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Seabird Attraction to Trawler Discards

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Seabird Attraction to Trawler Discards

by

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PREFACE

The Alaska Fisheries Science Center (AFSC), National Marine Fisheries Service, NOAA, engaged in a series of studies designed to gain a better understanding of seabird interactions with the Alaska groundfish trawl fisheries and the factors that affect those interactions. This is an important issue in part due to seabird mortalities associated with those fisheries, including known incidental takes of Laysan albatross (*Phoebastria immutabilis*). In 2003 the Alaska groundfish trawl fisheries were included in the short-tailed albatross (*P. albatrus*) Biological Opinion (USFWS 2003) due to the use of Laysan albatross as a bycatch proxy for short-tailed albatross in conjunction with the sighting of these seabirds around trawl vessels as they fished and processed catch. The work in this report focuses on seabird attendance and use of discards and offal. The project was managed and the results were analyzed by the primary author (Zador) while under contract (AB133F07SE2500) to the Alaska Fisheries Science Center. This work originally constituted a chapter of Zador's doctoral thesis at the University of Washington's School of Aquatic and Fisheries Sciences in Seattle. For information on other AFSC seabird research or collaborative studies, please contact the second author (Fitzgerald) at shannon.fitzgerald@noaa.gov.

CONTENTS

ABSTRACT

The potential for spatial and temporal overlap of seabirds and the groundfish trawl fishery in Alaska waters is influenced in part by the attractiveness of the vessels to the birds. Seabirds are attracted to vessels as a source of food via the fishery discards. The composition of discharged material from Alaska groundfish trawl vessels varies from whole discarded fish to heads, offal macerated to 1 cm chunks, and watery slurry containing little fish matter, depending on the processing capabilities on board. Understanding the relative attractiveness of the discharged material is important for assigning relative risk among trawl vessels. We conducted a pilot study to measure the relative attractiveness of discard type to seabirds. This study relied on volunteer efforts from observers in the AFSC's North Pacific Groundfish Observer Program to count the numbers of seabirds feeding within discharge plumes alongside trawl vessels. Observers recorded the numbers of birds, discharge type, and concurrent vessel activity. The study was designed to perform on multiple platforms with multiple observers and require little time or specific bird knowledge. The results suggest that the season during which observations were made and the discard type had the greatest influence on the number of birds feeding in plumes. The fact that the number and type of seabird present in the marine systems varies due to migratory patterns or breeding phenology may be the most important factor in determining how many seabirds are feeding in discharge plumes, and therefore in the vicinity of trawl gear and exposed to the risk of mortality

INTRODUCTION

Tens of thousands of seabirds are killed by fishing gear each year (Nel and Taylor 2003). There is evidence that the mortality rates are high enough that some seabird populations have been negatively affected (Robertson and Gales 1998). Seabird bycatch has been reported in a wide range of fisheries including longlining, gill netting, and trawling (Julian and Beeson 1998; Nel et al. 2002; Northridge 1991; Weimerskirch et al. 2000). Trawl-related seabird mortality is of particular concern as approximately 30% of the global annual fishery catch (in tons) is taken by trawl gear (Watson et al. 2006). Seabirds can strike or become entangled in trawl gear (the net and the cables that tow it) while feeding on the water or flying near the trawling vessels as they move through the water (Sullivan et al. 2006b). Trawl-induced seabird mortality is particularly difficult to quantify because, although some birds become entangled in the net or impaled on cable splices and can be observed when the gear is hauled onboard, others that strike the cables fall into the water and go unobserved.

An integral component of understanding the risk to seabirds of incidental mortality by trawl gear is determining under what conditions, and to what degree, seabirds are attracted to vessels. Seabirds approach fishing vessels as a potential source of food via the fish and fish matter discarded from the vessels at sea (Weimerskirch et al. 2000). Birds are drawn to the discards and congregate in the immediate vicinity of the discard chute(s)(Sullivan et al. 2006b). Vessel attractiveness is influenced by multiple factors at different scales: (1) the regional level (i.e., seasonal distribution of a species),

(2) the area scale (i.e., as affected by the concentration of fishing vessels), and (3) the vessel scale (i.e., whether a vessel is discarding or not, and the type of discards). Although it is a necessary precondition that birds be attracted to the vessel for them to be harmed, it is not necessarily the case that more birds in the region, area, or around the vessel automatically implies more birds killed. Nevertheless, prohibiting trawlers from discarding fish or fish matter in an effort to reduce attractiveness to seabirds has been shown to greatly reduce incidental mortality around vessels (Wienecke and Robertson 2002).

The Alaska groundfish trawl fishery is the largest by tonnage in the United States and spans the Bering Sea, Aleutian Islands, and Gulf of Alaska waters (AFSC 2007). One of the targeted species, walleye pollock (*Theragra chalcogramma*), comprises the second largest single species fishery globally (FAO 2004). Trawl-related incidental mortality is of particular concern in this fishery because of its spatial and temporal overlap with the endangered short-tailed albatross (*Phoebastria albatrus*; (Zador et al. in review). Although no short-tailed albatross have been reported as killed by trawlers, two mortalities in a 5-6 year time period would trigger an Endangered Species Act management consultation that could lead to immediate closure of the fishery. In addition, the North Pacific, and Alaska waters specifically, are also home to millions of other seabirds (Byrd et al. 2005), many of which are found in close association with fishing vessels, including trawlers (Melvin et al. 2004).

During 1999 - 2004, 192 - 250 vessels were active each year in the Alaska groundfish trawl fishery (AFSC 2007). The fishery has several target fish species, including pollock, Pacific cod (*Gadus macrocephalus*), and sablefish (*Anoplopoma fimbria*), and occurs year-round over much of the Alaska shelf and slope. Vessels typically range in size from 58 - 376 feet and can be categorized as either catcher vessels (i.e., delivering whole fish to at-sea or shore-based fish processing plants), or catcher-processors (i.e., with some type of processing capability onboard). All vessels have fishery-associated discards; however, the amount and type of discard differs among vessel types. Whole fish are discarded by all vessels due to catch restrictions on certain species that are 'prohibited' from being landed, such as Pacific halibut (*Hippoglossus stenolepis*). Fish heads are discarded by all processors. Processors also discard fish parts macerated to 1 cm pieces, the composition of which differs depending on the degree of processing. Finally, watery slurry with little fish matter is discharged from vessels with fish meal plants. Discharge type has been shown to be differentially attractive to seabirds (review in (Furness et al. 2007)).

The goal of this study was to explore to what degree discard type affected the number of seabirds attracted to the immediate vicinity of the vessel, ostensibly within range of impact by warps (cables towing the trawl net) or third wires (net sonar cable). Given that seabirds appear to prefer more easily swallowed discards (Furness et al. 2007), we tested the hypothesis that the number of birds feeding in discard plumes would be influenced by the size and composition of the discards. In particular, we expected that discharge composed of macerated fish matter would attract the most birds and post-fish meal processing waste and whole discarded fish would attract fewer, respectively. We also tested the hypotheses that vessel activity during the counts and the season would influence bird abundance. The study was also designed to assess the efficacy of using observers to voluntarily collect data, in addition to their regular duties, that could further inform managers about seabird bycatch risk.

METHODS AND MATERIALS

Data Collection

Discards from groundfish trawl vessels are passed through chutes into the water while vessels are fishing or are underway. As a vessel moves forward, the discharged material creates a plume trailing alongside and behind the vessel; the shape of the plume widens with distance from the vessel depending on vessel speed and sea state. During 2006, fisheries observers working onboard groundfish trawl vessels were asked to count the number of seabirds actively feeding in the first 20 m of the discard plumes emanating from any chosen chute once per day (Fig. 1, Appendix). Species-specific abundance was not measured because fisheries observers are not specifically trained in live seabird identification. The study was designed to require a minimum amount of time, no specific knowledge of birds, and to be flexible enough to perform well on multiple platforms with multiple observers working independently. The 20 m distance was chosen to measure the attractiveness of the discards at a fine scale and also minimize the number of birds to count (which can number in the 1,000s within a 100 m hemisphere radiating from the stern of a vessel in this fishery (Melvin et al. 2004). On each vessel, observers knew the distance from the chute(s) to the stern, and estimated 20 m relative to this fixed measurement. For each observation, observers made three counts 5 minutes apart. The repeated counts showed little variation (mean CV = 0.33), so the data were analyzed using the third count only to allow for the most well practiced, and presumably accurate, count.

In addition to the number of birds, observers also recorded the type of discharge: whole fish (W), post-fish meal processing waste (P), macerated fish and offal (M) or combinations thereof. Discards of multiple types were categorized by the highest degree of processing: W, M, and P in increasing order. In most cases, discard type corresponded with vessel type. All vessels discarded prohibited species whole. Vessels that discarded only W were mid-sized catcher vessels (60 – 125 ft in length) with no processing capability on board. Vessels that discarded P were large catcher-processors (>125 ft in length) with onboard fish meal plants. Two groups of vessels macerated waste before discarding. Surimi and/or fillet-producing catcher-processors were large vessels (>125 ft in length) that macerated heads, guts, tails and bones. Head-and-gut catcher-processors were mid- to large-sized vessels (107 - 238 ft in length) that removed, macerated, and discarded only heads and guts. For this study, discards from these vessels were differentiated as M-S and M-H, respectively.

Observers also recorded the specific activity of the vessel during the count: trawling, setting, hauling back, or steaming. Trawling vessels had nets actively fishing. Setting and hauling back were net deployment and retrieval times, respectively. Haulback also included the special case – short-wiring – during which the catch was brought to the surface and held close to the vessel until on-board processing facilities could accommodate the catch. Steaming vessels were underway but not fishing. Counts were summarized by discard type, vessel activity during the count, and season (winter: Dec. - Feb.; spring: Mar. - May; summer: Jun. - Aug.; fall: Sep. - Nov.).

Data Analysis

The data on bird abundance did not satisfy the assumptions underlying standard GLM (Generalized Linear Model) error models. Variances in seabird abundance in discard plumes were high no matter how data were grouped. In all cases, mean counts were well below variances, indicating the data were highly overdispersed compared to the expectation if the data were Poisson-distributed. Moreover, the high frequency of an absence of birds led to a zero-inflated dataset that was inconsistent with the expectations if the data were negative-binomially distributed ($P < 0.001$). Finally, the data set was unbalanced, with no data for several combinations of factors. The analysis of the data therefore focused on the presence of zero observations using a GLM in which the response variable (presence or absence of birds) was treated as a binomially-distributed random variable. Discard type (M-H and M-S only due to small sample sizes of other categories), season and activity were treated as factors, and the best model was evaluated using forward selection with F-tests from a null model to a full model.

A power analysis was conducted to determine the number of observations needed to distinguish a difference between bird abundance (rather than simply presence / absence) in discharge plumes at the $\alpha = 0.05$ level with 90% probability given the observed difference between the M-H and M-S plumes. Groups of 400 – 1,200 simulated counts for each plume were generated by resampling (with replacement) the observations in M-H and M-S plumes 1,000 times and then determining the sample size for each plume type at which 900 of the 1,000 groups led to a significant difference at $\alpha = 0.05$ when the data were analyzed using a negative binomial GLM with the factor "discharge type". The focus of the power analysis was on the M-S and M-H data sets because the data sets for W and P are too small to have much confidence that a power analyses based on resampling data with replacement would be reliable.

RESULTS AND DISCUSSION

The composition and particle size of fishery discards have been cited as directly influential in attracting seabirds – predominantly procellariids – in the immediate vicinity of fishing vessels. Macerating discards to sizes suitable for feeding is thought to increase attraction to discards (Furness et al. 2007). In Kerguelen shelf waters, the higher attractiveness to seabirds of longline vessels that macerated their discards compared with trawlers that discarded intact heads, tails, and guts was attributed to the smaller size of the macerated discards (Weimerskirch et al. 2000). In a second Southern Ocean study, Wienecke and Roberts (2002) attributed the relative lack of seabird bycatch observed in Patagonian toothfish (*Dissostichus eleginoides*) trawlers with onboard fish meal plants, in part, to the lack of fish material in the discharged processing waste.

In this study, the highest numbers of birds were counted in the plumes with macerated discards (Table 1; Fig. 2); however, there were also many zero counts. Conversely, there were no high counts of birds in plumes composed of post-fish meal processing waste (max = 60). Unfortunately, sample sizes were too small and patterns in bird abundance in discharge plumes too variable to reject the hypothesis that birds are equally attracted to discards composed of macerated fish matter (M-H and M-S), of only whole fish, or of post fish meal processing waste. However, discard type had a significant effect on the proportion of counts with zero birds; the best model to explain the presence / absence of seabirds included discard type, season, and interactions between season and discard type (Table 2).

In addition to unbalanced and small sample sizes, patterns in bird abundance in discharge plumes may have been obscured because plumes were often composed of multiple discard types due to the differential processing of prohibited, unwanted, and targeted catch. The categorizations used maximized the differences in discard type because discards were grouped by the most highly processed type, and vessels with fish meal plants discarded only whole fish or post-meal processing slurry. However, as seabirds cannot consume whole, large discarded fish, it is unlikely that the presence of whole fish mixed with macerated or post-fish meal plant discards influenced the attractiveness of the discards. It is also conceivable that the overall volume of discards may affect bird abundance. Large factory trawlers, such as in the M-S and P categories, process large quantities of fish and discharge waste nearly continuously. Smaller vessels with lesser processing capabilities produce lower volumes of discards (Furness et al. 2007). Differences in discard volume should have been captured in comparisons between M-H and M-S groups given the nature of the vessel sizes in the M-H and M-S categories. Indeed, the trend in the data is in the direction of more birds with greater discard volume (Table 1, Fig. 2). Although these results look promising for distinguishing relative differences in attractiveness of discard types (Fig. 2), the variability in counts and unbalanced design precluded definitive conclusions. The high variance in the counts may be due to the low sample sizes. The power analysis indicated that 1,200 observations would be needed to be able to detect a significant difference in bird abundance in discharge plumes of two of the most similar discard types, M-H and M-S, at the $\alpha = 0.05$ level with 90% probability (Fig. 3). Fewer observations are expected to be needed to detect differences among discard type when grouped as W, M, and P.

The seasonal pattern in regional seabird abundance has been shown to correlate with relative abundances at vessels and with numbers caught in trawl nets in Southern Ocean and South Atlantic fisheries (Gonzalez-Zevallos and Yorio 2006; Sullivan et al. 2006b; Weimerskirch et al. 2000). In Alaska, seabird abundance is known to vary seasonally due to the absence of large numbers of Southern Ocean migrants, such as sooty and short-tailed shearwaters (*P. griseus* and *P. tenuirostis*), during winter (Shaffer et al. 2006). However, Hunt et al. (2005) estimated total prey consumption by seabirds in the Gulf of Alaska (GOA) to be higher in winter (September-April) than summer (May-August), which they attributed to an influx of seabirds, including seaducks, from the far west or north into the GOA. Counts in this study were highest in fall (maximum and mean counts), and consistently high (median) in winter (Fig. 4). Season had a significant influence of the proportion of counts with zero birds (Table 2). Almost half of the counts during spring had no birds present in discharge plumes, whereas almost 90% of the winter and fall observations contained birds (Table 1). Garthe et al. (1996) found that discard consumption rates by seabirds were higher in winter than summer in the North Sea, a result of unavailability of sandeels (*Ammodytes* spp.), the major prey of most seabirds in the region (Furness et al. 2007). In the Alaska trawl fishery, the total volume of discards is the greatest in the fall and lowest in the winter (Furness et al. 2007).

Several studies have suggested that vessel activity, in particular net retrieval, can influence the number of birds attending trawlers. Weimerskirch et al. (2000) observed white-chinned petrels (*Procellaria aequinoctialis*) getting caught in trawl nets close to the surface, either during setting or haulback. Gonzalez-Zevallos et al. (2007) found that net-related incidental mortality of sooty shearwaters *(P. griseus)*, great shearwaters (*P. gravus)*, Magellanic penguins (*Spheniscus magellanicus)*, and imperial cormorants (*Phalocrocorax atriceps*) in an Argentinean trawl fishery occurred during haulback only. An earlier study (Gonzalez-Zevallos and Yorio 2006) also recorded elevated numbers of seabirds approaching trawlers during haulback. However, mean numbers were as high during haulback with no discarding as when discarding occurred while towing, suggesting that the birds were attracted to multiple sources of food (i.e., from the nets and discards).

In this study, bird observations occurred during discarding only (i.e., when potential food was available). The highest mean and median counts occurred during gear setting (Fig. 5), although this result is probably influenced by the small sample size (10) in this category. The highest proportion of counts with zero birds occurred while vessels were trawling (Table 1), although the difference was not as pronounced as across the season (e.g., spring vs. other categories) or discard type (e.g., M-H vs. other categories) factors.

There were numerous observation periods where no birds were sighted in this study, and the variance among the counts was high. High variance may be inherent in the environment or due to influential factors that were not measured in this study. Additional factors which could influence the number of birds feeding in discharge plumes are the direction of wind relative to the vessel, the sea state, and the number of vessels in the vicinity. Wind patterns are thought to influence bird feeding and flight activity around vessels, leading to differences in contact rates (Melvin et al. 2004). Increasing sea state and wind speed have been shown to correlate with increasing contact rates of black-browed albatross (*Thalassarche melanophris*) with trawl gear (Sullivan et al. 2006b). Cross- and tail- winds have also been associated with increasing contact rates. The number of other vessels in the area of the observed vessel may influence the partitioning of birds, such that as vessels leave the fishing grounds, birds will move to the remaining vessels (Weimerskirch et al. 2000). However, in this study, the mean and median number of birds, and the proportion of zero counts, did not vary widely between steaming and haulback categories (Fig. 5, Table 1), suggesting that birds remained associated with vessels.

This study focused on factors that may influence the relative attractiveness of fishing vessels given no mitigation devices. Experiments have been conducted to determine the best mitigation measures to reduce seabird bycatch in the Alaska trawl fishery (Melvin et al. 2004) as well as Falkland Islands trawl fleet (Sullivan et al. 2006a). Regulations to prohibit discharge have been implemented in the Australian toothfish trawl fishery in the hopes of reducing attractiveness to seabirds, and thus incidental mortality (Wienecke and Robertson 2002). Furness et al. (2007) suggest that liquidation of discards may also be a suitable mechanism for reducing vessel attractiveness. Short of altering fishery gear or processing, understanding the relative attractiveness of discard types in the Alaska groundfish trawl fishery could provide managers with an additional variable to use to assess risk. Expanding this pilot study to increase sample sizes, coverage, and to measure additional potentially influential factors, such as wind speed and the number of vessels, will provide data that are of use to managers and researchers assessing incidental mortality risks in the Alaskan trawl fishery as well as other fisheries world-wide.

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Table 1.-- Bird abundance and the proportion of zeros by discharge type, vessel activity, and season (n = 271 counts).

		n	Bird Abundance		Proportion of Zeros
			Mean	CV	
Discharge type					
	M-H	191	30.49	1.81	0.39
	M-S	69	37.65	1.23	0.17
	P	6*	26.83	0.79	0.17
	W	5*	29.60	1.36	0.00
Activity**					
	Haulback	35	30.66	2.00	0.23
	Setting	10	88.20	0.70	0.10
	Steaming	56	34.20	2.03	0.29
	Trawling	159	27.15	1.43	0.39
Season					
	Winter	31	46.61	1.28	0.13
	Spring	110	23.84	1.47	0.50
	Summer	94	28.59	1.56	0.26
	Fall	36	55.50	1.61	0.14

* Excluded from the analysis of the presence / absence data.

** Eleven observations did not specify vessel activity.

Table 2.-- Binomial general linear model chosen as best model using forward selection with F-tests.

	df	Deviance	Residual df	Residual deviance	P
Null			248	320.98	
Season	3	28.98	245	292.00	<0.001
Type	1	10.38	244	281.62	0.001
Season:Type	3	21.12	241	260.50	<0.001

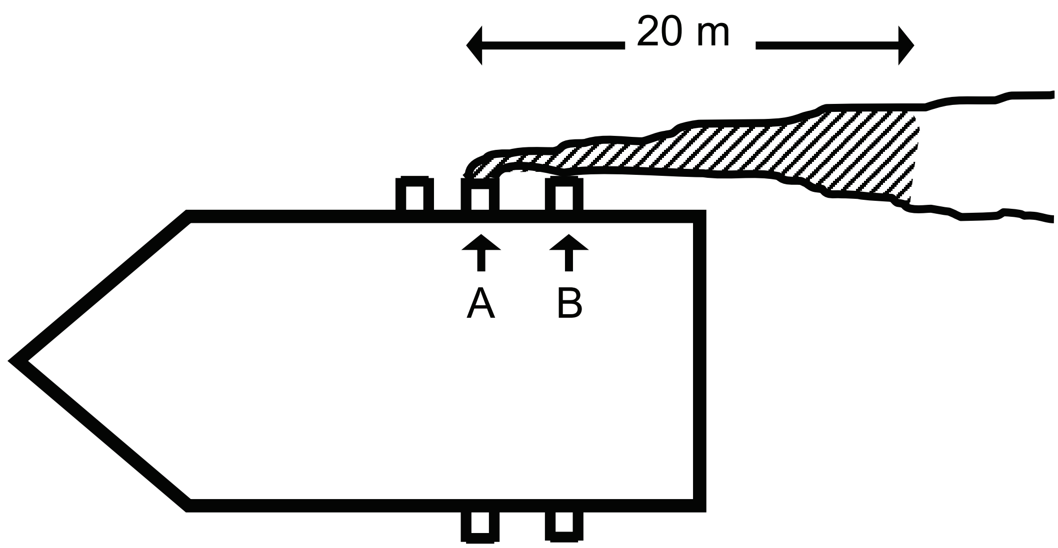

Figure 1.-- Diagram of a hypothetical vessel with a macerated waste discard plume discharged from a starboard chute (A). The observed portion of the plume, the first 20 m, is indicated by diagonal lines. Additional discards may be discharged concurrently from adjacent chutes (e.g., B). These discards may be of the same type as in A (e.g., macerated) or different (e.g., whole fish).

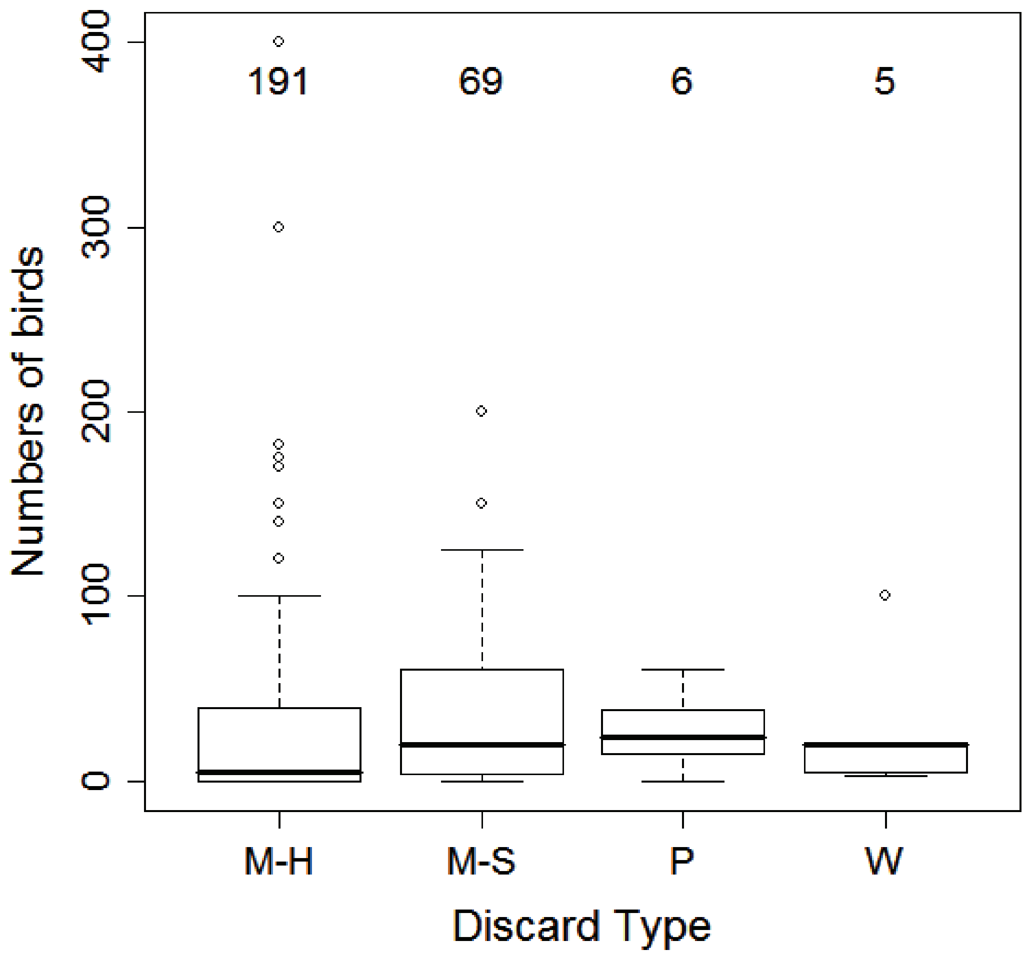

Figure 2.-- Bird abundance within the first 20 m of the waste discard plume summarized by discard type. Thick bars, boxes, and whiskers represent medians, quartiles, and 1.5 quartile ranges, respectively. Sample sizes are indicated at the top of the plot. Circles are outliers beyond the 1.5 quartile range.

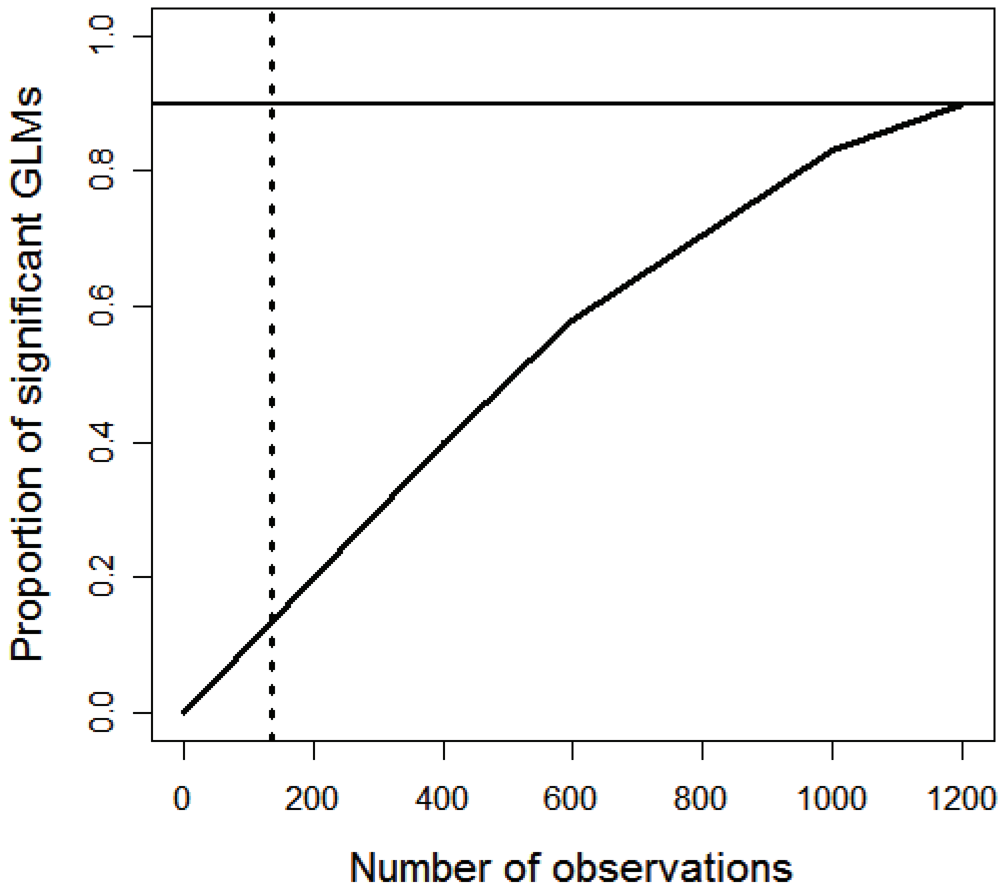

Figure 3.-- Results of a power analysis to determine the number of observations required to detect a significant difference at the $\alpha = 0.05$ level between bird abundance in M-H and M-S discards (represented by the thick line). The dotted line represents the current number of observations; the thin line represents 90% probability.

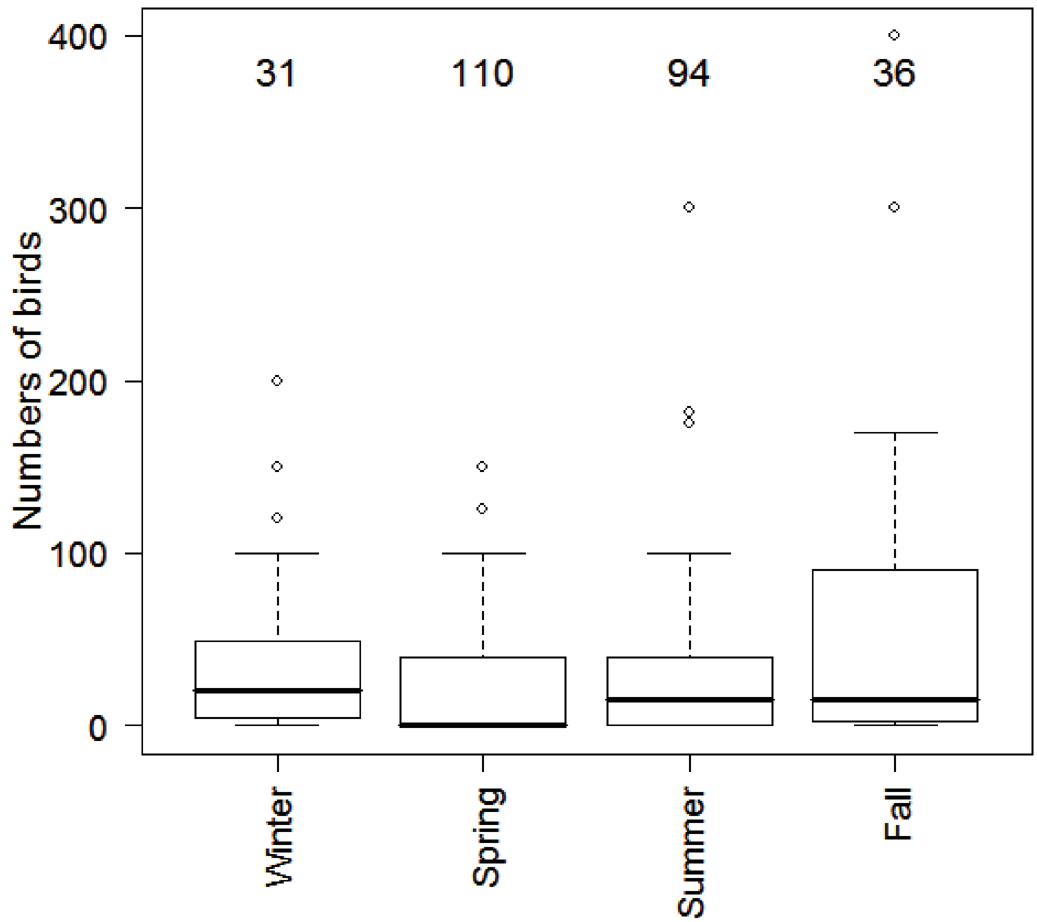

Figure 4.-- Bird abundance in discard plumes across seasons. Thick bars, boxes, and whiskers represent medians, quartiles, and 1.5 quartile ranges, respectively. Sample sizes are indicated at the top of the plot. Circles are outliers beyond the 1.5 quartile range.

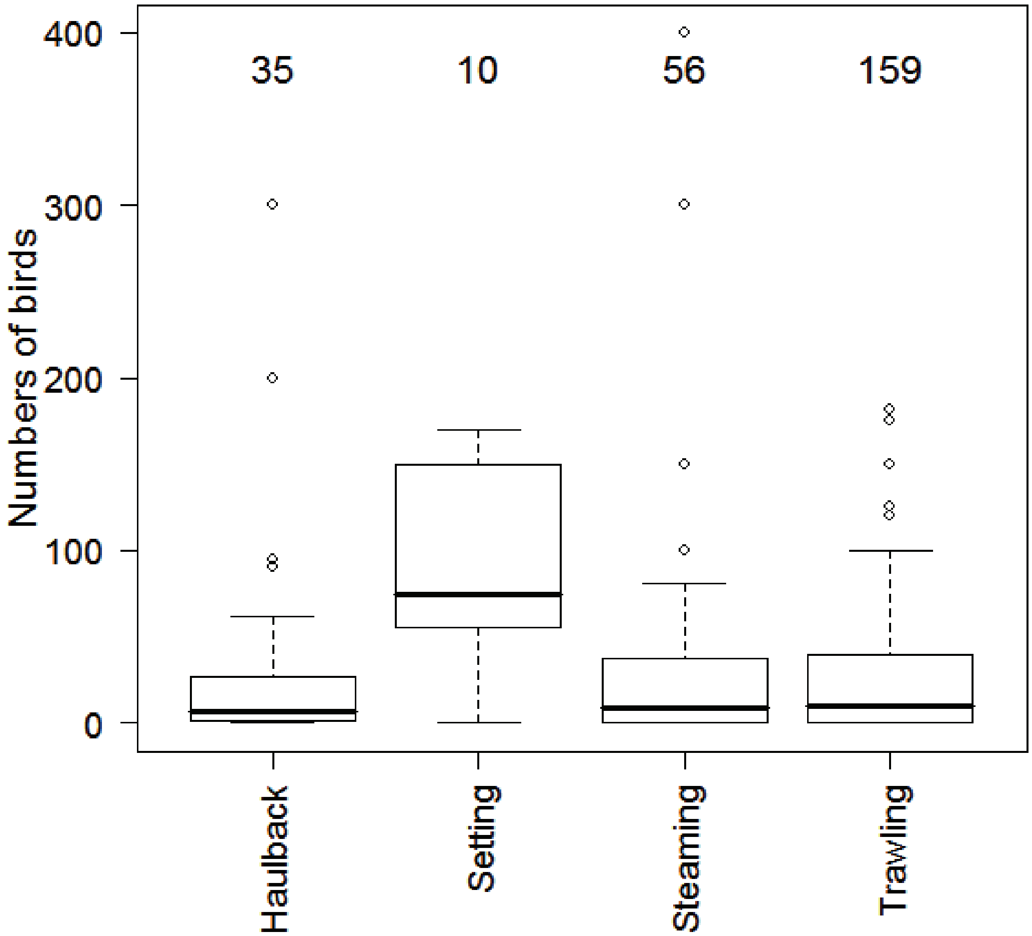

Figure 5.-- Bird abundance in discard plumes during varying vessel activities. Thick bars, boxes, and whiskers represent medians, quartiles, and 1.5 quartile ranges, respectively. Sample sizes are indicated at the top of the plot. Circles are outliers beyond the 1.5 quartile range.

APPENDIX --The data sheet used by observers to record bird abundance in discard plumes.

Quantifying Seabird Attraction to Trawler Discharge Datasheet

Purpose: To count the number of birds on the water within the first 20 meters of the discharge plume.

Vessel Name: ____________________Cruise Number: __________Vessel Code:________Observer Name: ______________________

Draw Chute Location(s) and circle observed chute	Haul/Date/ Discharge start time	Discharge Type (circle)	If discharge is coming through the chute in a STEADY STREAM Take 1 count every 5 minutes	If discharge is coming through the chute in REGULAR PULSES Take 1 count after each pulse	Weather/Vessel Activity Example Wind Direction
	Haul ________ Date ________ Discharge Start Time __________ Or Continuous (circle)	Whole Macerated Head & Gut Post Oil/Meal processing	Count 1 - # of birds __________ Count 2 - # of birds __________ Count 3 - # of birds __________	Time ________ Time ________ Time ________	Beaufort _______________ Wind Direction (Draw arrow across boat) Vessel Activity (circle) Trawling Steaming Setting Haulback
	Haul ________ Date ________ Discharge Start Time __________ Or Continuous (circle)	Whole Macerated Head & Gut Post Oil/Meal processing	Count 1 - # of birds __________ Count 2 - # of birds __________ Count 3 - # of birds __________	Time ________ Time ________ Time ________	Beaufort _______________ Wind Direction (Draw arrow across boat) Vessel Activity (circle) Trawling Steaming Setting Haulback
	Haul ________ Date ________ Discharge Start Time __________ Or Continuous (circle)	Whole Macerated Head & Gut Post Oil/Meal processing	Count 1 - # of birds __________ Count 2 - # of birds __________ Count 3 - # of birds __________	Time ________ Time ________ Time ________	Beaufort _______________ Wind Direction (Draw arrow across boat) Vessel Activity (circle) Trawling Steaming Setting Haulback
	Haul ________ Date ________ Discharge Start Time __________ Or Continuous (circle)	Whole Macerated Head & Gut Post Oil/Meal processing	Count 1 - # of birds __________ Count 2 - # of birds __________ Count 3 - # of birds __________	Time ________ Time ________ Time ________	Beaufort _______________ Wind Direction (Draw arrow across boat) Vessel Activity (circle) Trawling Steaming Setting Haulback