Prince William Sound
Regional Citizens' Advisory Council

Contract No. 910.16.01

Winter Species in Prince William Sound, Alaska, 1989-2016

Submitted by:

Anne Schaefer
Prince William Sound Science Center
PO Box 705
300 Breakwater Ave.
Cordova, AK 99574

Principal Consultants:

Mary Anne Bishop, Ph.D., Prince William Sound Science Center, Phone: (907) 424-5800 x228, Email: mbishop@pwssc.org

Anne Schaefer, M.Sc., Prince William Sound Science Center, Phone: (907) 424-5800 x240, Email: aschaefer@pwssc.org

FINAL REPORT

September 2016

Table of Contents

List of Tables

List of Figures

Appendices

Abstract

We conducted a literature search and developed a bibliography of research conducted on biological resources during winter in Prince William Sound (PWS) since the 1989 *Exxon Valdez* oil spill. The literature search returned 133 unique results documenting the presence of 188 species, including 61 zooplankton, 1 mollusk, 1 echinoderm, 7 crustaceans, 61 fish, 50 birds, and 6 mammal species. However, the species list included with the bibliography is by no means a comprehensive list of all species present in PWS during winter. We were unable to find any published studies or reports documenting sea cucumbers, sea urchins, jellyfish, octopus, and several marine mammal species known to occur in PWS throughout the year. Our bibliography is useful for identifying sensitive biological resources in the Sound and can be used as a tool to inform and update oil spill contingency plans.

Introduction

In March 1989, the *Exxon Valdez* ran aground on Bligh Reef in Prince William Sound (PWS), Alaska. The spill released approximately 11 million gallons (257,000 barrels) of crude oil into the Sound and contaminated over 1000 miles of shoreline (Alaska Oil Spill Commission 1990). The estimated mortality from the spill included approximately 250,000 seabirds (Piatt et al. 1990), 2,600 sea otters (Garrot et al. 1993), 300 harbor seals (Loughlin 1994), 250 bald eagles (Bowman et al. 1993), as many as 22 killer whales (Loughlin 1994), and countless salmon and herring eggs.

Following the oil spill, Congress passed the Oil Pollution Act of 1990. This act requires oil storage facilities and vessels to develop and submit oil spill prevention and response plans detailing their responses in the event of accidental discharge. The PWS Subarea Contingency Plan (PWSSCP) documents the response plan for the PWS area and identifies sensitive areas, biological resources, and human-use resources within PWS that may be particularly sensitive to the effects of an oil spill. However during oil spill response drills, the staff of the PWS Regional Citizens' Advisory Council (RCAC) has at times noted response actions that perhaps demonstrate an under-appreciation of the biological resources that may be present in PWS during winter months.

To address these issues, we developed a bibliography documenting the presence of biological resources in PWS during the winter since the *Exxon Valdez* oil spill in 1989. This information is useful for the PWS RCAC to identify sensitive biological resources in the Sound, to identify gaps in knowledge of winter species, and to inform and update oil spill contingency plans such as the PWSSCP.

Methods

We used a variety of methods to identify research activities since 1989 that pertain to biological resources in PWS during winter months. First, we defined winter as the period occurring between November 1 and March 31. We then performed a literature search using the Web of Science and Google Scholar databases. The search parameters used were "Prince William Sound winter" with the time span restricted to 1989-2016. We also used the Exxon Valdez Oil Spill Trustee Council's Restoration Project Search using the following parameters: Geographic Regions- Prince William Sound; Professional Activities- Field research and data management. Additionally, we searched final reports submitted by the Alaska Department of Fish and Game (ADFG), U.S. Forest Service (USFS), PWS RCAC, and the National Oceanic and Atmospheric Administration (NOAA) directly on the agency websites. Additionally, we contacted 25 researchers from 10 agencies and organizations that conduct research or manage biological resources in PWS during winter. Of the 25, all but two responded to our inquiries. Researchers were contacted primarily by email, but were also interviewed over the phone or in person.

All applicable results were organized into a searchable bibliography using Microsoft Excel. All entries were completed as fully as possible. See Table 1 for a complete list of the data categories and definitions.

Results

Our search returned a total of 133 unique records of 188 species for the bibliography (See Appendix 1 for the complete list of records and Appendix 2 for list of species). In some cases, the bibliographic citations may have more than one entry associated with them if the research investigated more than one taxonomic grouping.

The bibliographic search returned studies documenting zooplankton, mollusks, echinoderms, crustaceans, fish, birds, and mammals (Table 2; Appendix 2). Most studies occurred either within a single winter month or throughout the entire winter period (Figure 1). March was the month in which the highest number of research activities occurred followed by November for all taxa except crustaceans (Figure 2).

Zooplankton

Five studies documented zooplankton presence, density, or distribution in PWS during winter. Two results were part of a long-term monitoring program that collected zooplankton samples all year round concurrent with oceanographic measurements (Campbell 2013; R. Campbell, PWSSC on-going project). Another project examined the influence of temperature on zooplankton, sampling in March (Foy and Norcross 2001). Sturdevant et al. (2001) conducted vertical zooplankton tows and assessed zooplankton presence in the stomachs of juvenile walleye pollock and Pacific herring to evaluate feeding habits and diet overlap between the two species. The fifth study sampled ballast water of tankers arriving to Port Valdez and examined variation in the biota of the water (Ruiz et al. 2000).

Mollusks

Mollusks were included in 14 studies, the majority of which involved collecting mussel tissues and sediments throughout PWS (Payne et al. 2010, 2008, 2006, 2005, 2003, 1998; Kinnetic Laboratories Inc. 2003, 2000, 1999, 1998; Babcock and Short 1996) or within Port Valdez (Salazar et al. 2002) to test for hydrocarbon concentrations. Planktonic-state mussels were also documented in tanker ballast water (Ruiz et al. 2000). Bishop et al. (1998) tested the feasibility of using predator enclosures to assess direct avian predator and sea otter effects on mussel density and size distribution. Only in the Babcock and Short (1996) and Bishop et al. (1998) studies was species identified (*Mytilus trossulus*); otherwise mussels were referred to as bivalves or gastropods (Ruiz et al. 2000), or simply as intertidal mussels.

Echinoderms

Echinoderms were documented in one study wherein the biota of ballast water from tankers arriving to Port Valdez was sampled (Ruiz et al. 2000). Species were not identified, but echinoderms in their planktonic form were among the top ten most abundant species groups in the samples.

Crustaceans

There were seven projects documenting crustacean presence in PWS during winter. In the aftermath of the oil spill, ADFG evaluated the impact of the spill on spot shrimp (*Pandalus platyceros*; Trowbridge 1992). Additionally, ADFG manages the sidestripe shrimp trawl fishery in PWS, which is open from April-August and October-December (Wessel et al. 2012). However, due to very low commercial participation, catch numbers are not readily available. ADFG also manages the Tanner and king crab fisheries (Rumble et al. 2014) and documents personal and subsistence harvest rates and patterns (ADFG 2008). Carls et al. (2016) collected spot (*P. platyceros*), coonstripe (*P. hypsinotis*), and pink shrimp (*P. borealis*) samples from Port Valdez to test for hydrocarbon concentration. Pacific glass shrimp (*Pasiphaea pacifica*) were documented as bycatch during trawls sampling for walleye pollock (Guttormsen and Jones 2010). Planktonic crustaceans were also noted in ballast water of tankers arriving to Port Valdez (Ruiz et al. 2000); species were not identified, but crustaceans were the second most abundant species group in the samples.

Fish

Fish were the most extensively studied species group, with 59 returned search results documenting 61 species. The majority of winter fish research focused on Pacific herring (*Clupea pallasii*), specifically overwinter survival of juvenile herring. Pacific herring have been studied extensively since 1993 when their populations crashed in PWS (Thorne and Thomas 2008; Carls et al. 2002). Research activities included surveying and sampling herring using a variety of techniques such as midwater trawls (Thorne 2010; Foy and Norcross 2001; Stokesbury et al. 2000; Sturdevant et al. 2001; Lewandoski and Bishop in review), gillnets (M. Bishop, PWSSC, on-going project), purse-seines (Thomas and Thorne 2003; Stokesbury et al. 2000; Willette et al. 1999), and cast-nets (M. Bishop, PWSSC, on-going project), acoustic surveys (Thorne 2010; Frid et al. 2007; Thomas and Thorne 2003; Thorne and Thomas 2002; Foy and Norcross 2001; Stokesbury et al. 2000; Willette et al. 1999; Kirsch and Thomas 1998, 1997; Thomas et al. 1995; K. Boswell, FIU, on-going project; P. Rand, PWSSC, on-going project), and aerial surveys (Thomas and Thorne 2003; Thorne and Thomas 2002). Herring were also captured as part of a validation study of the acoustic survey techniques (M. Bishop, PWSSC, on-going project). Herring were also tagged with acoustic transmitters and their movements detected with acoustic arrays (Eiler and Bishop 2016; Bishop 2015).

Herring samples have been collected and tested for disease (Hershberger e al. 2011; Marty et al. 2004). Researchers have also conducted energy content and diet analyses (Sturdevant et al. 2001; Foy and Paul 1999; Foy and Norcross 1999; J. Vollenweider, NOAA, on-going project), fatty acid analyses (R. Heintz, NOAA, on-going project), stable isotope analyses (Sewall et al. 2013; Kline and Campbell 2010; K. Gorman, PWSSC, on-going project), bomb calorimetry analyses (K. Gorman, PWSSC, on-going project), otolith microchemistry analyses (Otis et al. 2010; Otis and Heintz 2003), and genetic analyses (Wildes et al. 2011). The impact of upper trophic level predators on herring populations (Rice et al. 2011; Bishops and Powers 2013; Bishop et al. 2015) and ecosystem-level mechanisms influencing herring mortality (Cooney et al. 2001) have also been examined.

Walleye pollock (*Gadus chalcogrammus*) were documented in 15 studies. These studies involved hydroacoustic surveys (Guttormsen and Jones 2010; Frid et al. 2007; Thorne et al. 2002; Thomas and Thorne 2001; Stokesbury et al. 2000; Thorne and Thomas 2000; Kirsch and Thomas 1998, 1997; Thomas and Stables 1995; NOAA 1991) and aerial surveys (Thorne et al. 2002), and sampling using trawls, gillnets, seines, and longlines (Bishop and Powers 2013; Thomas and Thorne 2001; Stokesbury et al. 2000; Sturdevant et al. 2001; Bechtol 1999; NOAA 1991). Fish were sampled for gut content analysis (Bishop and Power 2013) and energy content analysis (Paul et al. 1998). ADFG manages the walleye pollock fishery, which is open from January until March, unless the catch limit is reached earlier. Since 1995, ADFG staff has conducted dockside sampling of pollock catches during the open season (Wessel et al. 2014).

Five studies documented lingcod (*Ophiodon elongates*) presence and movements during winter. From 2008 until 2010, Bishop et al. (2009, 2010) captured, acoustic-tagged, and tracked lingcod movements using an acoustic array. Lingcod were also captured for gut content analysis to evaluate the influence of predatory fish on herring populations (Bishop and Powers 2013). Additionally, ADFG manages the lingcod fishery in PWS, which is open from July-December. Since 2003, ADFG staff has performed dockside sampling of lingcod catches throughout the fishing season (Wessel et al. 2014) and documents recreational catches (Hochhalter et al. 2011).

Pacific cod (*Gadus microcephalus*) were documented in three studies. Cod were captured using pots and longlines and fitted with acoustic transmitters during the winters of 2013/14 and 2014/15. Their movements were monitored using acoustic arrays through May 2016 (Bishop

2015). Cod were also captured for gut content analyses to examine the effect of predatory fish on herring populations (Bishop and Powers 2013). ADFG manages the Pacific cod fishery in PWS, which is open all year round. Since 1994, dockside sampling of Pacific cod also has been conducted by ADFG throughout the entire winter period (Wessel et al. 2014).

Sharks and skates were included in six studies. Salmon sharks and Pacific sleeper sharks (*Somniosus pacificus*) were fitted with transmitters to study depth distribution, foraging ecology, and movement ecology (Carlisle et al. 2011; Frid et al. 2007; Hulbert et al. 2006; Hulbert et al. 2002) during winter. Big (*Raja binoculata*) and longnose skates (*R. rhina*) were also fitted with satellite tags to evaluate movement ecology of these species (T. Farrugia pers. comm). Gut contents from five species of skates (Big skates, longnose skates, Bering skates (*Bathyraja interrupta*), Aleutian skates (*Bathyraja aleutica*), and sandpaper skates (*Bathyraja kincaidii*)) were also documented (Bishop and Powers 2013).

Pacific halibut (*Hippoglossus stenolepis*), spiny dogfish (*Squalus acanthias*), Chinook salmon (*Oncorhynchus tshawytscha*), yellowfin sole (*Limanda aspera*), and rockfish (*Sebastes* spp.) were documented as part of the study evaluating the impact of predatory fish on herring populations (Bishop and Powers 2013). Pacific halibut, Chinook salmon, and rockfish also were included in the ADFG Fishery Management Report for the Prince William Sound management area (Hochhalter et al. 2011). Sablefish (*Anoplopoma fimbria*) were tagged in March as part of an on-going study by ADFG that began 2011 (Wessel et al. 2014). Pink salmon (*Oncorynchus gorbuscha*) were part of a study evaluating the influence of ecosystem-level mechanisms on mortality (Cooney et al. 2001). Bernard et al. (1995) conducted a mark-recapture survival study of individually marked Dolly Varden (*Salvelinus malma*). Finally, there were 46 other species documented as bycatch during trawl, gillnet, and longline surveys targeting other fish species (Appendix 2).

Birds

There were 43 studies documenting presence of 50 bird species in PWS during winter (See Appendix 2 for full list). Ship-based marine bird surveys, which were the dominant research activity (21 studies), have occurred relatively consistently since 1993. The majority of these surveys were conducted by the U.S. Fish and Wildlife Service (McKnight et al. 2008; Lance et al. 2001; Agler et al. 1998, 1997; Klosiewski and Laing 1994) and the Prince William Sound

Science Center (Bishop 2016, 2014; Bishop et al. 2015; Dawson et al. 2015; Bishop and Kuletz 2013, 2011), with additional surveys conducted by ABR, Inc. (Day 2006; Day et al. 1997, 1995) and researchers at Colorado State University (Wiens et al. 1996). These surveys documented all bird species encountered within a set strip-width from the survey vessel. Other projects focused on specific species, including marbled (*Brachyramphus marmoratus*) and Kittlitz's murrelets (*B. brevirostris*; Agler et al. 1998; Kendall and Agler 1998), harlequin duck (*Histrionicus histrionicus*; Rosenberg et al. 2005; Esler et al. 2000), Barrow's goldeneye (*Bucephala islandica*; Esler et al. 2000), and common murre (*Uria aalge*; Zuur et al. 2012; Piatt and Van Pelt 1997).

Levels of cytochrome P450 induction, which indicates oil exposure, were tested extensively in harlequin duck populations (Esler and Iverson 2010a, 2010b; Esler et al. 2010, 2002; Mulcahy and Esler 2010; Esler 2008; Trust et al. 2000; B. Ballachey, USGS, on-going project), and to a lesser degree, in Barrow's goldeneye populations (Esler et al. 2011; Trust et al. 2000).

Other research activities included tagging bald eagles (*Haliaeetus leucocephalus*), and harlequin ducks for survival analyses (Esler and Iverson 2010b; Esler et al. 2000; Bowman et al. 1995) and philopatry analysis (harlequin ducks only; Iverson and Esler 2006; Iverson et al. 2004), and satellite tagging of surf scoters (*Melanitta perspcillata*) and white-winged scoters (*M. fusca*; Rosenberg and Petrula 2001) and geolocator tagging of black-legged kittiwakes (*Rissa tridactyla*; McKnight et al. 2011) for movement analyses. Blood samples of harlequin ducks and Barrow's goldeneyes were surveyed for elements, antibodies, and hemoparasites (Heard et al. 2008), and also for genetic analyses (Lanctot et al. 1999). Foraging effort of marbled murrelets in Simpson Bay was observed (Morgan and Bishop 2011) and gulls were collected for diet analyses (Bishop et al. 1998). Finally, Paige and Wolfe (1997) and Fall and Zimpelman (2016) evaluated subsistence harvest of birds (including goldeneyes, mallards, mergansers, geese, and scoters) and bird eggs in communities surrounding Prince William Sound.

Mammals

Twenty-three studies documented presence and ecology of six marine mammal species in PWS: humpback whales (*Megaptera novaeangliae*), Dall's porpoise (*Phocoenoides dalli*), Steller sea lion (*Eumetopias jubatus*), harbor seal (*Phoca vitulina*), sea otter (*Enhydra lutris*), and river otter (*Lontra canadensis*).

There were seven studies documenting sea otter presence, distribution, survival, foraging ecology, and harvest during winter. From 1990-2006, the U.S. Fish and Wildlife Service conducts ship-based sea otter surveys every other year during March concurrent with their marine bird surveys (McKnight et al. 2008; Agler et al. 1997). From 1987-1990 and again from 1992-1994 survival of sea otter pups was estimated by monitoring pups associated with marked adults (Monnett and Rotterman 2000) and by marking and attaching radio-tags directly to sea otter pups (Ballachey et al. 2003). Bodkin et al. (2012) also radio-tagged sea otters, but attached archival time-depth recorders, as well, to evaluate sea otter foraging ecology. Reimer and Lipscomb (1998) noted an instance of cancer and viral infection a free-living sea otter. Finally, Fall and Zimpelman (2016) evaluated subsistence harvest of sea otters by residents of Chenega Bay and Cordova.

Harbor seals were documented in seven studies, four of which focused on diving behavior and movement ecology. Satellite-linked depth recorders were attached to adult and juvenile seals for analysis of diving behavior in PWS (Frost et al. 2001) and to evaluate regional differences in diving behavior of seals across the Gulf of Alaska (Hastings et al. 2004). Adults, juveniles, and pups were also fitted with satellite transmitters for a study of harbor seal movement in PWS (Lowry et al. 2006; Small 2005). Frid et al. (2007) conducted focal follows of seals to understand how individuals perceive the relative danger imposed by predators. Finally, Wolfe et al. (2009) and Fall and Zimpelman (2015) documented subsistence harvest of harbor seals by Alaska Natives.

Three studies focused on humpback whales. Research has included ship-based surveys and focal follows of individual whales to estimate predation rates by whales on Pacific herring (Rice et al. 2011; J. Straley, UAS-Sitka, on-going project). During focal follows, researchers also capture photographs of whale flukes, which are used to identify individual whales, and estimate adult survival rates (Mizroch et al. 2004).

Steller sea lions were the focus of five projects which were primarily centered on movement and foraging ecology. Pups and juvenile Steller sea lions were fitted with satellite tags and satellite-linked time at depth recorders to understand foraging decisions, movement patterns, and distribution (Frid et al. 2009, Raum-Suryan et al. 2004). Thomas and Thorne (2001) used infrared imaging to observe night-time predation of sea lions on Pacific herring. Thorne et al.

(2002) used a combination of aerial and hydroacoustic surveys to examine the interactions between sea lions, walleye pollock, and Pacific Herring. Finally, Wolfe et al. (2009) documented subsistence harvest of sea lions by Alaska Natives.

River otters were documented in three studies. From 1997-1998, Blundell et al. (2002) radio-tracked otters year-round from boats and fixed-wing aircrafts to examine social behaviors, such as cooperative foraging. We also found a paper synthesizing the results of research evaluating the impact of the Exxon Valdez oil spill on river otters (Bowyer et al. 2003). Finally, Fall and Zimpelman (2015) documented subsistence harvest of river otters in communities surrounding PWS.

There was one project documenting Dall's porpoise in PWS during winter months. This project involved ship-based surveys from 2007-2015 during November-January and March (J. Moran, NOAA, on-going project).

Discussion

As the search results demonstrate, PWS provides extensive protected habitat for wildlife during the winter months, which must be considered when planning management activities, such as response to natural or anthropogenic perturbations or damage assessments arising from perturbations. The bibliographic search returned studies including zooplankton, mollusks, echinoderms, crustaceans, fish, birds, and mammals (Table 2; Appendix 1, Appendix 2). We were unable to find any studies documenting sea cucumbers, sea urchins, jellyfish, octopus, and several marine mammal species in PWS during winter. The only documentation of squid presence was as bycatch during a walleye pollock trawl survey (Guttormsen and Jones 2010).

As a result of funding by the Exxon Valdez Oil Spill Trustee Council for long term monitoring, there is relatively consistent spatial and temporal coverage of zooplankton documentation since 2009 (Campbell 2013). There also has been extensive documentation of the marine birds occurring in PWS during winter months since the oil spill. From 1990-2006 surveys were conducted only during March. Since 2007 surveys have occurred during all winter months at least once, and spatial coverage in pelagic waters outside of bays and passages has expanded. Fish have been researched extensively in PWS, as well, particularly Pacific herring. Following the oil spill, the herring population in PWS crashed and has not yet recovered (Wiese 2015;

EVOS 2010). Due to the role of Pacific herring as a keystone species and its economic impact on commercial fisheries and coastal communities, the Exxon Valdez Oil Spill Trustee Council developed the Integrated Herring Restoration Program, aimed at determining the factors contributing to the herring population decline and identifying potential recovery actions. This program has since developed into the Herring Research and Monitoring Program which continues to evaluate causes of the population decline, and monitor recruitment, trend, and disease.

Fish populations are notoriously difficult to quantify over large spatial and temporal scales. However, considerable effort has been devoted to surveying herring and walleye pollock populations in PWS using acoustic, aerial, and trawl surveys. Documentation is much less complete for other fish species during winter, such as capelin, sharks, skates, salmon, flatfish, and other groundfish species such as sablefish and Pacific cod. However, ADFG provides annual finfish and groundfish management reports which documents catch numbers for each fishery (Wiese et al. 2015; Wessel et al. 2014).

We found 23 studies documenting the presence, distribution, relative abundance, foraging ecology, and movement ecology of six marine mammal species. However, work on Dall's porpoise was very limited (one study in progress, J. Moran, NOAA), and we could find no documentation of orca (*Orcinus orca*), harbor porpoise (*Phocoena phocoena*), or whale species other than humpback, although these species are known to occur in PWS throughout the year. For example, orca and harbor porpoise are seen during winter humpback whale (J. Moran, NOAA, pers. comm) and marine bird surveys (M. Bishop, PWSSC, pers. comm), but are not included in subsequent reports or publications.

Documentation was extremely limited for invertebrate species, particularly mollusks and echinoderms. Mollusk research primarily consisted of sampling for hydrocarbon concentrations, with most of the sampling occurring during March. Echinoderms were documented in a single study evaluating the biotic contents of ballast water (Ruiz et al. 2000). Therefore, we lack information regarding relative abundance, distribution, or species richness and how these metrics vary within or among years for each species group. Documentation of crustaceans in PWS during winter was limited, as well. Of the seven studies we found, five shrimp species and two crab species were noted. However, ADFG conducts an annual spot shrimp survey during the

month of October. Echinoderms, crabs, octopus, other shrimp species, and fish are routinely caught as by-catch and identified to the lowest taxonomic unit possible. We do not present the results of those surveys here, as October is outside the scope of this paper.

The species list included with the bibliography is by no means a comprehensive report of all species present in PWS during winter. Additional information regarding invertebrate and fish species that may be present in PWS during winter can be found in the following field guides: invertebrates and fish- Baldwin (2013), Byersdorfer and Watson (2010), Jorgensen (2009), Kramer et al. (2008), Stevenson et al. (2007), Gotshall (2005), Kramer and O'Connell (2003), O'Clair and O'Clair (1998), and Ricketts and Calvin (1939); and marine mammals- Wynne (2012).

It is probable that other research documenting the presence of winter species has been conducted in PWS. Studies may have been excluded because reports and publications were not available online or the scope of our search terms may have been too narrow. However, we tried to reduce the chances of missing available research by using multiple search platforms and databases, and by contacting researchers and agencies directly.

Acknowledgements

We are so grateful to the researchers and resource managers who took the time to respond to our inquiries: G. Blundell (University of Alaska-Fairbanks), J. Bodkin (USGS), M. Byerly (ADFG), R. Campbell (Prince William Sound Science Center (PWSSC)), J. Fall (ADFG), T. Farrugia (UAF), K. Goldman (ADFG), K. Gorman (PWSSC), K. Kloecker (USGS), S. Lewandoski (PWSSC), C. Matkin (North Gulf Oceanic Society), K. McLaughlin (McLaughlin Environmental Services), S. Moffitt (ADFG), J. Moran (NOAA), S. Pegau (PWSSC), M. Petrula (ADFG), J. Purcell (Western Washington University), P. Rand (PWSSC), M. Rehberg (ADFG), J. Straley (University of Alaska Southeast-Sitka), M. Wessel (ADFG), C. Westing (ADFG).

Literature Cited

Agler, B. A., S. J. Kendall, and D. B. Irons. 1998. Abundance and distribution of marbled and Kittlitz's murrelets in southcentral and southeast Alaska. The Condor 100: 254-265.

Agler, B. A., S. J. Kendall, P. E. Seiser, and D. B. Irons. 1997. Marine bird and sea otter abundance of Prince William Sound, Alaska: trends following the T/V Exxon Valdez oil spill, 1989-96. Exxon Valdez Oil Spill Restoration Project Final Report (Project 94159), U.S. Fish and Wildlife Service, Anchorage, AK.

Alaska Department of Fish and Game. 2008. Customary and traditional use worksheet, king crab and Tanner crab. Prince William Sound management area; and other background information. Alaska Department of Fish and Game. Special Publication No. BOF 2008-03, Anchorage, AK.

Alaska Oil Spill Commission. 1990. Spill: the wreck of the Exxon Valdez, Final Report. 210 pp.

Babcock, M. B. and J. W. Short. 1996. Prespill and postspill concentrations of hydrocarbons in sediments and mussels at intertidal sites within Prince William Sound and the Gulf of Alaska. Exxon Valdez Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Coastal Habitat Study Number 1B), National Oceanic and Atmospheric Administration, Juneau, AK.

Baldwin, A. 2013. Common seashore animals of southeastern Alaska. http://juneaunature.org/wp-content/uploads/2013/pdfs/baldwin2013.pdf

Ballachey, B. E., J. L. Bodkin, S. Howlin, A. M. Doroff, and A. H. Rebar. 2003. Correlates to survival of juvenile sea otters in Prince William Sound, Alaska 1992-1993. Canadian Journal of Zoology 81: 1494-1510.

Bechtol, W. R. 1999. Prince William Sound walleye pollock: current assessment and 2000 management recommendations. Alaska Department of Fish and Game, Regional Information Report No. 2A99-33, Anchorage, AK.

Bernard, D. R., K. R. Hepler, J. D. Jones, M. E. Whalen, and D. N. McBride. 1995. Some tests of the "Migration Hypothesis" for anadromous dolly varden (southern form). Transactions of the American Fisheries Society 124: 297-307.

Bishop, M.A. 2016. Long-term monitoring of seabird abundance and habitat associations during late fall and winter in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Annual Report (Project 15120114-C), Prince William Sound Science Center, Cordova, AK.

Bishop, M. A. 2015. Connectivity of Prince William Sound Pacific cod (Gadus macrocephalus) populations: Gulf of Alaska migrants or fjord residents? North Pacific Research Board Annual Research Program Semi-Annual Progress Report (Project 1306). Prince William Sound Science Center, Cordova, AK.

Bishop, M. A. 2015. Tracking seasonal movements of adult Pacific Herring in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Project 14120111-B), Prince William Sound Science Center, Cordova, AK.

Bishop, M. A., J. T. Watson, K. Kuletz, and T. Morgan. 2015. Pacific herring (Clupea pallasii) consumption by marine birds during winter in Prince William Sound, Alaska. Fisheries Oceanography 24: 1-13.

Bishop, M. A. 2014. Long-term monitoring of seabird abundance and habitat associations during late fall and winter in Prince William Sound. Pages 3:70-78 in T. Neher et al. Quantifying temporal and spatial variability across the northern Gulf of Alaska to understand mechanisms of change. Science Synthesis Report of the Gulf Watch Alaska Program for the Exxon Valdez Oil Spill Trustee Council.

Bishop, M. A. and K. J. Kuletz. 2013. Seasonal and interannual trends in seabird predation on juvenile herring. Exxon Valdez Oil Spill Restoration Project Final Report (Project 10100132-H), Prince William Sound Science Center, Cordova, AK.

Bishop, M. A. and S. P. Powers, 2013. Top-down regulation by predatory fish on juvenile herring in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Project 10100132-G). Prince William Sound Science Center, Cordova, AK.

Bishop, M. A. and K. J. Kuletz. 2011. Seabird predation on juvenile herring in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Project 09081), Prince William Sound Science Center, Cordova, Alaska.

Bishop, M. A., B. F. Reynolds, and S. P. Powers. 2010. An in situ, individual-based approach to quantify connectivity of marine fish: ontogenetic movements and residency of lingcod. Plos ONE 5: e14267. doi: 10.1371/journal.pone.0014267

Bishop, M. A., B. F. Reynolds, and S. P. Powers. 2009. Tracking movements of lingcod Ophiodon elongatus in Prince William Sound using acoustic tags and arrays: expanding PWSSC partnerships, infrastructure, and capacity. Final Report to the Oil Spill Recovery Institute, Prince William Sound Science Center, Cordova, AK.

Bishop, M. A., P. M. Meyers, and S. P. Green. 1998. Mechanism of impact and potential recovery of nearshore vertebrate predators: avian predation on blue mussels component. Appendix B in Exxon Valdez Oil Spill Restoration Project Annual Report (Restoration Project 97025). Pacific Northwest Research Station, Cordova, AK and Center for Streamside Studies, Seattle, WA.

Blundell, G. M., M. Ben-David, and R. T. Bowyer. 2002. Sociality in river otters: cooperative foraging or reproductive strategies? Behavioral Ecology 13: 134-141.

Bodkin, J. L., B. E. Ballachey, H. A. Coletti, G. G. Esslinger, K. A. Kloecker, S. D. Rice. J. A. Reed, and D. H. Monson. 2012. Long-term effects of the 'Exxon Valdez' oil spill: sea otter foraging in the intertidal as a pathway of exposure to lingering oil. Marine Ecology Progress Series 447: 273-287.

Bowman, T. D., P. F. Schempf, and J. A. Bernatowicz. 1995. Bald eagle survival and population dynamics in Alaska after the "Exxon Valdez" Oil Spill. The Journal of Wildlife Management 59: 317-324.

Bowman, T. D. P. F. Schempf, and J. A. Bernatowicz. 1993. Effects of the Exxon Valdez oil spill on bald eagles. Exxon Valdez Oil spill State/Federal Natural Resource Damage Assessment Study Final Report (Bird Study Number 4), U.S. Fish and Wildlife Service, Anchorage, AK.

Bowyer, R. T., G. M. Blundell, M. Ben-David, S. C. Jewett, T. A. Dean, and L. K. Duffy. 2003. Effects of the Exxon Valdez Oil Spill on river otters: injury and recovery of a sentinel species. Wildlife Monographs 143: 1-53.

Byersdorfer, S. C. and L. J. Watson. 2010. Field guide to common marine fishes and invertebrates of Alaska. Alaska Sea Grant College Program, University of Alaska Fairbanks, Fairbanks, AK.

Campbell, R. 2013. PWS herring survey: Plankton and oceanographic observations. Exxon Valdez Oil Spill Restoration Project Final Report (Project 10100132A), Prince William Sound Science Center, Cordova, AK.

Carlisle, A. B., C. R. Perle, K. J. Goldman, and B. A. Block. 2011. Seasonal changes in depth distribution of salmon sharks (Lamna ditropis) in Alaskan waters: implications for foraging ecology. Canadian Journal of Fisheries and Aquatic Sciences 68: 1905-1921.

Carls, M. G., L. Holland, E. Pihl, M. A. Zaleski, J. Moran, and S. D. Rice. 2016. Polynuclear aromatic hydrocarbons in Port Valdez shrimp and sediment. Archives of Environmental Contamination and Toxicology. Doi: 10.1007/s00244-016-0279-3.

Carls, M. G. G. D. Marty, and J. E. Hose. 2002. Synthesis of the toxicological impacts of the Exxon Valdez oil spill on Pacific herring (Clupea pallasii) in Prince William Sound, Alaska, U.S.A Canadian Journal of Fisheries and Aquatic Sciences 59: 153-172.

Cooney, R. T., J. R. Allen, M. A. Bishop, D. L. Eslinger, T. Kline, B. L. Norcross, et al. 2001. Ecosystem control of pink salmon (Oncorhynchus gorbuscha) and Pacific herring (Clupea pallasii) populations in Prince William Sound, Alaska. Fisheries Oceanography 10: 1-13.

Dawson, N. M., M. A. Bishop, K. J. Kuletz, and A. F. Zuur. 2015. Using ships of opportunity to assess winter habitat associations of seabirds in subarctic coastal Alaska. Northwest Science, 89: 111-128.

Day, R. H. 2006. Seabirds in the northern Gulf of Alaska and adjacent waters, October to May. Western Birds 37: 190-214.

Day, R. H., S. M. Murphy, J. A. Wiens, G. D. Hayward, E. J. Harner, and L. N. Smith. 1997. Effects of the Exxon Valdez oil spill on habitat use by birds in Prince William Sound, Alaska. Ecological Applications 7: 593-613.

Day, R. H., S. M. Murphy, J. A. Wiens, G. D. Hayward, E. J. Harner, and L. N. Smith. 1995. Use of oil-affected habitat by birds after the Exxon Valdez oil spill, in Exxon Valdez Oil Spill: Fate and Effects in Alaska Waters, ASTM STP 1219. Eds: P. G. Wells, J. N. Butler, and J. S. Hughes. American Society for Testing and Materials, Philadelphia, PA.

Eiler, J. and M. A. Bishop. 2016. Tagging response and postspawning movements of Pacific herring, a small pelagic forage fish sensitive to handling. Transactions of American Fisheries Society 145: 427-439.

Esler, D., B. E. Ballachey, K. A. Trust, S. A. Iverson, J. A. Reed, A. K. Miles, J. D. Henderson, B. R. Woodin, J. J. Stegeman, M. McAdie, D. M. Mulcahy, and B. W. Wilson. 2011. Cytochrome P4501A biomarker indication of the timeline of chronic exposure of Barrow's goldeneyes to residual Exxon Valdez oil. Marine Pollution Bulletin 62: 609-614.

Esler, D. and S. A. Iverson. 2010a. Evaluating harlequin duck population recovery: CYP1A monitoring and a demographic population model. Exxon Valdez Oil Spill Restoration Project Final Report (Project 070816), Centre for Wildlife Ecology, Simon Fraser University, Delta, BC.

Esler, D., K. A. Trust, B. E. Ballachey, S. A. Iverson, T. L. Lewis, D. J. Rizzolo, D. M. Mulcahy, A. K. Miles, B. R. Woodin, J. J. Stegeman, J. D. Henderson, and B. W. Wilson. 2010. Cytochrome P4501A biomarker indication of oil exposure in harlequin ducks up to 20 years after the Exxon Valdez oil spill. Environmental Toxicology and Chemistry 29: 1138-1145.

Esler, D., and S. A. Iverson. 2010b. Female harlequin duck winter survival 11 to 14 years after the Exxon Valdez oil spill. Journal of Wildlife Management 74: 471-478Esler, D., T. D. Bowman, T. A. Dean, C. E. O'Clair, S. C. Jewett, and L. L. McDonald. 2000. Correlates of harlequin duck densities during winter in Prince William Sound, Alaska. The Condor 102: 920-926.

Esler, D. 2008. Quantifying temporal variation in harlequin duck cytochrome P4501A Induction. Exxon Valdez Oil Spill Restoration Project Final Report (Project 050777), Simon Fraser University, Delta, BC.

Esler, D., T. D. Bowman, K. A. Trust, B. E. Ballachey, T. A. Dean, S. C. Jewett, and C. E. O'Clair. 2002. Harlequin duck population recovery following the Exxon Valdez oil spill: progress, process and constraints. Marine Ecology Progress Series 241: 271-286.

Esler, D., T. D. Bowman, C. E. O'Clair, T. A. Dean, and L. L. McDonald. 2000. Densities of Barrow's goldeneyes during winter in Prince William Sound, Alaska in relation to habitat, food, and history of oil contamination. Waterbirds 23: 423-429.

Esler, D., J. A. Schmutz, R. L. Jarvis, and D. M. Mulcahy. 2000. Winter survival of adult female harlequin ducks in relation to history of contamination by the "Exxon Valdez" oil spill. The Journal of Wildlife Management 64: 839-847.

Exxon Valdez Oil Spill Trustee Council. 2010. Exxon Valdez oil spill restoration plan: update of injured resources and services. Exxon Valdez Oil Spill Trustee Council, Anchorage, AK.

Fall, J. A. and G. Zimpelman, editors. 2016. Update on the status of subsistence uses in Exxon Valdez oil spill area communities, 2014. Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 412, Anchorage, AK.

Foy, R. J. and B. L. Norcross. 2001. Temperature effects on zooplankton assemblages and juvenile herring feeding in Prince William Sound, Alaska. Herring: Expectations for a new millennium, Alaska Sea Grant College Program, AK-SG-01-04.

Foy, R. J. and A. J. Paul. 1999. Winter feeding and changes in somatic energy content of age-0 Pacific Herring in Prince William Sound, AK. Transactions of the American Fisheries Society 128: 1193-1200.

Foy, R. J. and B. L. Norcross. 1999. Spatial and temporal variability in the diet of juvenile Pacific herring (Clupea pallasii) in Prince William Sound, Alaska. Canadian Journal of Zoology 77: 697-706.

Frid, A., J. Burns, G. G. Baker, and R. E. Thorne. 2009. Predicting synergistic effects of resources and predators on foraging decisions by juvenile Steller sea lions. Oecologia 158: 775-786.

Frid, A., L. M. Dill, R. E. Thorne, and G. M. Blundell. 2007. Inferring prey perception of relative danger in large-scale marine systems. Evolutionary Ecology Research 9: 635-649.

Frost, K. J., M. A. Simpkins, and L. F. Lowry. 2001. Diving behavior of subadult and adult harbor seals in Prince William Sound, Alaska. Marine Mammal Science 17: 813-834.

Garrott, R. A., L. L. Eberhardt, and D. M. Burn. 1993. Mortality of sea otters in Prince William Sound following the Exxon Valdez oil spill. Marine Mammal Science 9: 343-359.

Gotshall, D. 2005. Guide to marine invertebrates: Alaska to Baja California, 2nd edition. Sea Challengers.

Guttormsen, M.A. and D. Jones. 2010. Results of the acoustic-trawl surveys of walleye pollock (Theragra chalcogramma) in the Gulf of Alaska, February-March 2010 (DY2010-01 and DY2010-02). AFSC Processed Rep. 2010-05, 85 p. Alaska Fish. Sci. Center, NOAA, Natl. Mar. Fish. Serv., Seattle, WA.

Hastings, K. K., K. J. Frost, M. A. Simpkins, G. W. Pendleton, U. G. Swain, and R. J. Small. 2004. Regional differences in diving behavior of harbor seals in the Gulf of Alaska. Canadian Journal of Zoology 82: 1755-1773.

Heard, D. J., D. M. Mulcahy, S. A. Iverson, D. J. Rizzolo, E. C. Greiner, J. Hall, H. Ip, and D. Esler. 2008. A blood survey of elements, viral antibodies, and hemoparasites in wintering harlequin ducks (Histrionicus histrionicus) and Barrow's goldeneyes (Bucephala islandica). Journal of Wildlife Diseases 44: 486-493.

Hershberger, P. K., D. Elliot, E. Emmenegger, J. Hansen, G. Kurath, J. Winton, R. Kocan, and S. LaPatra. 2011. Prince William Sound herring disease program, Exxon Valdez Oils Spill Restoration Project Final Report (Project 070819), USGS, Nordland, WA.

Hochhalter, S. J., B. J. Blain, and B. J. Failor. 2011. Recreational fisheries in Prince William Sound Management Area, 2008-2010. Alaska Department of Fish and Game, Fishery Management Report No. 11-54, Anchorage, AK.

Hulbert, L. B., M. F. Sigler, and C. R. Lunsford. 2006. Depth and movement behaviour of the Pacific sleeper shark in the north-east Pacific Ocean. Journal of Fish Biology 69: 406-425.

Hulbert, L. B. and S. D. Rice. 2002. Salmon shark, Lamna ditropis, movements, diet, and abundance in the eastern north Pacific Ocean and Prince William Sound, Alaska. NOAA Fisheries, Auke Bay Laboratory.

Iverson, S. A. and D. Esler. 2006. Site fidelity and the demographic implication of winter movements by a migratory bird, the harlequin duck Histrionicus histrionicus. Journal of Avian Biology 37: 219-228.

Iverson, S. A., D. Esler, and D. J. Rizzolo. 2004. Winter philopatry of harlequin ducks in Prince William Sound, Alaska. The Condor 106: 711-715.

Jorgensen, E. M. 2009. Field guide to squids and octopods of the eastern north Pacific and Bering Sea. Alaska Sea Grant College Program, Fairbanks, AK.

Kendall, S. J. and B. A. Agler. 1998. Distribution and abundance of Kittlitz's murrelets in southcentral and southeastern Alaska. Colonial Waterbirds 21: 53-60.

Kinnetic Laboratories Incorporated. 2003. Prince William Sound RCAC Long-term environmental monitoring program, 2000-2002 LTEMP Monitoring Report. PWS Regional Citizens' Advisory Council Monitoring Report, Kinnetic Laboratories Incorporated, Anchorage, AK.

Kinnetic Laboratories Incorporated. 2000. Prince William Sound RCAC Long-term environmental monitoring program, 1999-2000 LTEMP Monitoring Report. PWS Regional Citizens' Advisory Council Monitoring Report (Contract No. 608.00.1), Kinnetic Laboratories Incorporated, Anchorage, AK.

Kinnetic Laboratories Incorporated. 1999. Prince William Sound RCAC Long-term environmental monitoring program, 1998-1999 LTEMP Monitoring Report. PWS Regional Citizens' Advisory Council Monitoring Report (Contract No. 608.99.1), Kinnetic Laboratories Incorporated, Anchorage, AK.

Kinnetic Laboratories Incorporated. 1998. Prince William Sound RCAC Long-term environmental monitoring program, 1997-1998 LTEMP Monitoring Report. PWS Regional Citizens' Advisory Council Monitoring Report (Contract No. 608.98.1), Kinnetic Laboratories Incorporated, Anchorage, AK.

Kirsch, J. and G. L. Thomas. 1998. Acoustic biomass estimate of adult herring in Prince William Sound, Alaska, in spring 1998. Final Report to Alaska Department of Fish & Game. Prince William Sound Science Center, Cordova, AK.

Kirsch, J. and G. L. Thomas. 1998. Acoustic biomass estimate of adult walleye pollock in Prince William Sound, Alaska, in Winter 1998. Final Report to the Alaska Department of Fish and Game, Prince William Sound Science Center, Cordova, AK.

Kirsch, J. 1997. Acoustic biomass estimate of adult walleye pollock in Prince William Sound, Alaska, in Winter 1997. Final Report to the Alaska Department of Fish and Game, Prince William Sound Science Center, Cordova, AK.

Kirsch, J. and G. L. Thomas. 1997. Acoustic biomass estimate of adult herring in Prince William Sound, Alaska, in spring 1997. Final Report to Alaska Department of Fish & Game. Prince William Sound Science Center, Cordova, AK.

Kline, T.C. Jr. and R. W. Campbell. 2010. Prince William Sound herring forage contingency. Exxon Valdez Oil Spill Restoration Project Final Report (Project 070811), Prince William Sound Science Center, Cordova, AK.

Klosiewski, S.P. and K. K. Laing. 1994. Marine bird populations of Prince William Sound, Alaska, before and after the Exxon Valdez oil spill. NRDA Bird Study Number 2. Unpubl. Rep., U.S. Fish and Wildlife Service, Anchorage, AK.

Kramer, D. E., W. H. Barss, B. C. Paust, and B. E. Bracken. 2008. Guide to northeast Pacific flatfishes: families Bothidae, Cynoglossidae, and Pleuronectidae, second edition. Alaska Sea Grant College Program, Fairbanks, AK.

Kramer, D. E. and V. O'Connell. 2003. Guide to northeast Pacific rockfishes: genera Sebastes and Sebastolobus, fourth edition. Alaska Sea Grant College Program, Fairbanks, AK.

Lance, B. K., D. B. Irons, S. J. Kendall, and L. L. McDonald. 2001. An evaluation of marine bird population trends following the Exxon Valdez Oil Spill, Prince William Sound, Alaska. Marine Pollution Bulletin 42: 298-309.

Lanctot, R., B. Goatcher, K. Scribner, S. Talbot, B. Pierson, D. Esler, and D. Zwiefelhofer. 1999. Harlequin duck recovery from the Exxon Valdez oil spill: a population genetics perspective. The Auk 116: 781-791.

Laughlin, T. R. (ed). 1994. Marine mammals and the "Exxon Valdez". Academic Press, San Diego, CA.

Lewandoski, S. and M. A. Bishop. In review. Distribution of juvenile Pacific herring in relation to environmental and geospatial factors in Prince William Sound, Alaska.

Lowry, L. F., K. J. Frost, J. M. Ver Hoef, and R. A. DeLong. 2006. Movements of satellite-tagged subadult and adult harbor seals in Prince William Sound, Alaska. Marine Mammal Science 17: 835-861.

Marty, G. D., T. J. Quinn II, S. A. Miller, T. R. Meyers, and S. D. Moffitt. 2004. Effect of Disease on Recovery of Pacific Herring in Prince William Sound, Alaska. Exxon Valdez Oil Spill Restoration Project Final Report (Project 030462), University of California, Davis, CA.

McKnight, A., D. B. Irons, K. M. Sullivan, and R. M. Suryan. 2011. Winter dispersal and activity patterns of post-breeding black-legged kittiwakes Rissa tridactyla from Prince William Sound, Alaska. Marine Ecology Progress Series 442: 241-253.

McKnight, A., K. M. Sullivan, D. B. Irons, S. W. Stephensen, and S. Howlin. 2008. Prince William Sound marine bird surveys, synthesis, and restoration. Exxon Valdez Oil Spill Restoration Project Final Report (Project 080751), U.S. Fish and Wildlife Service, Anchorage, AK.

Mizroch, S. A., L. M. Herman, J. M. Straley, D. A. Glockner-Ferrari, C. Jurasz, J. Darling, S. Cerchio, C. M. Gabriele, D. R. Salden, and O. von Ziegesar. 2004. Estimating the adult survival rate of central north Pacific humpback whales (Megaptera novaeangliae). Journal of Mammology 85: 963-972.

Monnett, C. and L. Mignon Rotterman. 2000. Survival rates of sea otter pups in Alaska and California. Marine Mammal Science 16: 794-810.

Morgan, T. C. and M. A. Bishop. 2011. Body condition of marbled murrelets: consequences for overwinter survival during a period of collapsed herring stocks. North Pacific Research Board Project Final Report 819, Prince William Sound Science Center, Cordova, AK.

Mulcahy, D. M. and D. Esler. 2010. Survival of captive and free-ranging harlequin ducks (Histrionicus histrionicus) following surgical liver biopsy. Journal of Wildlife Diseases 46: 1325-1329.

NOAA Alaska Fisheries Science Center. 1991. Echointegrator/Midwater trawl survey of spawning pollock in the Gulf of Alaska. NOAA Ship Miller Freeman Cruise Results (Cruise No. 90-01).

O'Claire, R. M. and C. E. O'Claire. 1998. Southeast Alaska's rocky shores. Plant Press, Auke Bay, AK.

Otis, E. O., R. Heintz, and J. Maselko. 2010. Investigation of Pacific Herring (Clupea pallasii) stock structure in Alaska using otolith microchemistry and heart tissue fatty acid composition. Exxon Valdez Oil Spill Restoration Project Final Report (Project 070769), Alaska Department of Fish and Game, Homer, AK.

Otis, E. O. and R. Heintz. 2003. Evaluation of two methods to discriminate Pacific herring (Clupea pallasii) stocks along the northern Gulf of Alaska. Exxon Valdez Oil Spill Restoration Project Final Report (Project 02538), Alaska Department of Fish and Game, Homer, AK.

Paige, A. and R. Wolfe. 1997. The subsistence harvest of migratory birds in Alaska-compendium and 1995 update. Alaska Department of Fish and Game, Technical Paper No. 228. Juneau, AK.

Paul, A. J., J. M. Paul, and R. L. Smith. 1998. Seasonal changes in whole-body energy content and estimated consumption rates of age 0 walleye pollock from Prince William Sound, Alaska. Estuarine, Coastal, and Shelf Science 47: 251-259.

Payne, J. R., W. B. Driskell, J. W. Short, and M. L. Larsen. 2010. Long term environmental monitoring program, 2006-2008 LTEMP Monitoring Report. PWS Regional Citizens' Advisory Council Monitoring Report (Contract No. 951.07.01, 951.08.01), J.R. Payne Environmental Consultants, Inc., Encinitas, CA.

Payne, J. R., W. B. Driskell, J. W. Short, and M. L. Larsen. 2008. Long term environmental monitoring program, 2005-2006 LTEMP Monitoring Report. PWS Regional Citizens' Advisory Council Monitoring Report (Contract No. 951.06.1), J.R. Payne Environmental Consultants, Inc., Encinitas, CA.

Payne, J. R., W. B. Driskell, J. W. Short, and M. L. Larsen. 2006. Long term environmental monitoring program, 2004-2005 LTEMP Monitoring Report. PWS Regional Citizens' Advisory Council Monitoring Report (Contract No. 951.05.1), J.R. Payne Environmental Consultants, Inc., Encinitas, CA.

Payne, J. R., W. B. Driskell, and J. W. Short. 2005. Long term environmental monitoring program, 2003-2004 LTEMP Monitoring report. PWS Regional Citizens' Advisory Council Monitoring Report (Contract No. 951.04.1), J.R. Payne Environmental Consultants, Inc., Encinitas, CA.

Payne, J. R., W. B. Driskell, and J. W. Short. 2003. PWSRCAC-EVOS Long-term environmental monitoring program: 2002-2003 LTEMP monitoring report. Exxon Valdez Oil Spill Gulf Ecosystem Monitoring and Research Project Final Report (Project 030623), Prince William Sound Regional Citizens' Advisory Council, Anchorage, AK.

Payne, J. R., W. B. Driskell, and D. C. Lees. 1998. Long term environmental monitoring program data analysis of hydrocarbons in intertidal mussels and marine sediments, 1993-1996. PWS Regional Citizens' Advisory Council Final Report (Contract No. 611.98.1), J.R. Payne Environmental Consultants, Inc., Encinitas, CA.

Piatt, J. F. and T. I . Van Pelt. 1997. Mass-mortality of guillemots (Uria aalge) in the Gulf of Alaska in 1993. Marine Pollution Bulletin 34: 656-662.

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. The Auk 107: 387-397.

Raum-Suryan, K. L., M. J. Rehberg, G. W. Pendleton, K. W. Pitcher, and T. S. Gelatt. 2004. Development of dispersal, movement patterns, and haul-out use by pup and juvenile Steller sea lions (Eumetopias jubatus) in Alaska. Marine Mammal Science 20: 823-850Rice, S. D., J. R. Moran, J. M. Straley, K. M. Boswell, and R. A. Heintz. 2011. Significance of whale predation on natural mortality rate of Pacific herring in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 100804). National Marine Fisheries Service, Juneau, AK.

Reimer, D. C. and T. P. Lipscomb. 1998. Malignant seminoma with metastasis and herpesvirus infection in a free-living sea otter (Enhydra lutris). Journal of Zoo and Wildlife Medicine 29: 35-39.

Rice, S. D., J. R. Moran, J. M. Straley, K. M. Boswell, and R. A. Heintz. 2011. Significance of whale predation on natural mortality rate of Pacific herring in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Restoration Project 100804). National Marine Fisheries Service, Juneau, AK.

Ricketts, E. F. and J. Calvin. 1939. Between Pacific tides. Stanford University Press, Redwood City, CA.

Rosenberg, D. H., M. J. Petrula, D. D. Hill, and A. M. Christ. 2005. Harlequin duck population dynamics: measuring recovery from the Exxon Valdez oil spill. Exxon Valdez Oil spill Restoration Project Final Report (Project 040407), Alaska Department of Fish and Game, Anchorage, AK.

Rosenberg, D. H. and M. P. Petrula. 2001. Scoter life history and ecology: Linking satellite technology with traditional knowledge. Exxon Valdez Oil Spill Restoration Project Final Report (Project 99273). Alaska Department of Fish and Game, Anchorage, AK.

Rumble, J., M. Wessel, E. Russ, K. J. Goldman, R. L. Gustafson, and C. Russ. Cook Inlet and Prince William Sound area management report for Tanner and king crab fisheries through 2013. 2014. Alaska Department of Fish and Game, Fishery Management Report No. 14-08, Anchorage, AK.

Ruiz, G., A. H. Hines, G. Smith, and M. A. Frey. 2000. Chpt. 3: Biological characteristics of ballast water, from Biological invasions of cold-water coastal ecosystems: Ballast-mediated introductions in Port Valdez/ Prince William Sound, Alaska. PWS Regional Citizens' Advisory Council Final Report, Smithsonian Environmental Research Center, Edgewater, MD.

Salazar, M. H., J. W. Short, S. M. Salazar, and J. R. Payne. 2002. 2001 Port Valdez Monitoring, PWS Regional Citizens' Advisory Council Final Report (633.01.1), Applied Biomonitoring, Kirkland, WA.

Sewall, F. F., R. A. Heintz, and J. J. Vollenweider. 2013. Prince William Sound herring survey: value of growth and energy storage as predictors of winter performance in young-of-the-year herring from Prince William Sound. Exxon Valdez Oil Spill Trustee Council Final Report (Project 10100132-D), National Marine Fisheries Service, Juneau, AK.

Small, R. J., L. F. Lowry, J. M. Ver Hoef, K. J. Frost, R. A. DeLong, and M. J. Rehberg. 2005. Differential movements by harbor seal pups in contrasting Alaska environments. Marine Mammal Science 21: 671-694.

Stevenson, D. E., J. W. Orr, G. R. Hoff, and J. D. McEachran. 2007. Field guide to sharks, skates, and ratfish of Alaska. Alaska Sea Grant College Program, Fairbanks, AK.

Stokesbury, K. D. E., J. Kirsch, E. D. Brown, G. L. Thomas, and B. L. Norcross. 2000. Spatial distributions of Pacific herring, Clupea pallasii, and walleye pollock, Theragra chalcogramma, in Prince William Sound, Alaska. Fisheries Bulletin 98: 400-409.

Sturdevant, M. V., A. L. J. Brase, and L. B. Hulbert. 2001. Feeding habits, prey fields, and potential competition of young-of-the-year walleye pollock (Theragra chalcogramma) and Pacific herring (Clupea pallasii) in Prince William Sound, Alaska, 1994-1995. Fisheries Bulletin 99:482-501.

Thomas, G. L. and R. E. Thorne. 2003. Acoustical-optical assessment of Pacific herring and their predator assemblage in Prince William Sound, Alaska. Aquatic Living Resources 16: 247-253.

Thomas, G. L. and R. E. Thorne. 2001. Abundance and distribution of walleye pollock in Prince William Sound, Alaska. Electronic Proceedings of ACOUSTGEAR 200. International Symposium on Advanced Techniques of Sampling Gear and Acoustical Surveys for Estimation of Fish Abundance and Behavior, Hakodate, Japan.

Thomas, G. L. and R. E. Thorne. 2001. Night-time predation by Steller sea lions. Nature 411: 1013.

Thomas, G. L. and T. B. Stables. 1995. Winter 1995 estimate of the prespawning biomass of walleye pollock in Prince William Sound, Alaska. Final Report to the Alaska Department of Fish and Game, Prince William Sound Science Center, Cordova, AK.

Thomas, G. L., J. Kirsch, and J. Wilcock. 1995. Pacific herring biomass in the Knowles Head and Green Island areas of Prince William Sound, Alaska, in the fall of 1994. Regional Information Report No. 2A95-43, Alaska Department of Fish and Game, Anchorage, AK.

Thorne, R. E. 2010. Trends in adult and juvenile herring distribution and abundance in Prince William Sound. Exxon Valdez Oil Spill Restoration Project Final Report (Project 070830), Prince William Sound Science Center, Cordova, AK.

Thorne, R. E. and G. L. Thomas. 2008. Herring and the "Exxon Valdez" oil spill: an investigation into historical data conflicts. ICES Journal of Marine Science 65:44-50.

Thorne, R. E., G. L. Thomas, and J. J. Goering. 2002. Interactions among Steller sea lions, pollock, and herring and an examination of variability associated with acoustic surveys of pollock. Final Report to the Pollock Conservation Cooperative, Prince William Sound Science Center, Cordova, AK.

Thorne, R. E. and G. L. Thomas. 2000. Assessment of adult walleye pollock abundance in Prince William Sound, Alaska, Winter 2000. Final Report to the Oil Spill Recovery Institute (Contract 00-10-03), Prince William Sound Science Center, Cordova, AK.

Trowbridge, C. 1992. Injury to Prince William Sound spot shrimp. Exxon Valdez Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Subtidal Study Number 5). Alaska Department of Fish and Game, Anchorage, AK.

Trust, K. A., D. Esler, B. R. Woodin, and J. J. Stegeman. 2000. Cytochrome P450 1A induction in sea ducks inhabiting nearshore areas of Prince William Sound, Alaska. Marine Pollution Bulletin 40: 397-402.

Wessel, M., J. Rumble, K. J. Goldman, E. Russ, M. Byerly, and C. Russ. 2014. Prince William Sound Registration Area E Groundfish Fisheries Management Report, 2009-2013. Fishery Management Report No. 14-42, Alaska Department of Fish and Game, Divisions of Sport Fish and Commercial Fisheries, Anchorage, AK.

Wessel, M., C. E. Trowbridge, and C. Russ. 2012. Prince William Sound area management report for Dungeness crab, shrimp, and miscellaneous shellfish fisheries 2011. Alaska Department of Fish and Game, Fishery Management Report No. 12-05, Anchorage, AK.

Wiens, J. A., T. O. Crist, R. H. Day, S. M. Murphy, and G. D. Hayward. 1996. Effects of the Exxon Valdez oil spill on marine bird communities in Prince William Sound, Alaska. Ecological Applications 6: 828-841.

Wiese, A., T. Sheridan, J. Botz, S. Moffitt, and R. Brenner. 2015. 2014 Prince William Sound area finfish management report. Alaska Department of Fish and Game, Fishery Management Report No 15-34. Anchorage, AK.

Wildes, S. L., J. J. Vollenweider, H. T. Nguyen, and J. R. Guyon. 2011. Genetic variation between outer-coastal and fjord populations of Pacific herring (Clupea pallasii) in the eastern Gulf of Alaska. Fishery Bulletin 109: 382-393.

Willette, T. M., G. S. Carpenter, K. Hyer, and J. A. Wilcock. 1999. Herring natal habitats. Exxon Valdez Oil Spill Restoration Project Final Report (Project 97166), Alaska Department of Fish and Game, Cordova, Alaska.

Wolfe, R. J., J. A. Fall, and M. Riedel. 2009. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2008. Alaska Native Harbor Seal Commission and Alaska Department of Fish and Game Division of Subsistence, Technical Paper No. 347. Anchorage, AK.

Wynne, K. 2012. Guide to marine mammals of Alaska, fourth edition. Alaska Sea Grant College Program, Fairbanks, AK.

Zuur, A. F., N. Dawson, M. A. Bishop, K. Kuletz, A. A. Saveliev, and E. N. Ieno. 2012. Two-stage GAMM applied on zero inflated Common Murre density data. Pages 149-188 in A. F. Zuur, A. A. Saveliev, E. N. Ieno (eds). Zero Inflated and Generalized Linear Mixed Models with R. Highland Statistics Ltd., Newburgh, United Kingdom.

Table 1: The data categories and definitions for the bibliography of winter species in Prince William Sound, Alaska.

Data Category	Definition
ID	Identification number of each unique citation*
Last Name	Surname of lead author
First Name	Forename of lead author
Agency/Institution	Agency/company affiliation of lead author
Other Collaborators	Fore/surnames of co-author(s)
Taxon	Taxonomic grouping of study specie(s)
Scientific Names	Binomial name of study specie(s)
Common Names	Common name of study specie(s)
Years	Year(s) in which research occurred
Winter Months	Winter month(s) (November-March) in which research occurred
Project Months	All months in which research occurred in Prince William Sound
Location	Prince William Sound (PWS), unless more specific project locations given
Status	Complete or Ongoing
Final Product Type	Final Report NA: Ongoing project Publication: peer-reviewed scientific publication Report
Final Product Citation	Citation for the final product. If final product not available, lists project name.
Notes	Brief note summarizing project

*Note: There are repeated identification numbers for studies with more than one entry.

Table 2: Search results of the number of studies that have occurred in Prince William Sound, Alaska during winter for each taxonomic group/species since 1989. Only focal study species are listed below. See Appendix 2 for list of species observed as bycatch and for list of avian species observed during marine bird surveys.

Taxonomic Grouping	Species Common Name(s)	Number of Studies
Zooplankton	NA	5
Mollusks	Blue Mussels	14
Echinoderms	NA	1
Crustaceans	Spot Shrimp, Coonstripe Shrimp, Pink Shrimp, Sidestriped Shrimp, Pacific Glass Shrimp	5
	Tanner Crab, King Crab	2
Fish	Pacific Herring	35
	Walleye Pollock	15
	Lingcod	5
	Pacific cod	3
	Salmon Shark	2
	Pacific Sleeper Shark	2
	Pacific Halibut, Chinook Salmon, Rockfish	2
	Other (Big and Longnose Skates, Dolly Varden, Spiny Dogfish, Pink Salmon, Yellowfin Sole, Sablefish)	1 each
Birds	Harlequin Ducks	15
	Marine Birds**	14
	Barrow's Goldeneye	4
	Marbled Murrelet	2
	Kittlitz's Murrelet	2
	Common Murre	2
	Other (Black-legged Kittiwake, Scoters, Bald Eagles, Glaucous-winged Gulls, Mallard, Canada Geese, Cackling Geese, Snow Geese, Mergansers)	1 each
Mammals	Sea Otters	7
	Harbor Seals	7
	Steller Sea Lions	5
	Humpback Whales	3
	River Otters	3
	Dall's Porpoise	1

**See Appendix 2 for list of bird species observed during marine bird surveys.

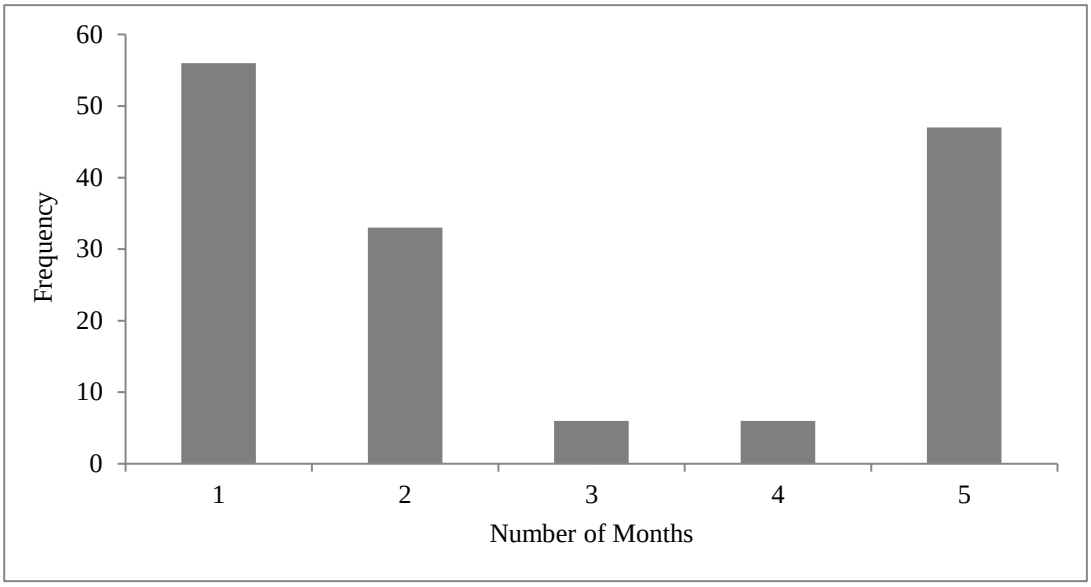

Figure 1. Duration of research activities by month. Most studies occurred either within a single winter month or throughout the entire winter period.

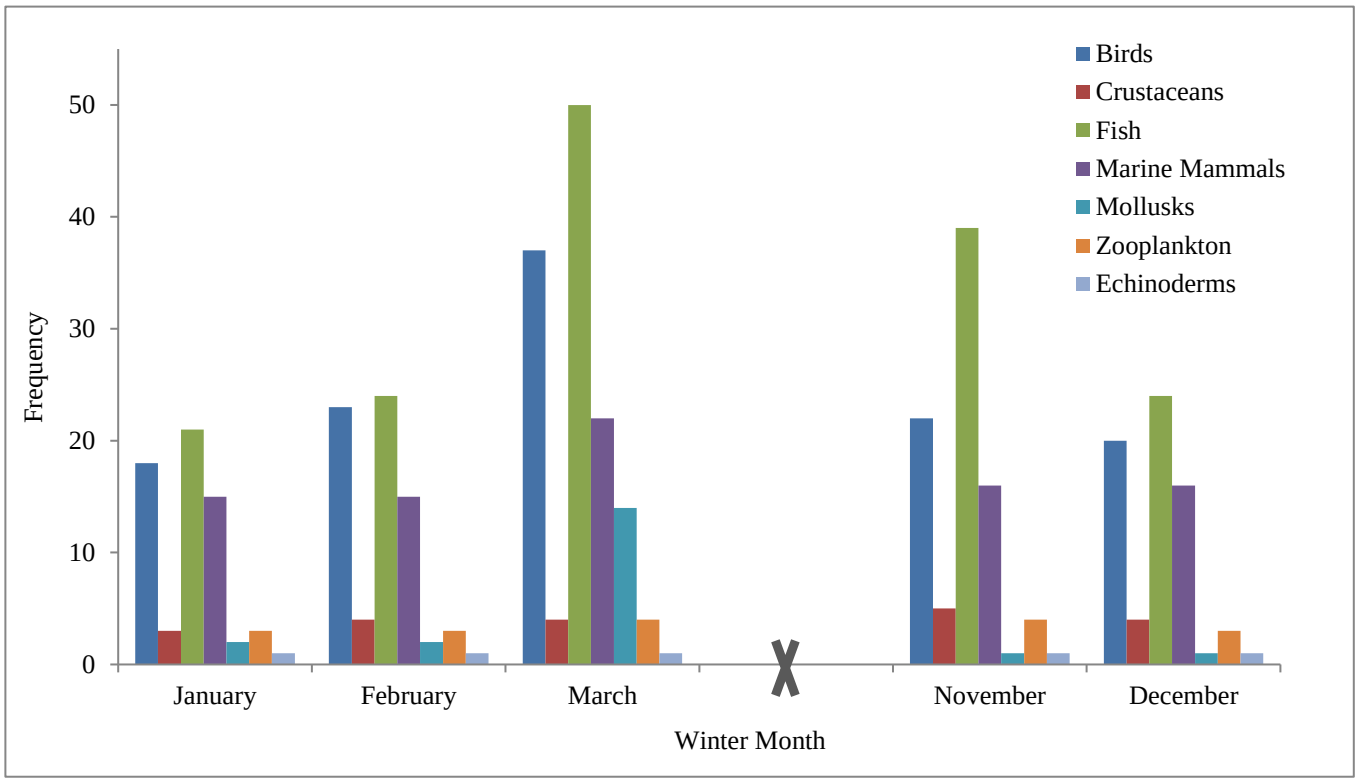

Figure 2. Months in which species groups were studied. March was the month in which the highest number of research activities occurred for all taxa except for crustaceans.