Preassessment Data Report #4:

Results of a Drift Experiment to Estimate Seabird Carcass Deposition on Beaches at Unalaska Island, Alaska, in the Vicinity of the Wreck of the M/V *Selendang Ayu*

Drift blocks washed ashore in Skan Bay, January 8, 2005

G. V. Byrd[1]
J. H. Reynolds[2]

[1]U. S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, 95 Sterling Highway, Suite 1, Homer, AK 99603
[2]U. S. Fish and Wildlife Service, Division of Natural Resources, MS-221, 1011 E. Tudor Road, Anchorage, AK 99503

7 March 2007 – Final Report

INTRODUCTION

On 8 December 2004, the Selendang Ayu ran aground and broke in half in rough seas off Unalaska Island, Alaska (53°38'N, 167° 07'W). An estimated 354,218 gallons of oil (339,538 gallons of bunker oil [IFO 380] and 14,680 gallons of marine diesel and miscellaneous oils) were released. Estimates of the number of marine birds killed by the spill depend on variables such as the proportion of birds killed that actually wash ashore. This variable is typically estimated by using drift blocks to simulate carcasses (e.g., Flint and Fowler 1998).

Drift blocks were deployed from the M/V *Tiĝlax̂*, which arrived in the area December 23, 2004. The drift blocks were released at the first subsequent opportunity when wind directions were similar to those at the time of the wreck. Recovery of drift blocks during beach surveys for carcasses and oil are summarized here.

METHODS

Drift Blocks

Drift blocks were made of wood with dimensions: 4"x 4" x 8" -- approximately 10 cm x 10 cm x 20 cm and weighted to simulate king eiders (Figure 2). The blocks were painted orange to facilitate relocation on beaches, and each had a unique number and a tag indicating that anyone finding a block should contact the U.S. Fish and Wildlife Service (FWS) for a reward.

Deployment

On January 4, 2005, between 11:30-11:50h, Jeffrey C. Williams and the crew aboard the M/V *Tiĝlax̂* released 165 drift blocks. Blocks were deployed in nine groups ranging from 8 to 40 blocks each to approximate natural distributions of major species of birds at risk: for example, a group of 40 was deployed to simulate species that form dense flocks like black scoters (*melanitta nigra*) or crested auklets (*Aethia cristatella*) and small bunches of 8 - 10 were deployed to approximate other species of waterbirds. Blocks were deployed along a 2 km-long transect, stretching approximately 1 to 3 km northeast of the Selendang Ayu wreck (Figure 2).

At the time of deployment the wind was WNW at 20-25 knots and the swell was NW at 8 ft. Although the wind direction was roughly onshore, similar to the conditions at the time of the spill, the wind velocity and sea state were not as extreme. Nevertheless, January 4 was the first opportunity to deploy blocks under on shore wind conditions, and the conditions during deployment were the closest conditions to those at the time of the wreck since the arrival of the M/V *Tiĝlax̂* in the area. The wind and swell continued from that direction for 24-36 hours after the blocks were deployed, but by mid-day January 6 the wind had changed to SE 20-30 knots (offshore) and these conditions continued for several days thereafter.

All personnel working on beaches in the spill area were informed, via both the Unified Command and community meetings, of the deployment and how to report recovered blocks. A reward was offered for recovered blocks.

Beach Surveys for Drift Blocks

Drift block recovery occurred as part of the beach surveys for oiled wildlife carcasses. The survey region covered the geographic extent of beaches known at that time to have been oiled from the wreck of the *Selendang Ayu*: the north shore of Makushin Bay to Pumicestone Bay (Figure 1).

Two types of beach surveys were conducted: rigorous, replicate surveys of sample beaches to estimate the number of oiled wildlife carcasses in the area, conducted by FWS crews from the M/V *Tiĝlax̂* (Table 1), and single visit surveys of beaches to document the extent of oiling and opportunistically collect oiled wildlife carcasses, conducted by pre-SCAT crews, known as Rapid Assessment Teams (Table 2). Survey teams retrieved any blocks they discovered (Figure 2). For each block, all beach crews were instructed to record the beach segment, date, block number, and whether the block was visibly oiled or not.

The M/V *Tiĝlax̂* survey crew periodically revisited a set of beaches to detect newly deposited blocks and thus allow estimation of deposition rate (Table 1). Probability of block recovery, combining both deposition and detection, were estimated using only observations of blocks made within 14 days of deployment since murre carcasses are estimated to sink within 14 days (Wiese 2003). Confidence intervals for the recovery probability were calculated using the method based on the relationship between the F distribution and the binomial distribution Zar (1996, p 524). Blocks recovered on single visit surveys by pre-SCAT teams and others were to be included under the assumption that a block could have washed ashore within 14 days and remained on the beach indefinitely until discovery.

RESULTS

At 20:30h on January 4, approximately 11 hours after the blocks were deployed, personnel aboard the M/V *Commitment* reported that orange drift blocks were seen "everywhere" in the water in Skan Bay (e.g., Figure 3a). Within the fourteen days following deployment, 165 beach surveys were conducted: 77 by the M/V *Tiĝlax̂* crew (Table 1), 88 by the pre-SCAT teams and others (Table 2, ignoring the M/V *Tiĝlax̂* surveys identified in Table 1).

Blocks were first found ashore on January 8 (Table 1).

> "We found 16 drift blocks on SKS 18 segment 4. The blocks on the beach were easily observed while we were in a skiff approaching the shore. All 16 blocks were oiled and we disposed of them as oily waste after recording the ID numbers and location. After our beach surveys, I surveyed the shoreline of SKS 10,11,12,18, and SKN 1,2,15 from a skiff looking for more drift blocks. I found a small cluster of 10 blocks several hundred meters up the beach from SKS 18 segment 4 [still in SKS 18]. I recorded the numbers, but left the blocks on the beach since they were not on our beach survey segments and are susceptible to rewash. Only 1 of these blocks found off our survey beach segment 4 (359) was oiled." (J.C. Williams log on January 8, 2005, Williams 2005).

The latter group of 10 blocks referred to by Williams was subsequently recovered 8 hours later by another beach oil survey crew from the support vessel M/V *Commitment*. No other block recoveries within the 14 day window following deployment were reported.

Block deposition rate could not be calculated due to the lack of further recoveries. Block recovery probability was estimated as 16% = 26 / 165 with a 95% confidence interval of (11%, 22%). Block recovery probability was specifically defined as the probability that a drift block released near the wreck was deposited on a surveyed beach in the area known, at the time, to have been oiled and subsequently recovered during surveys within the 14 day window. The probability that a recovered block was visibly oiled was estimated as 65% = 17 / 26 with 95% confidence interval (48%, 80%).

Some blocks that drifted away from Unalaska Island were later found throughout the Aleutians:

Block # 394 was found at Adak Island on 31 May 2005;
Block # 490 was reported found on 12 July 2005 from Walt Bay on Atka Island;
Block # 417 was found 31 December 2005 at the southern tip of Umnak Island; and
Block # 379 was found 7 January 2006 on the east side of Shemya Island.

DISCUSSION

Carcass deposition on beaches following an oil spill is influenced by many factors such as wind, current direction and velocity. The recovery rate of objects experimentally dropped at sea, i.e. carcasses or blocks, and recovered in subsequent beach searches is highly variable and generally small (Hope-Jones et al, 1970; Bibby and Lloyd, 1977; Piatt et al, 1990; Threlfall and Piatt, 1983; Hlady and Burger, 1993; Piatt and Ford, 1996). A review of experimental deposition studies incorporating systematic beach surveys reported recovery rates ranging from 0-59%, with a median of 11% (Piatt and Ford 1996).

The drift block release was relatively near shore, similar to the source of the oil. The release was conducted during the first opportunity in which wind and sea conditions were similar to that at the time of the spill. Conditions were similar in direction but not as extreme in magnitude (wind velocity, sea state) as during the spill.

Using the block recovery estimate as an estimate of deposition rate requires assuming that block persistence and detection are both 1.0, otherwise the recovery rate estimate of 16% *underestimates* the deposition rate. While block persistence was likely high, as they would not be removed by scavengers, it was likely not perfect as they were susceptible to rewash. Block detection was also likely high due to coloring and unique shape, but less than perfect due to reality of beach surveys. The recovery estimate also does not account for the uneven distribution of survey effort across beaches within the spill zone following drift block deployment (Figure 2, Tables 1 and 2).

The beaches where blocks were found were directly down wind from the point of release. This distribution of recoveries fits with previous studies that concluded wind direction was a primary determinant of carcass drift (Hlady and Burger 1993, Flint and Fowler 1998). All recoveries were located on catchment beaches (see Table 2), indicating that deposition was probably influenced by wind and local currents (Flint and Fowler 1998).

ACKNOWLEDGEMENTS

Paul Flint made essential contributions to this report. Tremendous thanks to the following individuals for the their assistance in implementing this study and in reviewing the report: the crew of the M/V *Tiĝlax̂* - Kevin Bell, Dan McNulty, Dennis Haunschild, John Faris, Dan Erickson, Joe Isenhour, Bob Ward, Eric Nelson; Jeff Williams, Leslie Slater, Becky Howard, Bill Schaff, Greg McClelland, Ty Wyatt, Janis Krukof, Kent Sundseth, Jeff Lewis, Cris Dippel, Andy Aderman, Don Dragoo, Arthur Kettle, Greg Thomson, Steve Kendall, Gary Wheeler, Pat Walsh, Fred Broerman, Ken Gates, Kristine Sowl, Thomas Siekaniec, Clay McDermott, Delia Person, Michael Winfree, Suzann Speckman, Merban Cebrian, Jennie Wetzel, Ingrid Harrald, and especially Laurie Daniel.

REFERENCES

Bibby, C.J. and Lloyd, C.S. 1977. Experiments to determine the fate of dead birds at sea. Biological Conservation 12: 295-309.

Flint, P.L. and A.C. Fowler 1998. A Drift Experiment to Assess the Influence of Wind on Recovery of Oiled Seabirds on St. Paul Island, Alaska. Marine Pollution Bulletin 36: 165-166.

Hlady, D.A. and Burger, A.E. 1993. Drift-block experiments to analyze the mortality of oiled seabirds off Vancouver Island, British Columbia. Marine Pollution Bulletin 26: 495-500.

Hope-Jones, P., G. Howells, E.I.S. Rees, and J. Wilson 1970. Effect of the 'Hamilton Trader' oil on birds in the Irish Sea in May 1969. British Birds 63: 97-110.

Piatt, J.F. and R.G. Ford. 1996, How many seabirds were killed by the *Exxon Valdez* oil spill?: pp. 712–719. *In* S. D. Rice, R. B. Spies, D. A. Wolfe, and B. A. Wright [EDS.], Proceedings of the *Exxon Valdez* oil spill symposium. Am. Fisheries Soc. Symposium 18, Bethesda, MD.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorek and D.R. Nysewander 1990. Immediate impact of the Exxon Valdez oil spill on marine birds. Auk 107: 387-397.

Threlfall, W. and J.F. Piatt 1983. Assessment of offshore oil mortality and corpse drift experiments. Unpublished report for Mobil Oil Canada, Ltd., St. John's Memorial University, Newfoundland.

Weise, F.K. 2003. Sinking rates of dead birds: improving estimates of seabird mortality due to oiling. Marine Ornithology 31:65-70.

Williams, J.C. 2005. Activity log of damage pre-assessment activities in response to the wreck of the M/V Selendang Ayu, 22 December 2004 -15 January 2005. U.S. Fish and Wildl. Rep. AMNWR 05/02. Homer, AK.

Zar, J. 1996. Biostatistical Analysis (3rd ed.). Prentice Hall, Upper Saddle River, New Jersey.

Figure 1. Drift Block Search Areas post-deployment

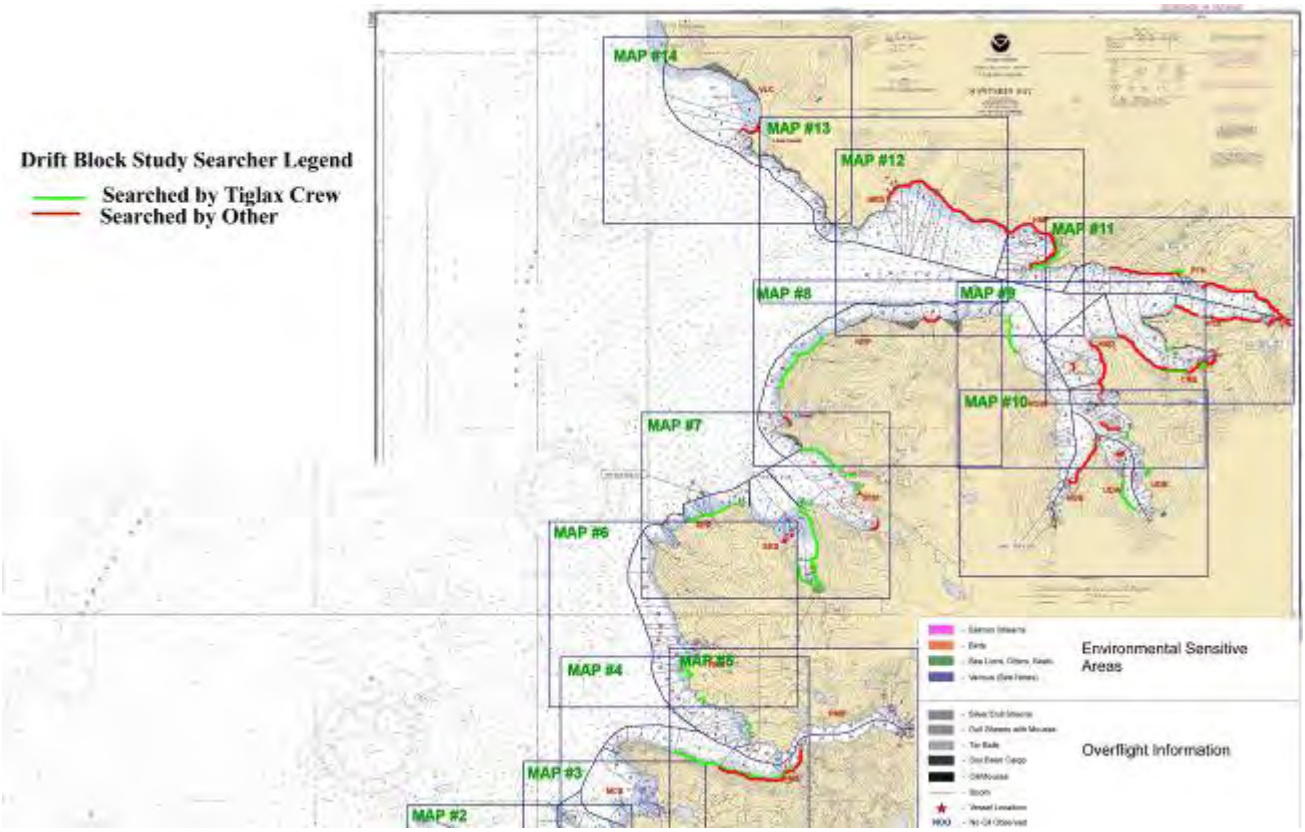

Table 1. Fourteen day replicate survey effort by M/V *Tiĝlax̂* crew following drift block deployment near the Selendang Ayu wreck, January 2005. A blank in the Comments column means ground survey conducted but no items found.

Beach Segment	Date	Survey Crew	Comments
SKN 8	6 Jan	Tiglax	
SKN 11	6 Jan	Tiglax	
SKN 15	6 Jan	Tiglax	
SPR 9	7 Jan	Tiglax	Soybeans on beach
SPR 10	7 Jan	Tiglax	Soybeans on beach
SPR 11	7 Jan	Tiglax	Soybeans on beach
SPR 13	7 Jan	Tiglax	
KFP 5	7 Jan	Tiglax	
KFP 9	7 Jan	Tiglax	
KFP 10	7 Jan	Tiglax	
KFP 11	7 Jan	Tiglax	
PMS 5	8 Jan	Tiglax	
PMS 6	8 Jan	Tiglax	
PMS 8	8 Jan	Tiglax	
PMN 4	8 Jan	Tiglax	
PMN 10	8 Jan	Tiglax	
PMN 14	8 Jan	Tiglax	
SKS 12	8 Jan	Tiglax	
SKS 18	8 Jan	Tiglax	16 drift blocks found on beach, recorded and collected.
SKS 10	8 Jan	Tiglax	Surveyed by skiff just offshore
SKS 11	8 Jan	Tiglax	Surveyed by skiff just offshore
SKS 12	8 Jan	Tiglax	Surveyed by skiff just offshore
SKS 18	8 Jan	Tiglax	Surveyed by skiff just offshore
SKN 1	8 Jan	Tiglax	Surveyed by skiff just offshore
SKN 2	8 Jan	Tiglax	Surveyed by skiff just offshore
SKN 15	8 Jan	Tiglax	Surveyed by skiff just offshore
CNB 3	9 Jan	Tiglax	
CNB 10	9 Jan	Tiglax	
CNB 19	9 Jan	Tiglax	
UDW 1	9 Jan	Tiglax	
UDW 7	9 Jan	Tiglax	
UDE 7	9 Jan	Tiglax	
UDE 9	9 Jan	Tiglax	
UDE 13	9 Jan	Tiglax	
NGW 2	9 Jan	Tiglax	
SKN 8	11 Jan	Tiglax	Replicate survey
SKN 11	11 Jan	Tiglax	Replicate survey
SKN 15	11 Jan	Tiglax	Replicate survey
KFP 5	11 Jan	Tiglax	Replicate survey
KFP 9	11 Jan	Tiglax	Replicate survey
KFP 10	11 Jan	Tiglax	Replicate survey
KFP 11	11 Jan	Tiglax	Replicate survey
PTN 10	12 Jan	Tiglax	
HMP 6	12 Jan	Tiglax	

Beach Segment	Date	Survey Crew	Comments
CNB 19	12 Jan	Tiglax	Replicate survey
SPR 9	13 Jan	Tiglax	Replicate survey
SPR 10	13 Jan	Tiglax	Replicate survey
SPR 11	13 Jan	Tiglax	Replicate survey
SPR 13	13 Jan	Tiglax	Replicate survey
PMS 5	14 Jan	Tiglax	Replicate survey
PMS 6	14 Jan	Tiglax	Replicate survey
PMS 8	14 Jan	Tiglax	Replicate survey
PMN 4	14 Jan	Tiglax	Replicate survey
PMN 10	14 Jan	Tiglax	Replicate survey
PMN 14	14 Jan	Tiglax	Replicate survey
SKS 12	14 Jan	Tiglax	Replicate survey
SKS 18	14 Jan	Tiglax	Replicate survey
NGW 2	17 Jan	Tiglax	Replicate survey
UDE 13	17 Jan	Tiglax	Replicate survey
UDE 7	17 Jan	Tiglax	Replicate survey
UDE 9	17 Jan	Tiglax	Replicate survey
UDW1	17 Jan	Tiglax	Replicate survey
UDW7	17 Jan	Tiglax	Replicate survey
PMN 10	18 Jan	Tiglax	Replicate survey
PMN 14	18 Jan	Tiglax	Replicate survey
SKN 11	18 Jan	Tiglax	Replicate survey
SKN 15	18 Jan	Tiglax	Replicate survey
SKN 8	18 Jan	Tiglax	Replicate survey
CNB 10	19 Jan	Tiglax	Replicate survey
CNB 19	19 Jan	Tiglax	Replicate survey
CNB 3	19 Jan	Tiglax	
CNB 9	19 Jan	Tiglax	
HMP 5	19 Jan	Tiglax	
HMP 6	19 Jan	Tiglax	Replicate survey
HMP 7	19 Jan	Tiglax	
KFP 11	19 Jan	Tiglax	Replicate survey
PTN 10	19 Jan	Tiglax	Replicate survey

Table 2. Coastline segment classification based on observations from the M/V *Tiĝlax̂*, December 25-26, 2004 and drift block survey schedule, January 4–19, 2005 (Figure 1).

Map No.	NOAA section	NOAA segment	Beach code[a]	Beach Type	Drift block search[b]
14	**VLC**	1	N	headland	
14	**VLC**	2	C/E	sand / cobble	
14	**VLC**	3	N	cobble / boulder	
14	**VLC**	4	E	headland	
14	**VLC**	5	C	sand	✓
14	**VLC**	6	E	sand	✓
14	**VLC**	7	E	sand	
14	**VLC**	8	N	inlet	
14	**VLC**	9	E	sand	
14	**VLC**	10	E	boulder	
13	**MKS**	1	P	sand & some boulder	✓✓✓
13	**MKS**	2	P	sand	✓✓
13	**MKS**	3	P	sand	✓✓
13	**MKS**	4	N	sand	✓
13	**MKS**	5	P	sand	✓✓
13	**MKS**	6	P	sand	✓✓
13	**MKS**	7	P	sand	✓
13	**MKS**	8	P	sand & headland	✓
13	**MKS**	9	P	sand & gravel	✓
13	**MKS**	10	N		
13	**MKS**	11	P	cobble & gravel	
13	**MKS**	12	P	cobble	
13	**MKS**	13	N	bedrock	
13	**MKS**	14	N	bedrock	
13	**MKS**	15	N	bedrock	
13	**MKS**	16	E	small cobble beach	
13	**MKS**	17	N		
13	**MKS**	18	N/E	cobble / beach / cliff	
12	**HMP**	1	N		
12	**HMP**	2	P	cobble	
12	**HMP**	3	N		
12	**HMP**	4	N		
12	**HMP**	5	N		✓✓✓
12	**HMP**	6	P	bedrock	✓✓✓✓
12	**HMP**	7	P		✓✓
12	**HMP**	8	P	cobble	✓
12	**HMP**	9	N		
12	**HMP**	10	P	cobble	✓✓
12	**HMP**	11	N	rocky outcrop	✓✓✓
12	**HMP**	12	P	cobble	✓
12	**HMP**	13	P	boulder, bedrock	✓
11	**PTN**	1	N		✓✓

Map No.	NOAA section	NOAA segment	Beach code[a]	Beach Type	Drift block search[b]
11	**PTN**	2	N		✓
11	**PTN**	3	P	gravel / cobble	
11	**PTN**	4	P	gravel / cobble	✓✓
11	**PTN**	5	P		
11	**PTN**	6	P		
11	**PTN**	7	N		
11	**PTN**	8	N		
11	**PTN**	9	N		
11	**PTN**	10	C	gravel / cobble	✓✓✓✓
11	**PTN**	11	N		✓
11	**PTN**	12	P	cobble / small boulders	✓
11	**PTN**	13	P	cobble / small boulders	
11	**PTN**	14	P	cobble / small boulders	
11	**PTN**	15	P	cobble / small boulders	
11	**PTS**	1	P	gravel / small boulders	✓
11	**PTS**	2	P		
11	**PTS**	3	P	cobble / small boulder	✓
11	**PTS**	4	P	small boulder	✓
11	**PTS**	5	N		
11	**PTS**	6	N	creek	
11	**PTS**	7	P		✓
11	**PTS**	8	N		✓
11	**PTS**	9	N		✓
11	**PTS**	10	N	creek	✓
11	**PTS**	11	N	creek	✓
11	**CNB**	1	P	small boulder / vegetation	✓
11	**CNB**	2	N	stream	✓
11	**CNB**	3	P		✓✓✓
11	**CNB**	4	N	stream	✓
11	**CNB**	5	P		✓
11	**CNB**	6	N	stream	✓
11	**CNB**	7	P		✓
11	**CNB**	8	N	creek	✓
11	**CNB**	9	P	alluvial fan	✓✓
11	**CNB**	10	P	alluvial fan	✓✓✓
11	**CNB**	11	N	delta	✓
11	**CNB**	12	N	creek	✓
11	**CNB**	13	N	delta	✓
11	**CNB**	14	P		✓
11	**CNB**	15	N		✓
11	**CNB**	16	P	bedrock	
11	**CNB**	17	P	bedrock	
11	**CNB**	18	N	stream	
11	**CNB**	19	C	cobble	✓✓✓
11	**CNB**	20	P	boulder / small boulder	
11	**CNB**	21	P	small boulder/cobble	✓
11	**AND**	1	C	cobble	✓

Map No.	NOAA section	NOAA segment	Beach code[a]	Beach Type	Drift block search[b]
11	**AND**	2	P	broken	
11	**AND**	3	N		✓
11	**AND**	4	N		
11	**AND**	5	P	boulder / cobble	
11	**AND**	6	C	boulders	✓
11	**AND**	7	C	boulders / bedrock / headlands	
11	**AND**	8	P	boulder / cobble / small headlands	
10	**UDE**	1	N		
10	**UDE**	2	N	stream	
10	**UDE**	3	P	cobble / gravel	
10	**UDE**	4	P		
10	**UDE**	5	N		
10	**UDE**	6	N		
10	**UDE**	7	P	cobble	✓✓
10	**UDE**	8	N	stream	
10	**UDE**	9	P	cobble	✓✓
10	**UDE**	10	P	cobble / gravel	
10	**UDE**	11	N	stream	
10	**UDE**	12	P	narrow cobble / shale	
10	**UDE**	13	P	gravel / cobble	✓✓
10	**UDE**	14	P		
10	**UDE**	15	N		✓
10	**UDE**	16	P	gravel / cobble	
9	**UDE**	17	P		
9	**UDE**	18	N	creek	
9	**UDE**	19	P	gravel	
9	**UDE**	20	N	creek	
9	**UDE**	21	P	narrow cobble bedrock	
9	**UDE**	22	C		✓
9	**UDE**	23	N		
9	**UDE**	24	N		
10	**UDW**	1	P	boulder	✓✓✓
10	**UDW**	2	P	boulder	
10	**UDW**	3	not evaluated		
10	**UDW**	4	P	bedrock	✓
10	**UDW**	5	P	bedrock	
10	**UDW**	6	N		
10	**UDW**	7	P	small boulder	✓✓
10	**UDW**	8	P		
10	**NGE**	1	not evaluated		
10	**NGE**	2	not evaluated		
10	**NGE**	3	P		
10	**NGE**	4	N	creek	
10	**NGE**	5	N		
10	**NGE**	6	P	mix of cobble, bedrock, boulders	✓

Map No.	NOAA section	NOAA segment	Beach code[a]	Beach Type	Drift block search[b]
10	**NGE**	7	P	cobble / boulder	✓
9	**NGW**	1	C	cobble	
9	**NGW**	2	P	cobble	✓✓
9	**NGW**	3	N	stream	
9	**NGW**	4	P	cobble	
9	**NGW**	5	P	cobble	
9	**NGW**	6	N	stream	
9	**NGW**	7	P	boulder, cobble, gravel	
10	**NGW**	8	P	cobble	
10	**NGW**	9	N	stream	
10	**NGW**	10	P	cobble	
10	**NGW**	11	N	stream	
10	**NGW**	12	P		
10	**NGW**	13	P		
10	**NGW**	14	P		
10	**NGW**	15	P		
10	**NGW**	16	P		
8	**KFP**	1	E	gravel, cobble	
8	**KFP**	2	N	bedrock headland	
8	**KFP**	3	N	bedrock headland	
8	**KFP**	4	N	bedrock headland	
8	**KFP**	5	C	cobble	✓✓✓
8	**KFP**	6	N	stream	
8	**KFP**	7	E	boulder	✓
8	**KFP**	8	E	boulder	
8	**KFP**	9	C	boulder	✓✓
8	**KFP**	10	E	boulder	✓✓
8	**KFP**	11	E	boulder	✓✓✓
8	**KFP**	12	E	boulder	
8	**KFP**	13	N	bedrock, headland	
8	**KFP**	14	E	boulder	
8	**KFP**	15	E	cobble	✓
8	**KFP**	16	E	boulder	
8	**KFP**	17	E	cobble	
7	**SKN**	1	E	cobble, boulder	✓by skiff
7	**SKN**	2	N	rocky islet	✓by skiff
7	**SKN**	3	E	gravel, cobble large boulder	
7	**SKN**	4	N	stream	
7	**SKN**	5	E	gravel	✓✓
7	**SKN**	6	N	bedrock headland	
7	**SKN**	7	N	bedrock headland	
7	**SKN**	8	C		✓✓✓✓
7	**SKN**	9	N	bedrock headland	
7	**SKN**	10	N	bedrock headland	✓
7	**SKN**	11	C		✓✓✓
7	**SKN**	12	N	bedrock headland	
7	**SKN**	13	N	bedrock	

Map No.	NOAA section	NOAA segment	Beach code[a]	Beach Type	Drift block search[b]
7	**SKN**	14	N	stream	✓
7	**SKN**	15	E	cobble boulder	✓✓✓✓by skiff
7	**SKS**	1	E	cobble	
7	**SKS**	2	E	cobble	
7	**SKS**	3	E	cobble	
7	**SKS**	4	E	cobble	✓
7	**SKS**	5	N		
7	**SKS**	6	E	cobble	✓
7	**SKS**	7	N		
7	**SKS**	8	N	bedrock	
7	**SKS**	9	N	bedrock	✓
7	**SKS**	10	N	bedrock	✓by skiff
7	**SKS**	11	N	stream	✓by skiff
7	**SKS**	12	E	small boulders & bedrock	✓✓✓by skiff
7	**SKS**	13	P	gravel & bedrock	
7	**SKS**	14	N	stream	
7	**SKS**	15	P	gravel & bedrock	
7	**SKS**	16	N	bedrock outcrop	
7	**SKS**	17	N	islet	
7	**SKS**	18	C	bedrock headland, cobble	✓✓✓by skiff
7	**SPR**	1	E	60%headland, 40% gravel	
7	**SPR**	2	E	gravel	
7	**SPR**	3	N	stream	
7	**SPR**	4	E	gravel	
7	**SPR**	5	N	bedrock headland	
7	**SPR**	6	N	bedrock headland	
7	**SPR**	7	E	cobble	
7	**SPR**	8	N	islet	
7	**SPR**	9	E	bedrock headland	✓✓
7	**SPR**	10	E	boulder	✓✓
7	**SPR**	11	E	boulder	✓✓
7	**SPR**	12	E	boulder	
7	**SPR**	13	E	boulder	✓✓
7	**SPR**	14	N	bedrock headland	
5	**PMN**	1	N	cliffs/bedrock	
5	**PMN**	2	E	sand/gravel	
5	**PMN**	3	N	cliffs	
5	**PMN**	4	E	sand/gravel	✓✓
5	**PMN**	5	N	stream	
5	**PMN**	6	E	mostly cliff	
5	**PMN**	7	E	mostly bedrock	
5	**PMN**	8	E	1/2 beaches, cobble	
5	**PMN**	9	N	pointy bedrock	
5	**PMN**	10	E	large boulders / cobble	✓✓✓
5	**PMN**	11	E	gravel / cobble	
5	**PMN**	12	E	bedrock, gravel	
5	**PMN**	13	N	headland	

Map No.	NOAA section	NOAA segment	Beach code[a]	Beach Type	Drift block search[b]
6	**PMN**	14	E	bedrock beach	✓✓✓✓
6	**PMN**	15	E	bedrock beach	
6	**PMN**	16	C	cobble	
6	**PMN**	17	N	cliffs	
6	**PMN**	18	E	gravel beach	
6	**PMN**	19	N	cliffs	
6	**PMN**	20	N	islet	
6	**PMN**	21	N	stream	
6	**PMN**	22	N	bedrock cliffs	
6	**PMN**	23	N	boulder beach	
6	**PMN**	24	N	cliffs	
6	**PMN**	25	N	large boulders	
6	**PMN**	26	N	headlands, large boulders	
6	**PMN**	27	N	headlands, large boulders, rockslides	
6	**PMN**	28	N	bedrock headlands, large boulders	
5	**PME**	1	P	cobble gravel	
5	**PME**	2	N	islet	
5	**PME**	3	P	cobble / gravel	
5	**PME**	4	N	islet	
5	**PME**	5	P	cobble / small rock	
5	**PME**	6	P	cobble	
5	**PME**	7	N	stream	
5	**PME**	8	N	islet	
5	**PME**	9	P	delta	
5	**PME**	10	N	stream	
5	**PME**	11	N	islet	
5	**PME**	12	N	bedrock	
5	**PME**	13	N	bedrock	
5	**PME**	14	N	bedrock	
5	**PME**	15	N	bedrock	
5	**PME**	16	N		
5	**PME**	17	N	bedrock	
5	**PME**	18	N	bedrock	
5	**PME**	19	N	bedrock	
5	**PME**	20	N	cliff	
4	**PMS**	1	E	boulder	
4	**PMS**	2	E	boulder	
4	**PMS**	3	N	landslides / large boulders	
4	**PMS**	4	N	boulder / landslide / cobble	
5	**PMS**	5	E	boulder / landslide / cobble	✓✓
5	**PMS**	6	C	cobble / small boulder	✓✓✓
5	**PMS**	7	N	stream	
5	**PMS**	8	N	headland	✓✓✓
5	**PMS**	9	N	stream	
5	**PMS**	10	C	small cobble	✓✓
5	**PMS**	11	N	bedrock	
5	**PMS**	12	N	bedrock	

Map No.	NOAA section	NOAA segment	Beach code[a]	Beach Type	Drift block search[b]
5	**PMS**	13	N	bedrock - steep / narrow	
5	**PMS**	14	N	bedrock - steep / narrow	
5	**PMS**	15	P	cobble / bedrock	
5	**PMS**	16	P	cobble / gravel	
5	**PMS**	17	N	stream	
5	**PMS**	18	N	islet	
5	**PMS**	19	N	bedrock - steep / narrow	
5	**PMS**	20	P	cobble / gravel	
5	**PMS**	21	P	cobble / gravel	

[a] Beach Codes:

E = Exposed or high impact beaches (normally exposed to waves often with steep angles indicating frequent impacts);
C = Catchment (beaches with areas where large amounts of debris had accumulated);
P = Protected (not normally exposed to waves from the open sea);
N = No beach (cliffs or other unwalkable segments of coastline).

[b] Drift block search:

✓ = drift block search conducted, multiple ✓'s indicate replicate searches over the time frame of January 4 – 19, 2005.

Figure 2. Series of photographs illustrating the drift block experiment

Drift blocks (4x4x8 inch) with identification tag specifying reporting contact information

A small group deployment of drift blocks in the vicinity of the Selendang Ayu wreck.

Drift blocks washed up on shore in Skan Bay with the M/V Tiĝlax̂**,** in background.

Tiĝlax̂, beach survey crew, Leslie Slater, recording and collecting beached drift blocks.