Project Number: 10100132-H

Project Title: PWS Herring Survey: Seasonal and Interannual Trends in Seabird Predation on Juvenile Herring

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Time period covered: FY11

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Project website: ***http://www.pwssc.org/herringsurvey***   ***with additional information at www.pwssc.org/research/biological/seabirds/SeabirdOnHerring.htm***

Work Performed and Preliminary Results:

During FY2011, we performed diurnal and nocturnal surveys of marine bird distribution and abundance in Prince William Sound (PWS) during 1-10 November 2010, 7-16 March 2011, and 23-25 August 2011 cruises. As in previous years, both winter cruises focused on five bays in PWS that were historically known to hold large overwintering aggregations of juvenile herring including Eaglek, Simpson, Whale, Zaikof, and Lower Herring Bays. This year, we expanded the surveys to include four additional bays: Paddy, Twin, Fidalgo, and Windy Bay (Fig 1). During the March 2011 cruise, we opportunistically surveyed Main Bay and Naked Island. A second vessel sampled fish in and around transects to validate the acoustic surveys, sample herring for disease and energetics and sample potential herring predators. The late August cruise tested acoustic equipment for herring surveys around Simpson Bay in southeast PWS. Diurnal Bird observations were conducted using established U.S. Fish and Wildlife Service protocols (USFWS 2007). One observer using 10x binoculars recorded number of birds occurring within a strip transect width of 300 m (150 m both sides and ahead of the boat, in 3 distance bins of 50m).

Bird Numbers and Distribution

Compared with the previous November, we detected high numbers of birds during March 2011 surveys (Fig. 2). The largest concentration included >300 birds (primarily Common Murre) near an ice edge at the head of Eaglek Bay. We observed relatively high numbers of Common Murre in the other bays as well (Fig. 3), suggesting that foraging and/or winter weather conditions in PWS were favorable for murres relative to the Gulf of Alaska (GOA). Nevertheless**,** weather data collected by National Data Buoy Center (www.ndbc.noaa.gov/ maps/Alaska.shtml) did not show significant deviations from long-term monthly average sea surface temperatures (SST) in either PWS or the GOA (Fig. 4). Among the other species we recorded, Marbled Murrelet numbers were also relatively high in March 2011, in contrast to the previously observed pattern of higher abundance in November (2009 and 2010) compared to March (2010).

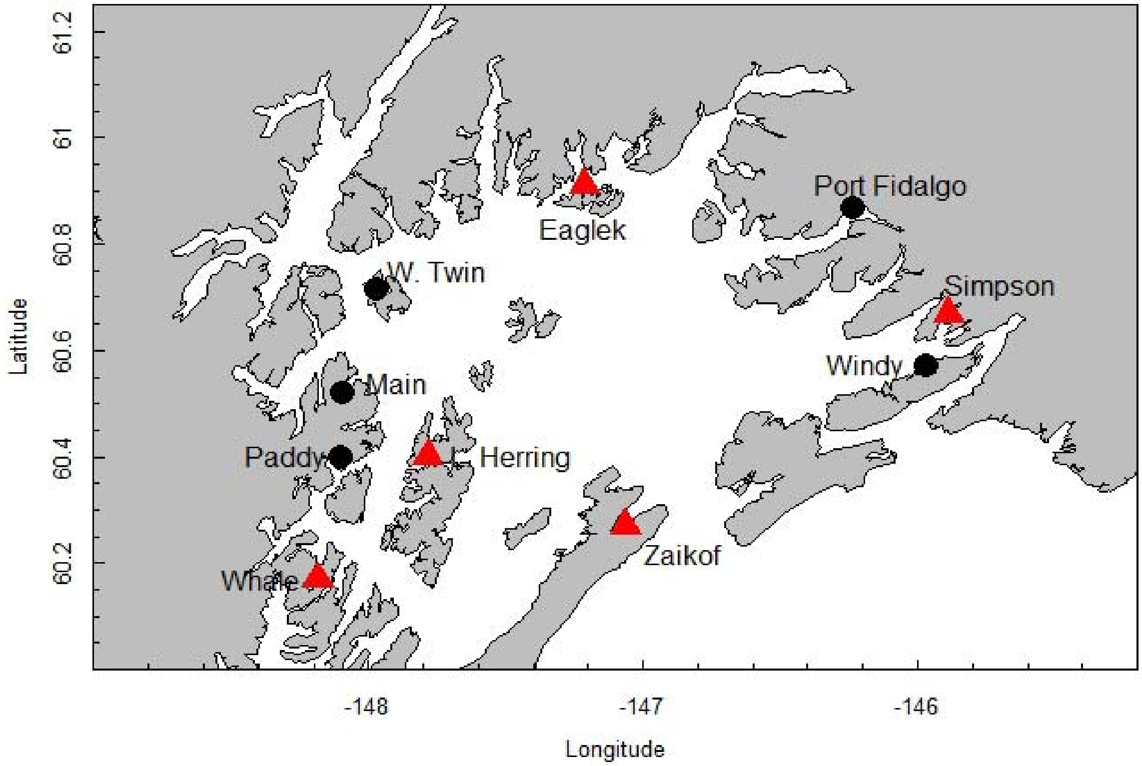
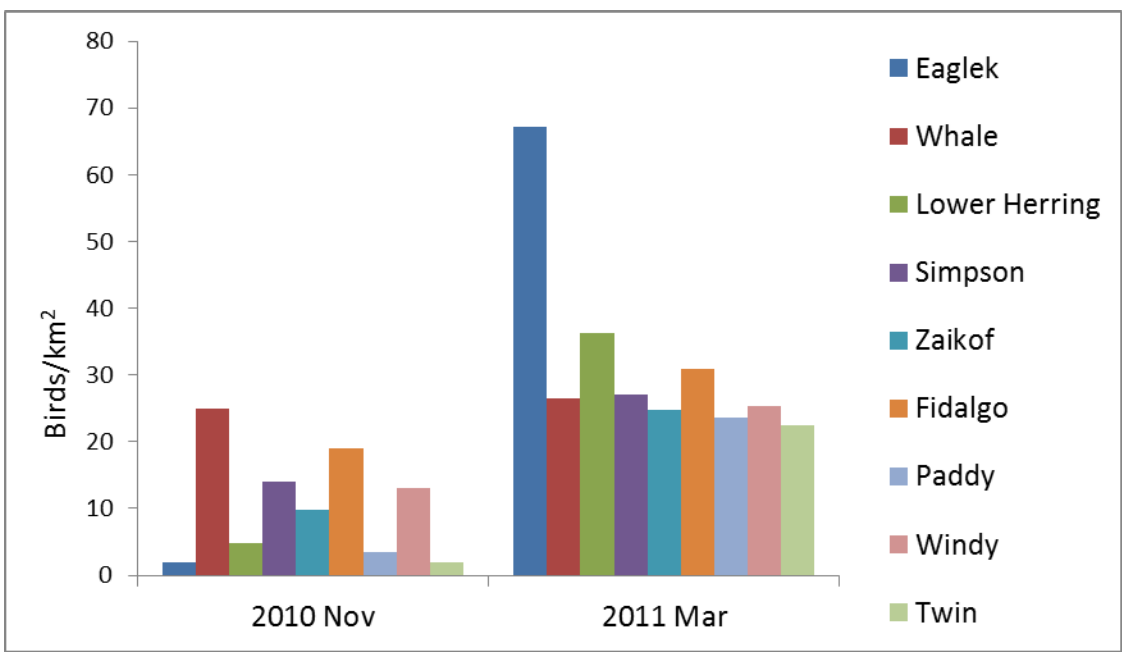
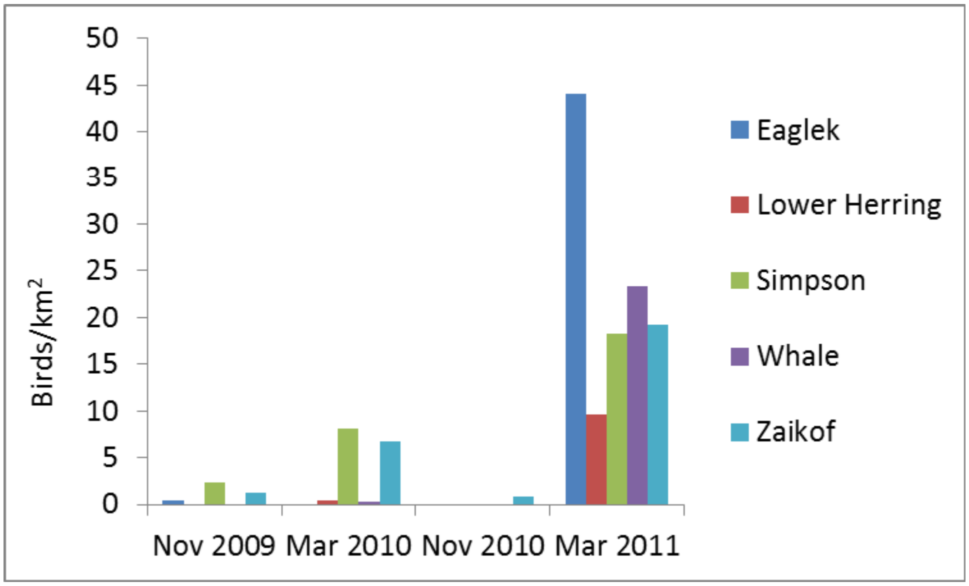


Fig. 1. Location of bird transects. Red triangles= bays surveyed Nov 2009, 2010 and Mar 2010, 2011; black circles = bays surveyed Nov 2010 and Mar 2011 except Main Bay (Mar 2011 only).



Fig, 2. Bird densities (birds/km2; flying birds excluded) by bay for November 2010 and March 2011. High bird numbers observed in March were primarily Common Murre..



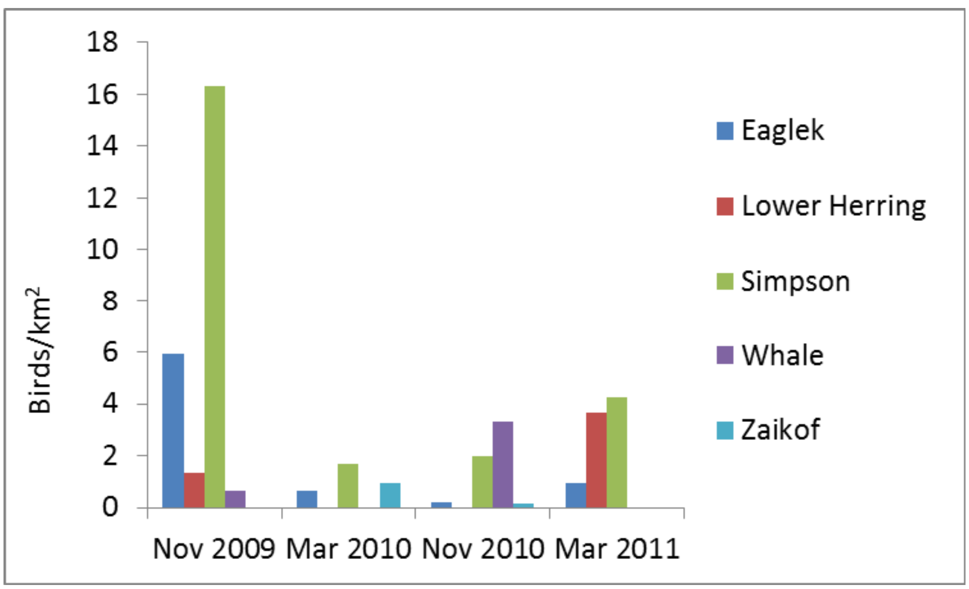


Fig. 3. Density (birds/km2) of Common Murre (top) and Marbled Murrelet (bottom) by bay during four winter cruises, November 2009 through March 2011. Detections are shown only for birds on the water and in the five bays surveyed both winters. .

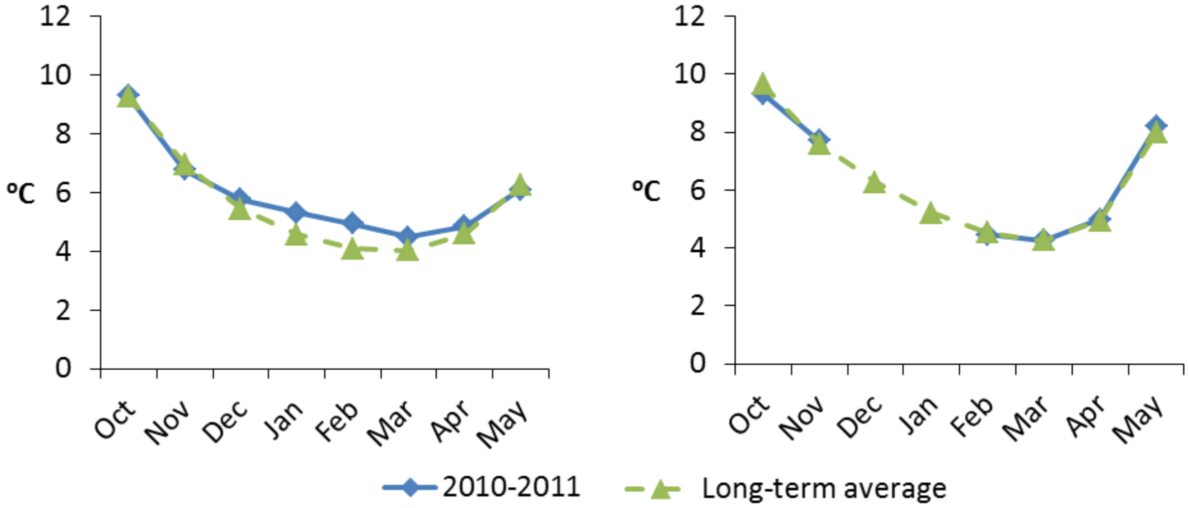


Fig. 4**.** Monthly average sea surface temperature (SST) in Gulf of Alaska (left) and Prince William Sound (right) for Oct 2010 to May 2011 as compared to respective long-term monthly average. Gulf of Alaska data NDBC buoy 46001, at 175NM South East of Kodiak (56.300 N 148.021 W) with long-term average SST from 1972 to 2010.Prince William Sound SST data from NDBC Buoy at West Orca Bay (60.593 N, 146.818 W). Long-term SST from 1995 to 2010.No data available from West Orca Bay for Dec 2010 and Jan 2011.

We assessed whether bird densities varied by cruise or bay for total birds observed and for selected abundant species: Common Murre, Marbled Murrelet, Pelagic Cormorant, Mew Gull, and large gulls (primarily Glaucous-winged Gull with smaller numbers of Herring Gull). For these analyses, we used generalized linear mixed effects (GLMM) models with a Poisson distribution. All statistical analyses were conducted in R (R development core team, Vienna, Austria) using the lme4 package (Bates et al. 2011). Two models were run for each species or species group. Our first model contained a fixed effect of cruise, but permitted intercepts to vary for each bay. A second model used bay as a fixed effect, but permitted intercepts for cruise to vary. This allowed exploration of which bays were biologically significant for each species group.

Our models revealed a significant relationship between bird densities and date for Common Murre and Marbled Murrelet (Table 1). For Common Murre, March 2011 was significantly higher than the other cruises, while for Marbled Murrelets the November 2010 cruise was significantly different from the other three cruises. When analyzed by bay, Zaikof, Twin and Paddy Bays had significant differences in total bird detections compared to other bays (Table 2)**.** However, we found no significant relationship between bird densities and bay for individual species.

Table 1. Models for bird distributions by cruise. Only species or species groups for which date was significant ($P \leq 0.05$) are shown.

Species or Group	Cruise Mo/Yr	Parameter Estimate	Standard Error	*Z*	*P*
Common Murre					
Intercept	(Nov09)	-1.471	0.92	-1.61	0.108
	Mar 10	1.343	1.02	1.31	0.190
	Nov 10	-1.316	1.62	-0.81	0.416
	Mar 11	3.213	0.92	3.48	**0.001**
Marbled Murrelet					
Intercept	(Nov09)	0.066	0.49	0.14	0.893
	Mar 10	-2.008	1.11	-1.81	0.070
	Nov 10	-1.472	0.75	-1.96	**0.050**
	Mar 11	-1.289	0.71	-1.83	0.068

Table 2. Models for bird distributions by bay. Only species or species groups for which bay was significant ($P < 0.05$) are shown.

Species or Group	Transect	Parameter Estimate	S.E.	*Z*	*P*
Total birds					
Intercept	(Simpson)	1.652	0.37	4.52	**0.000**
	Eaglek	-0.118	0.29	-0.41	0.683
	Whale	-0.631	0.34	-1.88	0.060
	Zaikof	-0.753	0.35	-2.15	**0.031**
	L. Herring	-0.602	0.33	-1.81	0.070
	Twin	-1.026	0.45	-2.27	**0.023**
	Fidalgo	-0.340	0.35	-0.97	0.335
	Windy	-0.755	0.41	-1.86	0.064
	Paddy	-0.858	0.42	-2.03	**0.042**

We assessed the influence of fish biomass on bird densities (total birds, Common Murre, Marbled Murrelet, Pelagic Cormorant, Mew Gull and large gulls). For these analyses, we used generalized linear mixed effects (GLMM) models. Our models contained a fixed effect of herring densities, but permitted intercepts to vary for each bay within each cruise. Because bird detections in March 2011 were unusually high, we excluded that cruise from the analyses. Our analyses showed a significant relationship between juvenile herring densities and detections for Common Murre ($P < 0.01$), but no significant relationships for total birds, Marbled Murrelet, Pelagic Cormorant, Mew Gull, and large gulls (Fig. 5).

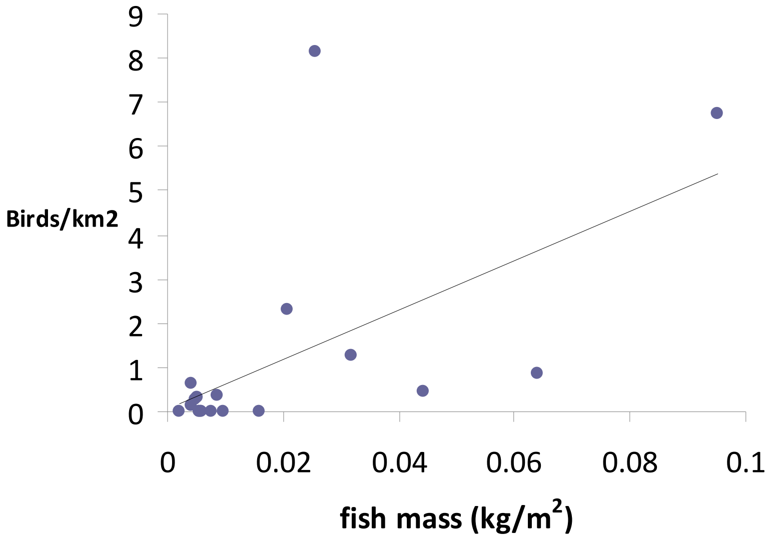


Fig. 5. Relationship between fish biomass (kg/m^2) in survey bays and Common Murre density (birds/km2). Prince William Sound, November 2009 and 2010 and March 2010. Data from 2011 were not included because of unusually high numbers of birds during that survey.

We compared total transect detections of Black-legged Kittiwake for November 2008 to March 2011 in the bays sampled during all six cruises (Eaglek, Simpson, Zaikof, East Whale, and West Whale) using Arc 10 GIS package (ESRI, Redlands, California, USA). We found large seasonal and interannual variation in Black-legged Kittiwake abundance (Fig. 6). Abundance in November was higher than in March during two of three seasons.

Nocturnal Surveys

In November 2009, we initiated a study to develop methodology for nocturnal avian surveys. We used two night survey methods. First, an infrared (IR) camera was mounted to the roof of the survey vessel (*MV Auklet*). IR images were displayed on a screen inside the cabin, permitting an observer to record observations in real time. In March 2011, we added a second IR camera next to the original camera on the roof of the vessel. We mounted the cameras side by side, such that together they provided a wider field of view pointing towards the front of the bow (Fig. 7). Our second survey method utilizes a Low Light Night Vision Monocular (NV) used by an observer stationed outside the cabin on the bow of the boat. The NV monocular is a 3rd generation ATN Night Storm produced by Black Lion Optics.

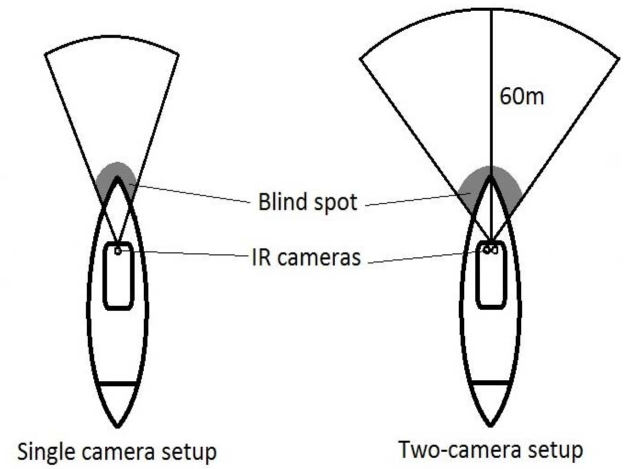


Figure 7. Illustration of two types of IR camera setups used in nocturnal survey.

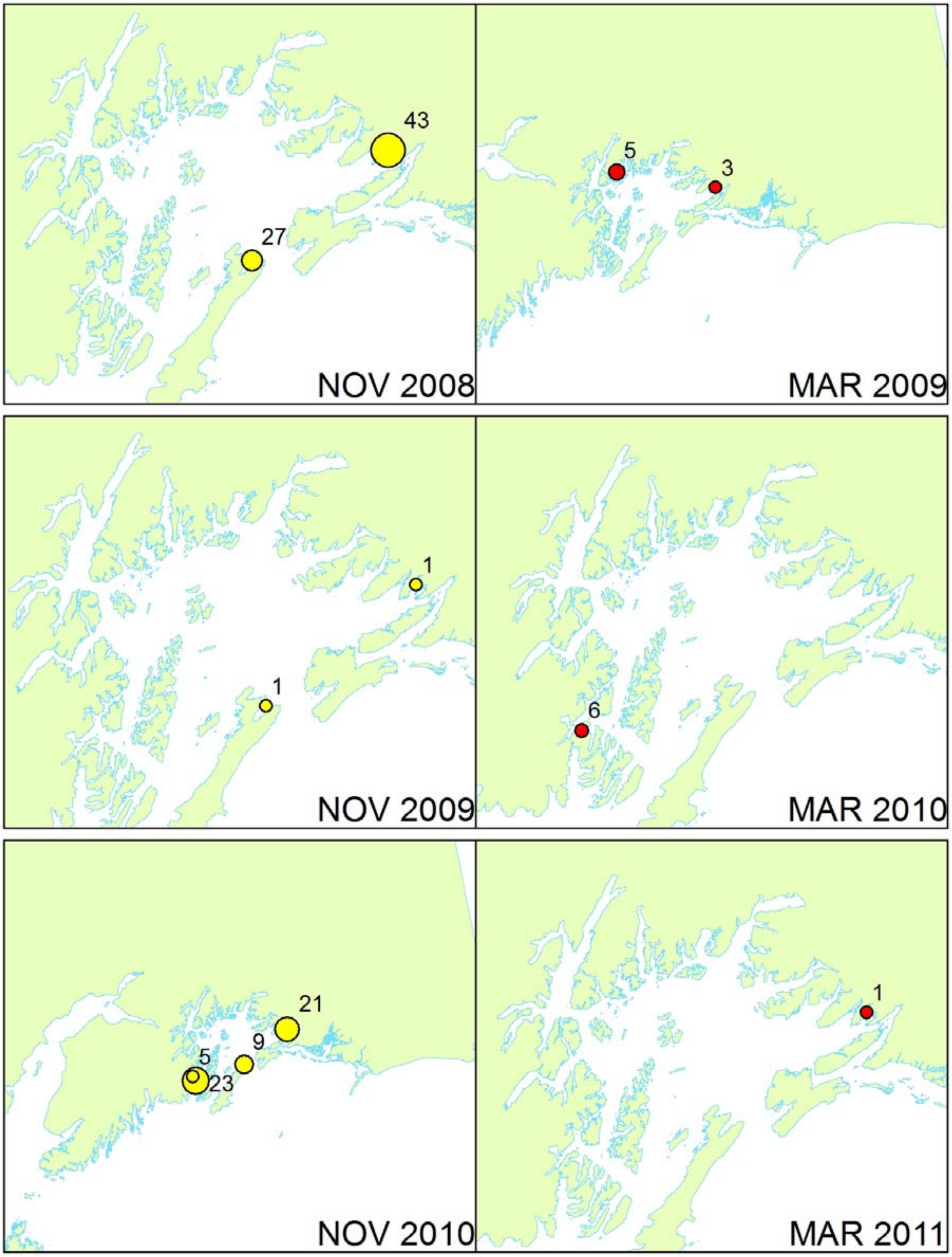


Figure 6. Abundance of Black-legged Kittiwake in Eaglek, Simpson, Zaikof, East Whale, and West Whale Bays from November 2008 cruise to March 2011 cruise. Yellow circles = total count per bay.

Due to inclement weather we were unable to conduct NV surveys during the November 2010 cruise. In 2011, with 10 surveys (as opposed to 5 in the previous year) we had higher nocturnal bird detections, primarily due to increased numbers of birds in the air. (Fig. 8). We are currently in the process of cataloging the IR video footages recorded during our nocturnal surveys. We are compiling a library of positively identified IR images so that future images can be identified by comparing behavior, shape and color intensity with previously identified images. This resource will greatly improve our ability to identify bird genus and enhance the utility of IR imaging in nocturnal bird surveys.

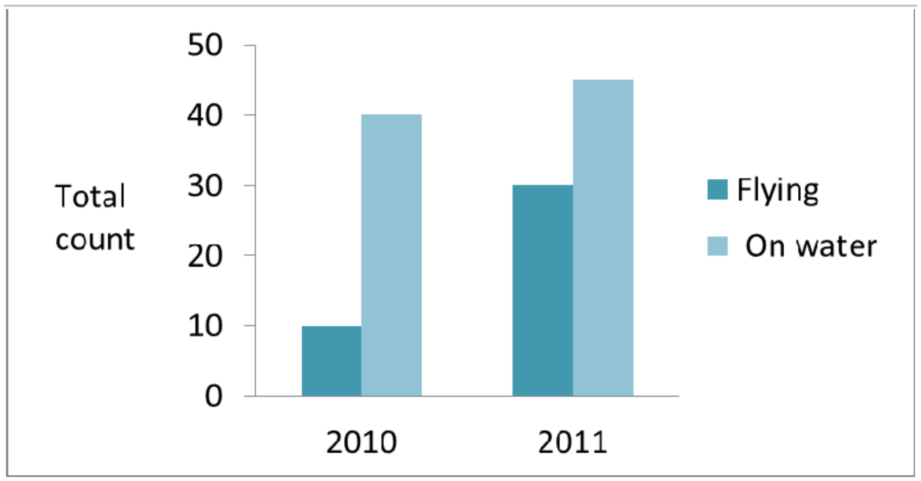


Fig. 8. Night survey monocular vision bird counts, 2010 March (n =5 bays) and 2011 March (n = 10 bays).

Future work:

Two winter herring cruises are scheduled for November 2011 and March 2012 to investigate herring-bird associations in PWS during the winter months. During these cruises we will continue to conduct both daytime and nocturnal bird surveys in conjunction with hydroacoustic herring surveys. In addition to the five bays that have been surveyed since November 2009 (Eaglek, Simpson, Whale, Zaikof, and Lower Herring), St. Matthews and Beartrap Bays in Port Gravina will be surveyed this next winter.

In September 2011, we will be participating in a 1-day WebNar conference in preparation for a special issue of Fisheries Oceanography on top-down predation on herring. We will be submitting a paper entitled, "Pacific herring consumption by marine birds during winter in Prince William Sound Alaska authored by Bishop, Watson, Morgan, and Kuletz.

Coordination/Collaboration:

Our project is part of the PWS Herring Survey Group. Field work is conducted concurrent with hydroacoustic herring surveys and with energetics, disease, and fish predator collections.

Principal investigator Bishop attended and presented at the May 2011 Herring Survey Group meeting in Cordova.

We have had additional discussions with Evelyn Brown regarding her aerial survey work, to investigate the potential for using data collected during her summer aerial surveys to examine the relationship between juvenile herring schools and marine birds. Dr. Brown has agreed to provide us with her summer 2010 data in October 2011, and the summer 2011 data at a later date.

We are also cooperating with Ron Heintz at National Oceanic Atmospheric Administration (NOAA) on the preparation of a special issue of *Fisheries Oceanography* on top-down effects on herring (see above under future work)

Community Involvement/TEK & Resource Management Applications:

During the May 2011 Herring Survey Group meeting in Cordova we participated in a question and answer session open to the public.

Information Transfer:

An article entitled, "Brrrr..surveying seabirds during winter" describing our EVOS project was published in the *Delta Sound Connections*. In May 2011, over 10,000 copies of this free newspaper were placed at airports and various tourist areas in southcentral Alaska.

Public Outreach:

On the PWS Science Center web site, we have two pages that provide information on the project.

The first web page is under the PWS Herring Group *http://www.pwssc.org/herringsurvey*

The second web page is under the avian research program:

http://www.pwssc.org/research/biological/seabirds/SeabirdOnHerring.htm

Budget Changes: No major budget changes are anticipated at this time.

Literature Cited:

Bates, D., M. Maechler and B. Bolker. 2011. lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-39. http://CRAN.R-project.org/package=lme4