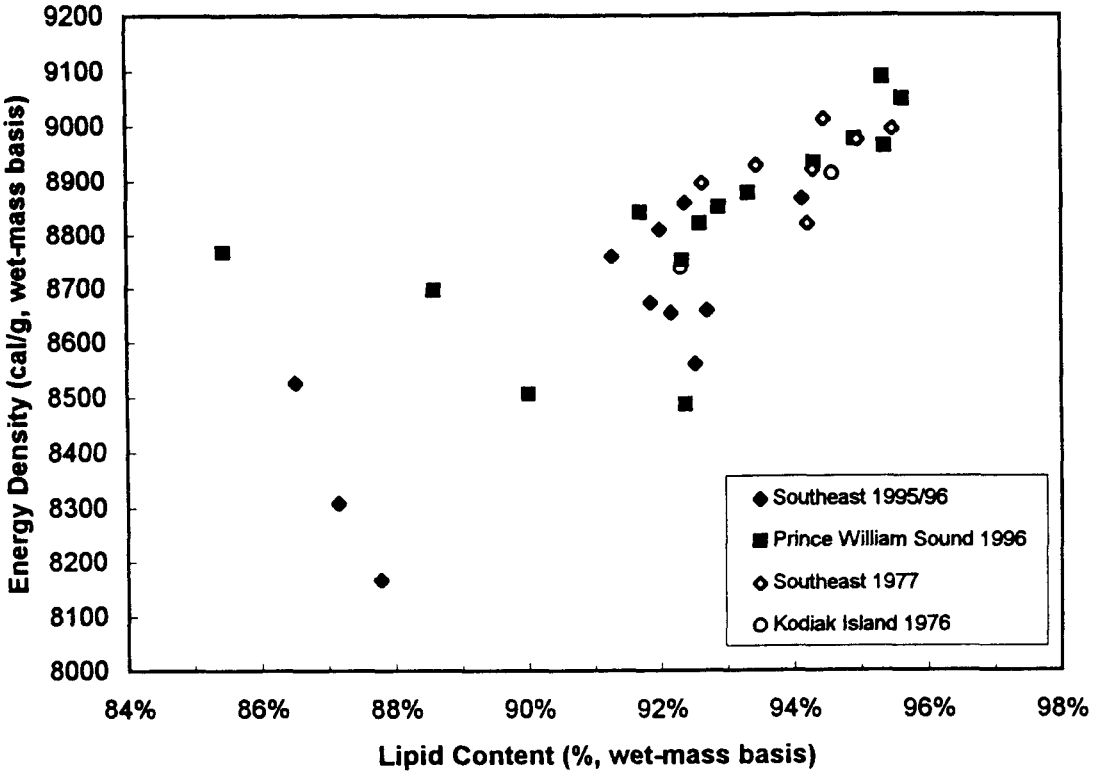

Figure 3. Energy density and lipid content of harbor seal (*Phoca vitulina*) blubber collected from seals in southeast Alaska, Prince William Sound and Kodiak Island.

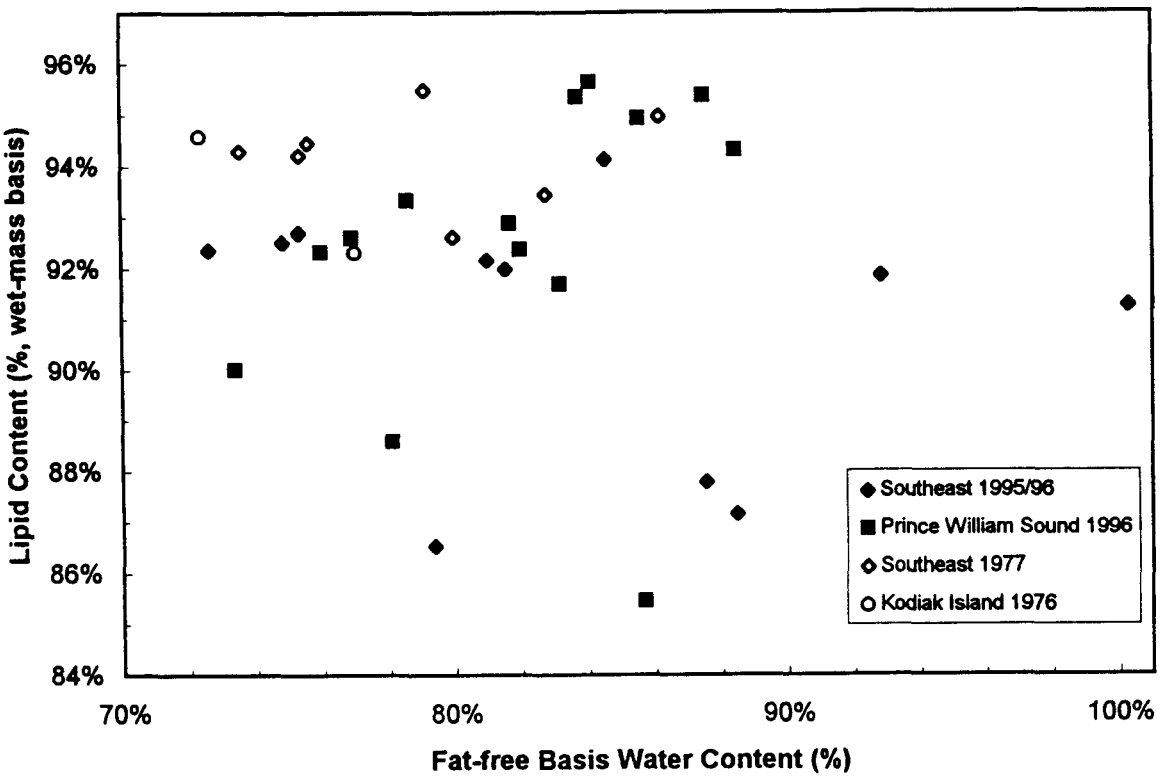

Figure 5. Lipid (wet-mass basis) and water (fat-free basis) content relationship for harbor seal (*Phoca vitulina*) blubber from seals collected in southeast Alaska, Prince William Sound and Kodiak Island.

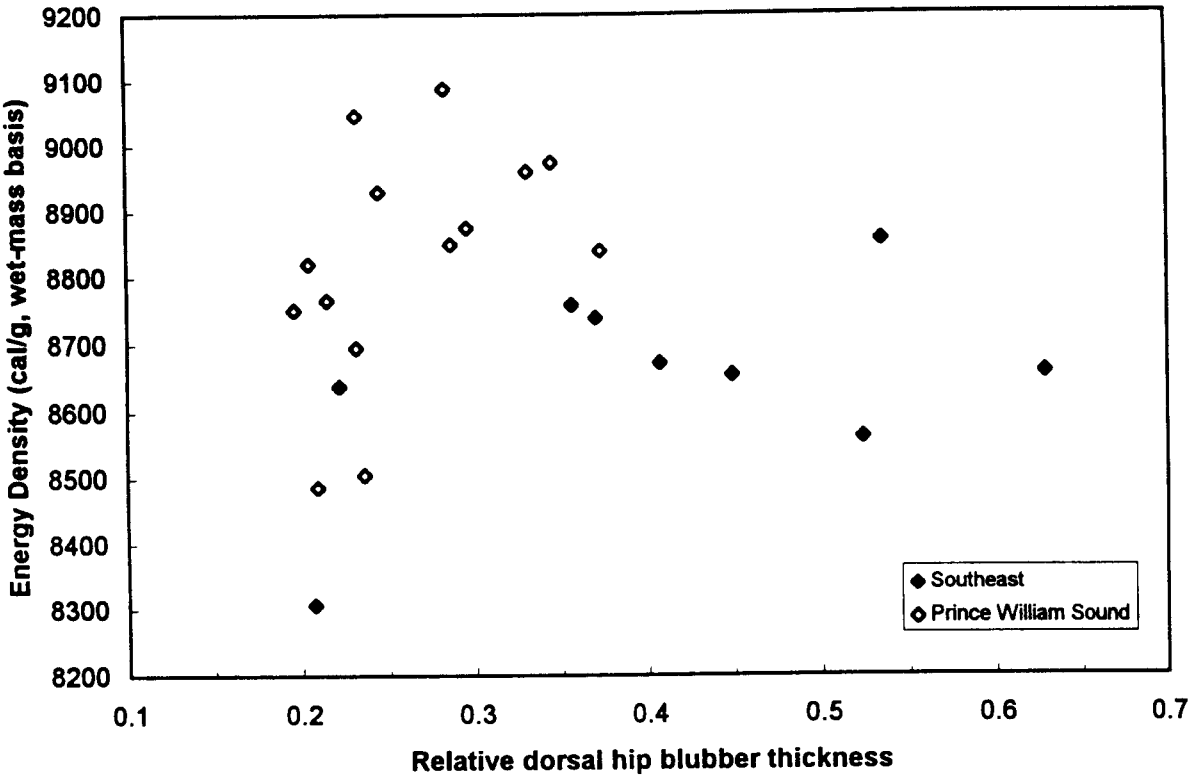

Figure 7. Harbor seal (*Phoca vitulina*) blubber energy densities for dorsal hip blubber thicknesses relative to hip girth, for samples collected from southeast Alaska and Prince William Sound during 1995-96.

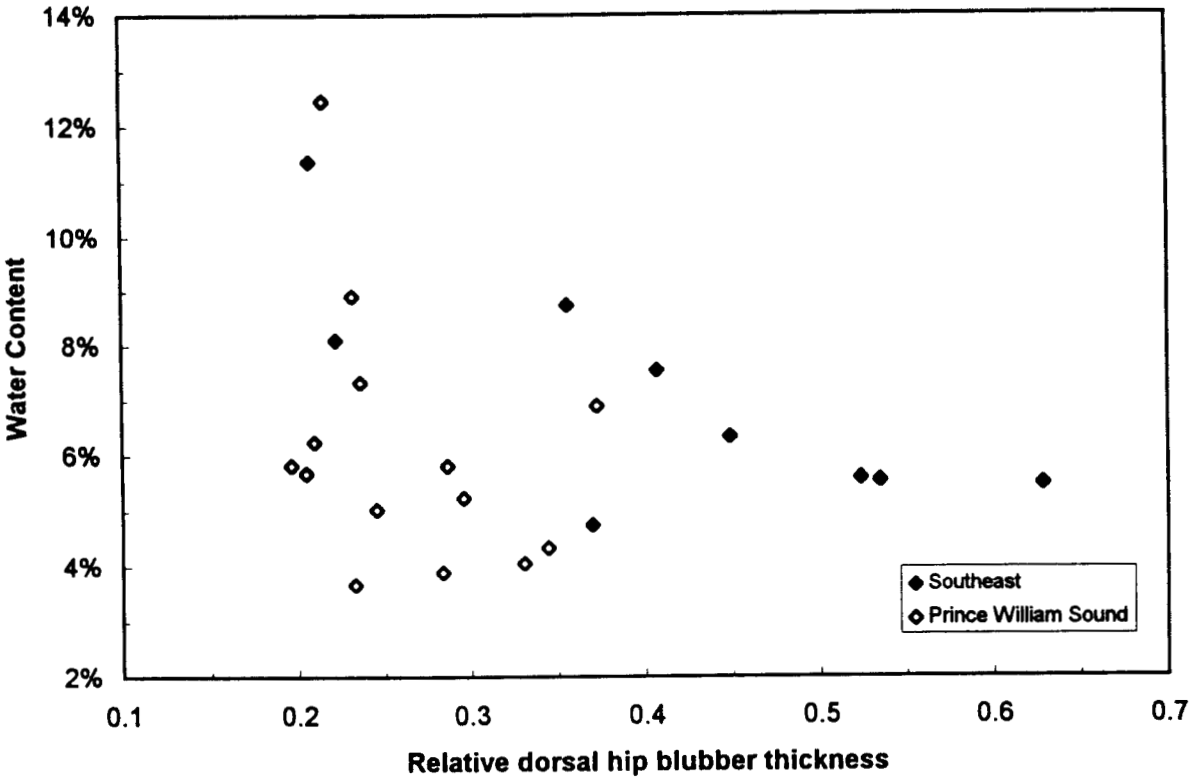

Figure 9. Harbor seal (*Phoca vitulina*) blubber water content and dorsal hip blubber thickness relative to hip girth for samples collected from southeast Alaska and Prince William Sound during 1995-96.

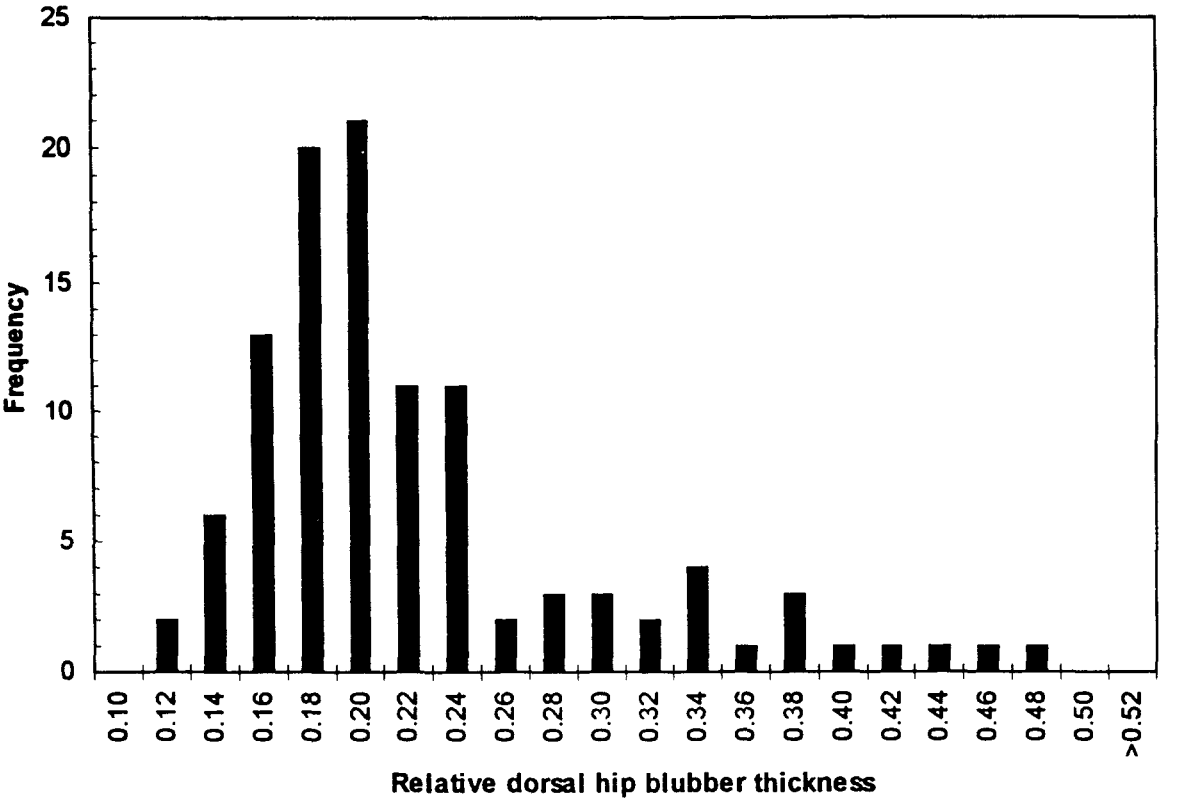

Figure 11. Histogram of relative dorsal hip blubber thickness measurements for harbor seals (*Phoca vitulina*) measured during Spring and Fall months 1993-96 at Kodiak Island, Prince William Sound and southeast Alaska (n = 107).

Appendix 1, continued. Summary of harbor seal (*Phoca vitulina*) blubber composition data.

AF Number	Section	Water (%)	Dry mass basis Lipid (%)	Wet mass basis Lipid (%)	Gross Heat (cal/g)	Fat-Free Basis Water (%)	Density (g/cm^3)	Ash (%)
SE-3-77		4.3	99.1	95.0	8973.54	86.2		
SE-5-77		4.4	98.3	94.2	8820.11	75.3		
SE-6-77		4.2	98.3	94.3	8919.84	73.6		
SE-7-77		5.4	98.5	93.5	8928.38	82.8		
SE-10-77		3.6	98.9	95.5	8993.57	79.1		
SE-12-77		5.9	98.1	92.6	8895.53	80.0		
SE-15-77		4.2	98.4	94.5	9011.60	75.6		
KOD-5-76		3.9	98.3	94.6	8912.99	72.4		
KOD-8-76		5.9	97.8	92.3	8738.15	77.0		

Appendix 2, continued. Bomb calorimetry determinations of harbor seal (*Phoca vitulina*) blubber samples.

ID	Section	Wet Mass (g)	ACID (cal) End	ACID (cal) Start	ACID (cal) Total	Fuse (cal)	Gross Heat (cal/g)	Comments
13820	head	0.9288	14.3	1.9	12.4	15.0	8944.83	
13820	hip	1.0047	26.0	14.3	11.7	16.3	8708.17	
13820	hip	0.8525	37.4	26.0	11.4	12.0	8609.46	
13821	head	0.9762	25.3	12.4	12.9	15.6	8288.29	
13821	head	0.8238	35.3	25.3	10.0	16.3	7981.03	
13821	hip	0.8774	49.0	37.4	11.6	10.8	8628.39	
13821	hip	0.8294	12.4	0.9	11.5	13.9	8494.45	
13822	head	1.0092	49.2	35.3	13.9	15.3	8736.91	
13822	head	0.8711	11.0	0.1	10.9	16.2	8675.54	
13822	hip	0.9222	22.7	11.0	11.7	11.1	8772.29	
13822	hip	0.9379	35.2	22.7	12.5	15.7	8573.32	
13823	head	0.9672	48.0	35.2	12.8	16.0	8809.44	
13823	head	0.8191	11.0	0.9	10.1	16.4	8374.02	
13823	hip	0.9642	24.8	11.2	13.6	10.8	8920.13	
13823	hip	0.9008	36.9	24.8	12.1	15.8	8560.61	
13882	hip	1.0292	11.8	1.5	10.3	12.2	8819.19	
13882	hip	0.9875	20.2	11.8	8.4	12.0	8822.46	
13883	hip	1.0010	31.5	20.2	11.3	11.5	8922.18	
13883	hip	1.0649	44.1	31.5	12.6	15.2	8831.45	
13884	hip	1.0273	12.6	0.9	11.7	14.4	8872.96	
13884	hip	0.9863	23.5	12.6	10.9	15.2	8808.96	
13885	hip	1.0387	34.2	23.7	10.5	15.3	8751.50	
13885	hip	1.0403	46.1	34.2	11.9	15.7	8781.73	
13886	hip	0.9836	12.0	0.3	11.7	15.7	8855.72	
13886	hip	1.0019	24.2	13.2	11.0	15.3	8648.48	
13887	hip	1.0322	35.7	24.7	11.0	16.0	8548.60	
13887	hip	0.9930	46.8	35.7	11.1	16.2	8424.32	
13888	hip	1.0178	12.3	0.9	11.4	13.2	8668.10	

Appendix 2, continued. Bomb calorimetry determinations of harbor seal (*Phoca vitulina*) blubber samples.

ID	Section	Wet Mass (g)	ACID (cal) End	ACID (cal) Start	ACID (cal) Total	Fuse (cal)	Gross Heat (cal/g)	Comments
KOD-5-76		0.9812	35.4	23.2	12.2	16.5	9010.41	
KOD-5-76		0.9899	47.8	35.4	12.4	16.5	8815.56	
KOD-8-76		0.9940	26.0	14.1	11.9	17.5	8732.20	
KOD-8-76		0.9527	38.1	26.0	12.1	13.0	8744.10	
SE-10-77		0.9839	11.9	0.0	11.9	12.5	8999.57	
SE-10-77		0.9384	23.7	11.9	11.8	15.8	8987.57	
SE-12-77		0.9768	35.1	23.7	11.4	15.9	8848.63	
SE-12-77		1.0203	47.4	35.1	12.3	12.3	8942.43	
SE-15-77		0.9725	11.9	0.5	11.4	15.4	9013.90	
SE-15-77		0.9619	23.2	11.9	11.3	11.8	9009.29	
SE-3-77		0.9486	12.7	1.6	11.1	21.1	9066.82	
SE-3-77		1.0353	24.9	12.7	12.2	17.8	8880.26	
SE-5-77		1.0034	37.0	24.9	12.1	16.4	8740.91	
SE-5-77		1.0292	49.6	37.0	12.6	17.7	8899.31	
SE-6-77		1.0457	12.6	0.5	12.1	16.8	8915.62	
SE-6-77		0.9706	24.4	12.7	11.7	17.6	8924.06	
SE-7-77		1.0230	36.9	24.4	12.5	16.2	8900.62	
SE-7-77		0.9282	47.7	36.9	10.8	16.3	8956.13	
SSL 764W		0.3959	25.7	22.8	2.9	18.8	7750.84	Soot in cup, incomplete burn. Mass too small.
SSL 764W		0.2748	34.4	32.3	2.1	10.1	7233.08	Soot in cup, incomplete burn. Mass too small.
SSL 764W		0.2900	4.7	0.0	4.7	12.8	8243.63	Soot in cup, incomplete burn. Mass too small.
SSL 764W		0.8571	31.2	20.5	10.7	16.4	8140.73	
SSL 764W		0.7707	40.8	31.2	9.6	17.0	8320.90	

Appendix 3, continued. Lipid extraction data of harbor seal (*Phoca vitulina*) blubber collected by subsistence harvest or archived by Alaska Department of Fish and Game.

AF Number	Section	Wet Mass Basis Blubber (g)	Dry Mass Basis Blubber (g)	Final Mass (g)	Lipid (g)	Dry Mass Basis Lipid (%)
13886		0.5946	0.5600	0.0088	0.5512	98.4%
13887		0.6722	0.6302	0.0115	0.6187	98.2%
13887		0.5589	0.5240	0.0098	0.5142	98.1%
13888		0.6928	0.6310	0.0251	0.6059	96.0%
13888		0.7086	0.6454	0.0197	0.6257	96.9%
13889		0.5478	0.5265	0.0094	0.5171	98.2%
13889		0.5578	0.5361	0.0005	0.5356	99.9%
13890		0.6232	0.5775	0.0173	0.5602	97.0%
13890		0.7024	0.6509	0.0247	0.6262	96.2%
13891		0.6320	0.6046	0.0078	0.5968	98.7%
13891		0.5745	0.5496	0.0034	0.5462	99.4%
13892		0.5561	0.5336	0.0045	0.5291	99.2%
13892		0.5288	0.5074	0.0035	0.5039	99.3%
13893		0.6128	0.5772	0.0055	0.5717	99.0%
13893		0.5129	0.4831	0.0120	0.4711	97.5%
13894		0.6121	0.5813	0.0056	0.5757	99.0%
13894		0.6591	0.6259	0.0058	0.6201	99.1%
13895		0.6307	0.6075	0.0054	0.6021	99.1%
13895		0.6197	0.5969	0.0049	0.5920	99.2%
SE-3-77		0.5351	0.5142	0.0044	0.5098	99.1%
SE-3-77		0.6074	0.5837	0.0057	0.5780	99.0%
SE-5-77		0.7021	0.6715	0.0121	0.6594	98.2%
SE-5-77		0.5519	0.5279	0.0082	0.5197	98.4%
SE-6-77		0.6368	0.6101	0.0114	0.5987	98.1%
SE-6-77		0.6292	0.6028	0.0098	0.5930	98.4%
SE-7-77		0.5693	0.5384	0.0075	0.5309	98.6%
SE-7-77		0.5637	0.5331	0.0084	0.5247	98.4%
SE-10-77		0.6643	0.6406	0.0072	0.6334	98.9%
SE-10-77		0.6029	0.5814	0.0063	0.5751	98.9%
SE-12-77		0.7646	0.7195	0.0158	0.7037	97.8%
SE-12-77		0.9557	0.8994	0.0146	0.8848	98.4%
SE-15-77		0.5545	0.5313	0.0074	0.5239	98.6%
SE-15-77		0.7683	0.7361	0.0131	0.7230	98.2%
KOD-5-76		0.4559	0.4380	0.0072	0.4308	98.4%
KOD-5-76		0.5457	0.5243	0.0093	0.5150	98.2%
KOD-8-76		0.7699	0.7243	0.0175	0.7068	97.6%
KOD-8-76		0.8752	0.8234	0.0167	0.8067	98.0%