AVIAN PREDATION ON HERRING SPAWN
EVOS 96320-Q

FY 96 Executive Summary

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EXECUTIVE SUMMARY

Avian predation on herring spawn was studied at northern Montague Island during spring 1994 and 1995. Final results will be presented in a separate, final report to the *EXXON Valdez* Oil Spill Trustees Council on 30 June 1996. What follows is an executive summary on results to date.

This project was designed to provide critical information to test the Sound Ecosystem Assessment's natal hypothesis #2: that recruitment success of Pacific herring (*Clupea pallasi*) populations in Prince William Sound is related to physical processes and predation during early life stages. Results from this study will be incorporated into a sound-wide embryo survival model being developed by scientists at University of Alaska-Juneau. Our estimates of avian consumption of herring spawn will also provide a management tool for Alaska Department of Fish and Game (ADF&G) whereby they can readjust their adult herring spawner biomass estimates.

The objectives of this study are to:

1) Determine the species composition, timing, and distribution of birds foraging in herring spawn areas in the rocky intertidal and subtidal habitats.
2) Estimate the amount of herring spawn consumed by avian predators.

Herring spawn deposition occurred from 18-25 April 1994 and from 27 April-2 May 1995 with hatch beginning approximately 23 days after initial deposition. Prior to spawn initiation, 1994 aerial surveys (n=3) recorded gull numbers ranging between 15,600-25,700, and 1995 boat surveys (n=2) recorded 9,350-10,100 gulls in the vicinity of the herring schools. Of the gulls, approximately 90% were glaucous-winged gulls (*Larus glaucescens*) and 10% mew gulls (*Larus canus*).

We documented avian abundance and distribution for all species by both date and location in relation to herring spawn. In 1994, three species accounted for >90% of all boat observations in spawn areas (n=178,581 birds, 12 surveys): glaucous-winged gulls (57.7%), mew gulls (14.2%), and surfbirds (*Aphriza virgata*) (18.6%). Both years, surfbirds, offshore diving ducks, harlequin ducks (*Histrionicus histrionicus*), and black turnstones (*Arenaria melanocephala*) comprised >93% of all non-gull species in spawn areas. Offshore diving ducks were principally surf scoters (*Melanitta perspicillata*) but also included oldsquaws (*Clangula hyemalis*), white-winged scoters (*Melanitta fusca*), and greater scaup (*Aythya marila*).

Populations of mew gulls and glaucous-winged gulls in Prince William Sound (PWS) consist of year-round PWS residents and spring-summer resident birds. Surf scoters winter in small numbers in PWS including at Montague Island, however, the largest numbers are observed in migrant flocks in spring. Surfbirds and black turnstones are transient spring migrants occurring in large numbers almost exclusively at Montague Island in April and May. Between 20-25 April both years, migrant flocks of surf scoters, surfbirds, and black turnstones appeared at

Montague Island. While in 1994 their arrival coincided shortly after spawn deposition, in 1995 their arrival occurred just prior to the 27 April spawn initiation. At the same time, despite a nine day difference between years in spawn hatch date, in both years surfbirds and black turnstones numbers decreased to negligible numbers after 12 May as they moved on to their more northerly breeding areas.

We tested the hypothesis that birds were attracted to areas of spawn. We calculated the likelihood that a species would occur in a spawn area as opposed to a non-spawn area for an 18km stretch of shoreline that included approximately even amounts of spawn and no spawn. We found that the birds more likely to occur in spawn areas were generally the most numerous: shorebirds, gulls, dabbling and offshore diving ducks as well as bald eagles. Except for the bald eagle, all of these birds are either known or suspected herring spawn consumers. Piscivorous birds (cormorants, mergansers, murrelets, grebes) along with inshore diving ducks and corvids (both omnivorous) and canada geese (herbivorous) were equally likely to occur in a spawn area as a non-spawn area.

We used generalized linear models to test the hypothesis that the distribution, timing and abundance of gulls, offshore diving ducks and shorebirds is positively correlated with the dispersion, timing, and abundance of herring spawn. We ran stepwise glm models to determine the relationship of total birds and total glaucous-winged gulls (dependent variables) and biomass variables at ADF&G spawn deposition transects. We included an additional suite of independent variables. For both models, the same two variables were significant: total eggs ($P<0.001$) and the number of days spawn was laid ($P<0.02$ for glaucous-winged gulls, and $P<0.01$ for all birds). The models were both significant and explained 84.7% and 82.7% of the variation in total numbers of glaucous-winged gulls and all birds, respectively.

We tested the hypothesis that herring spawn is a major component in the diet of birds species foraging in herring spawn areas. In spring 1995 we collected and analyzed stomach contents of the most abundant avian species foraging in spawn areas in northern Montague Island. Herring spawn occurred in 100% of the glaucous-winged gulls, mew gulls, and surf scoters stomachs and in 75% and 69% of the surfbirds and black turnstones, respectively. Based on the stomach contents, we estimated that glaucous-winged gulls, mew gulls, surf scoters, and black turnstones obtained between 99-100% of their total daily energy from spawn.

We applied a bioenergetics model to estimate the daily herring spawn consumption for each of these five species. Our model is based on field metabolic rates (kJ/day), energy content of spawn (kJ/g), assimilation efficiency of spawn, and the proportion of daily energy acquired from herring spawn. Glaucous-winged gulls, the most numerous and the largest predator, had the highest daily consumption rate at 1.27 kg/day per individual. For the other four species, rate of herring spawn consumption was calculated at 1.15 kg/day per surf scoter, 0.58 kg/day per mew gull, 0.19 kg/day per surfbird and 0.16 kg/day per black turnstone. These estimates are probably low due to the seasonal energetic demands of migration and breeding for all five species.

We performed a sensitivity analyses for each of the five major predator's models to examine the implications of parameter uncertainty on their predicted herring spawn consumption. Four parameters (body mass, assimilation efficiency, proportion of energy acquired from herring spawn, and field metabolic rate) were evaluated for their effect on total herring spawn ingestion estimates. The sensitivity analyses showed that for all five species, body mass was the most important model input. An increase in a bird's body mass of +20% affected total herring spawn consumption by +30%, whereas a -20% mass decrease affected total consumption by -28%. Assimilation had the second largest effect on ingestion rate. A -20% decrease in assimilation efficiency increased total consumption by +25%. The model was least sensitive to changes in the proportion of spawn in the diet and the estimated field metabolic rate.

We applied our bioenergetics model to determine avian consumption of spawn along a 6.4km shoreline at Montague Island during 1994. Using ADF&G diver survey data, total eggs in the area were calculated at 333.5 metric tons on 5 May. We estimated that 19.24% of these eggs were removed from 5 May through 13 May 1994. Although these losses occurred relatively late in the spawn cycle (days 16-24), daily percent egg loss rate ranged from -1.6 to -4.4, with an average of -2.5% loss/day $\pm$ 0.34%. Our estimate of egg removal is probably low because some of the ADF&G spawn deposition transects incorporated into our total egg calculation were conducted between 2-4 May when relatively large numbers of glaucous-winged gulls were in the area.

In an ADF&G study on spawn loss in Prince William Sound, Biggs-Brown and Baker (1993) estimated an average daily egg loss at -3.8% per day for all water depths. Based on our preliminary analysis, we believe their egg loss estimate is low because (1) they attribute the majority of eggs lost due to wave or tidal action, and (2), average daily egg loss due to bird predation alone is probably much higher during the first ten days of spawn, when glaucous-winged gull numbers are at their peak.

We were unable to test the hypothesis that birds preferred viable to nonviable spawn such as windrow. Scan samples at 100x300m plots indicated that, except for the surf scoters, gull and shorebirds follow the tidelines and could be taking viable spawn. We rarely observed birds foraging farther than 3m from the tideline. We also visually assessed esophagus contents for viable eggs consumed. For all birds (n=23, 4 species) there was little evidence of a correlation between viable spawn in the guts and the date of collection (r=0.363, Pearson's correlation coefficient),. When we calculated the same correlation by species, we found surf scoters and glaucous-winged gulls to be correlated; however, no correlation was found between viable spawn in the guts and date of collection for mew gulls.

Table 1. Ratios, total numbers, and significance of bird species and groups observed on boat shoreline surveys in spawn and non-spawn areas. Ratios indicate the relative odds of being observed in a spawn area as opposed to a non-spawn area. Significance levels refer to results from an odds ratio test.

SPECIES	RATIO	TOTAL OBSERVED	P-VALUE
POSITIVE ASSOCIATION			
BONAPARTE'S GULLS	85.1	1,880	P < 0.001
OFFSHORE DIVERS	43.3	6,700	P < 0.001
MEW GULLS	32.1	26,211	P < 0.001
GLAUCOUS-WINGED GULLS	15.5	110,736	P < 0.001
DABBLING DUCKS	12.3	187	P < 0.001
HARLEQUIN DUCKS	11.9	4,698	P < 0.001
SURFBIRDS	5.6	40,006	P < 0.001
CALIDRIS SHOREBIRDS	7.7	617	P < 0.001
BALD EAGLES	3,7	222	P < 0.001
BLACK TURNSTONES	2.8	3,331	P < 0.001
BLACK OYSTERCATCHERS	1.4	73	P < 0.025
NEUTRAL			
CORVIDS	1.1	401	0.1 < P < 0.25
CORMORANTS	1.0	648	0.1 < P < 0.25
CANADA GEESE	0.9	354	0.1 < P < 0.25
MERGANSERS	0.6	480	0.1 < P < 0.25
MURRELETS	0.4	234	P > 0.25
INSHORE DIVERS	0.3	234	P > 0.25
GREBES	0.1	30	P > 0.25
NEGATIVE ASSOCIATION			
PIGEON GUILLEMOTS	0.0	15	P > 0.5

Table 2. Aggregate weight (%) of prey items in the esophagus and proventriculus of Glaucous-winged Gulls, Mew Gulls, and Surf Scoters. Surfbird and Black Turnstone data include gizzard contents. All birds collected from herring spawn areas on northern Montague Island, Spring 1994-1995.

	Gulls			Shorebirds	
Prey Items	**Glaucous-winged** 1995, n = 12	**Mew** 1995, n = 8	**Surf Scoter** 1995, n = 7	**Surfbird** 1994-95, n = 20	**Black Turnstone** 1994-95, n = 16
Herring eggs	98.6	88.9	99.4	69.0	70.4
Mytilus edulis	0	0	0	27.2	1.5
Balanus sp.	0	0	0	0.2	22.4
Gastropod sp.	0	0	0	1.3	0
Other	0.1	3.9	0	0.4	0.9
Vegetation	1.3	7.2	0.6	2.1	4.9

Table 3. Estimated herring spawn consumption per individual by species based on a model incorporating body mass of bird, estimated field metabolic rate, proportion of energy derived from spawn, and assimilation efficiency of spawn.

Species	Mean Mass (kg)	Agg. Energy of Herring Eggs in Diet	Herring Eggs Ingested per Bird	
			Eggs / Day	Kg / Day
Glaucous-wgd. Gull	1.33	100	558,700	1.27
Mew Gull	0.45	100	255,900	0.58
Surf Scoter	1.16	100	507,000	1.15
Surfbird	0.20	92	83,900	0.19
Black Turnstone	0.14	99	69,149	0.16

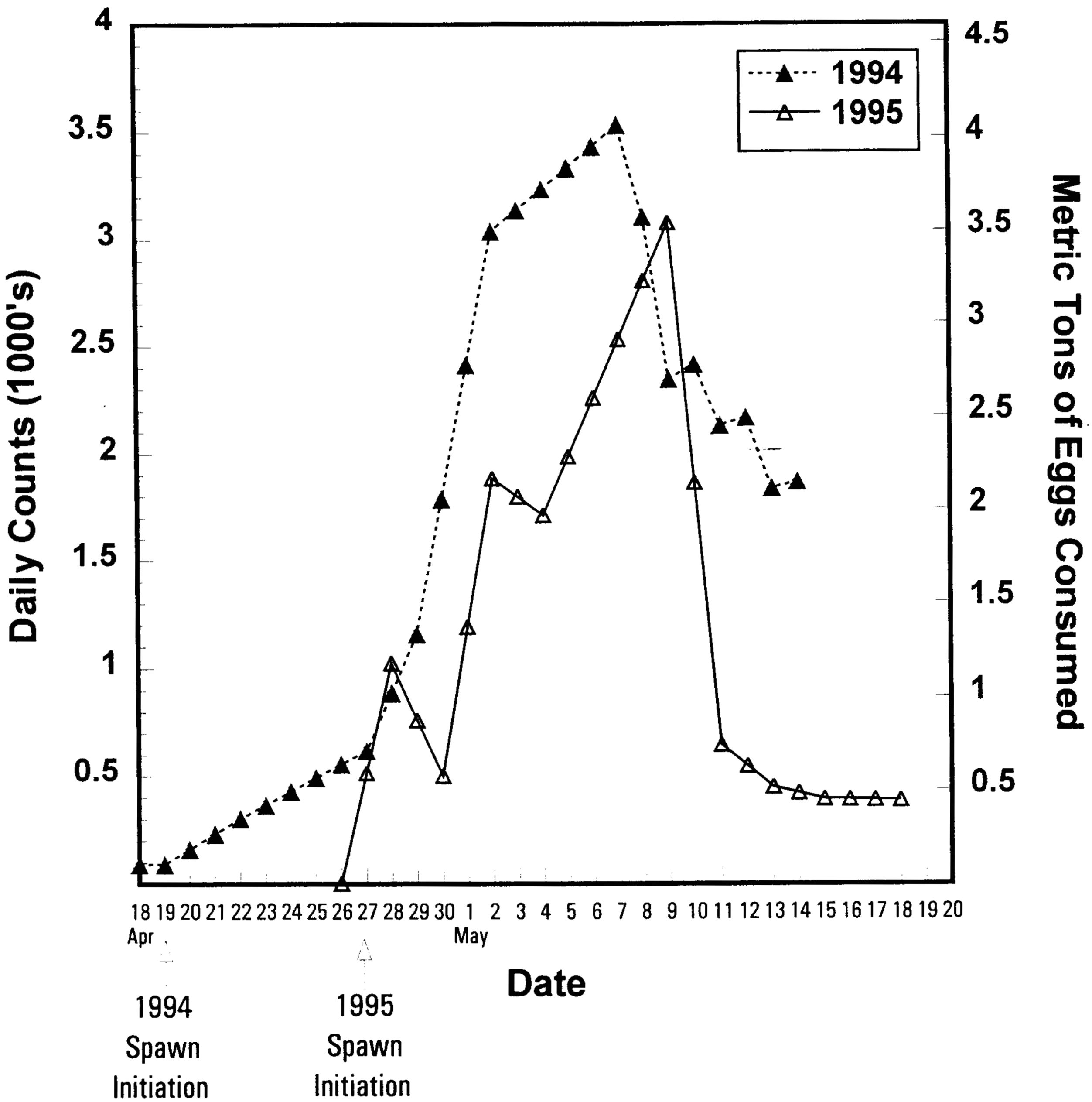

Figure 1. Surf Scoter abundance and herring spawn consumption at northern Montague Island, April-May 1994-95. Numbers determined from aerial surveys (1994) and boat surveys (1995). Grand totals: 1994 = 71.2 metric tons. 1995 = 31.7 metric tons.

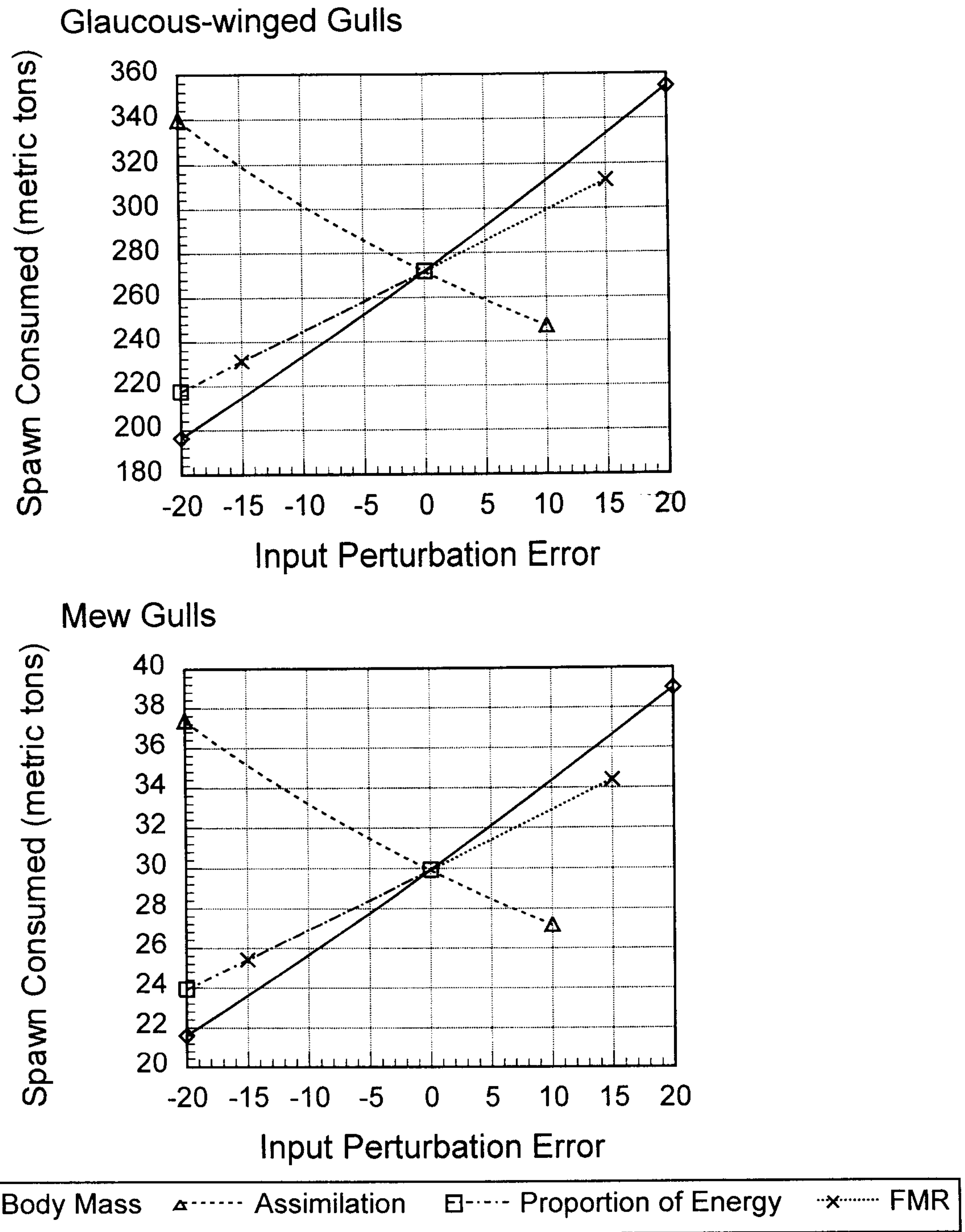

Figure 2. Sensitivity analyses estimate of spawn consumption model. Spawn consumed plotted as a function of possible errors (in %) in estimates of body mass, assimilation efficiency, proportion of energy derived from spawn, and field metabolic rate.

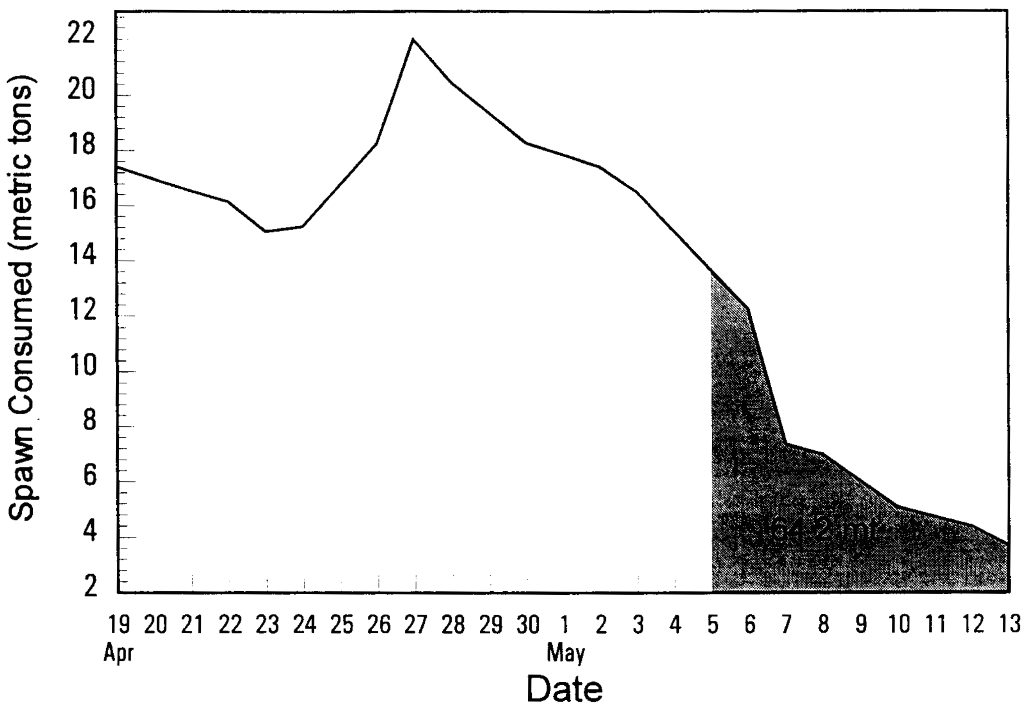

Figure 3. Total spawn consumption by glaucous-winged gulls, mew gulls, surfbirds, black turnstones, and surf scoter for a 6.4-km shoreline with spawn, Graveyard Point, Montague Island, Spring 1994. Area under curve after 5 May = 64.2 metric tons or 19.24% of an estimated 333.5 metric tons of eggs available on 5 May.

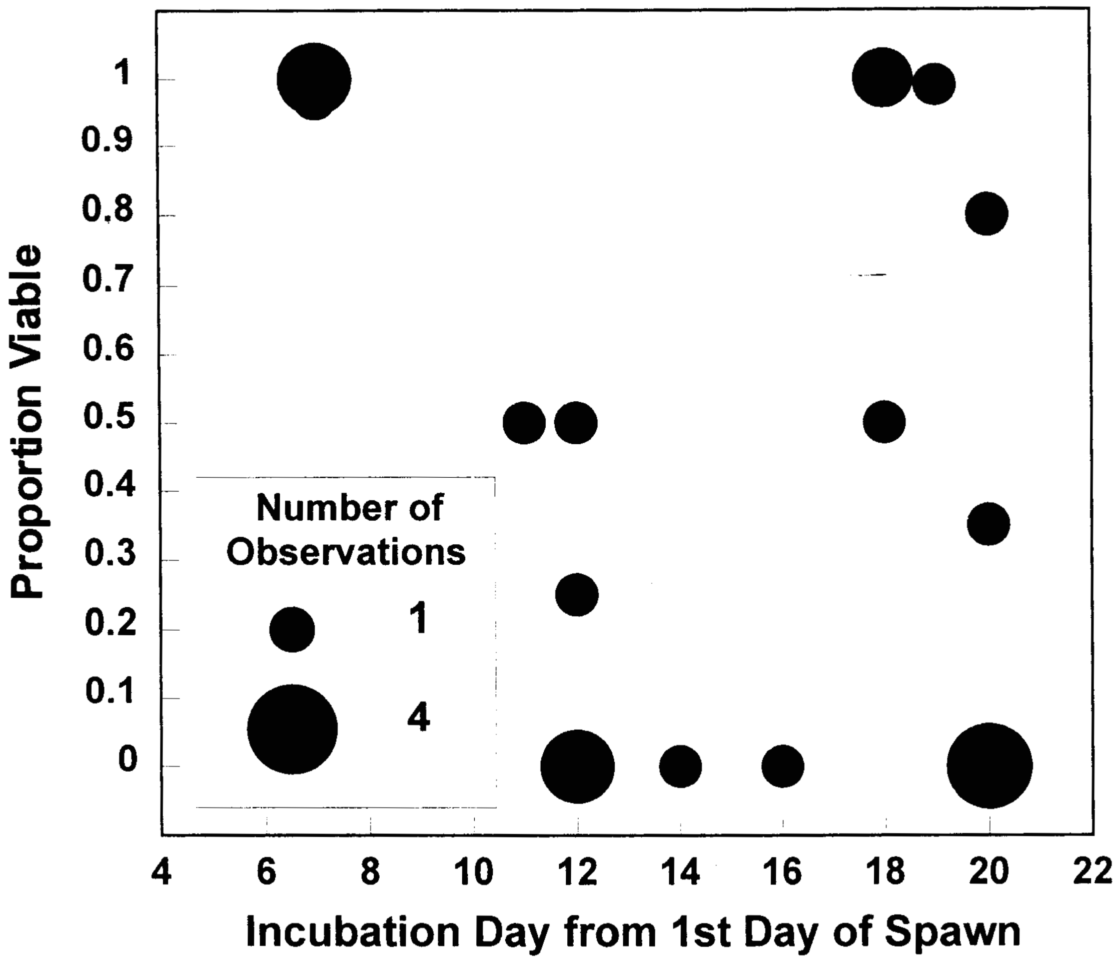

Figure 4. Proportion of viable spawn found in avian esophagi collected on northern Montague Island, Spring 1995. Species collected include glaucous-winged gulls (n = 7), mew gulls (n = 8), surf scoters (n = 6), and black turnstones (n = 2).