2022-2023

DELTA SOUND CONNECTIONS

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PRINCE WILLIAM SOUND SCIENCE CENTER

NATURAL HISTORY AND SCIENCE NEWS FROM PRINCE WILLIAM SOUND AND THE COPPER RIVER BIOREGION

THE FUTURE IS WATER

Photo credit: Ted Barmore.

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THE FUTURE IS WATER

Imagine a river of cold, mineral-rich water, slowly moving through ocean basins. Once this cold water sinks and begins to flow like a river within the ocean, it takes over one thousand years before it rises up towards the surface again, bringing with it ancient, dissolved gases and nutrients that act like fertilizers, stoking productivity as it upwells.

This is the global ocean conveyor belt, and it makes an appearance in the North Pacific Ocean and the northern Gulf of Alaska. Not far away in the upper Copper River watershed, glaciers made of so much frozen water inch their way through rocky canyons, grinding the substrate beneath them into fine dust.

This dust becomes the glacial flour that colors the water it suffuses and gets picked up in windstorms and deposited into the ocean.

This dust is rich in iron and it, too, acts like a fertilizer, supporting a bloom of plankton, plankton that becomes food for things higher up the food web...things we humans like to catch and eat.

Nearby in Prince William Sound, one of the fastest receding tidewater glaciers on earth retreats so far back into a valley that what used to be one face of the glacier has cleaved into two: a fork in the road in this changing landscape, revealing new habitat in its wake; habitat that may soon be colonized by salmon.

KATRINA HOFFMAN
President & CEO
Prince William Sound Science Center

What the future holds will be directly affected by water in all its forms: ice; rain; the sea. The presence, absence, form, and quality of water in our ecosystems directly affects the things we care about, not the least of which is the seafood that drives our region's core industry.

The future is water, and it will change us as we cause changes to it. Join us in imagining the kind of future you want for the water-dependent resources you care about and commit to taking one action today to help make that future a reality.

BIRD AND WILDLIFE CHECKLIST

RECOMMENDED BIRD/MAMMAL GUIDE: *Sibley's Field Guide to Birds of Western North America* by David Allen Sibley and the *Guide to Marine Mammals of Alaska* by Kate Wynne.
List compiled by the Prince William Sound chapter of the Audubon Society.
U = UNCOMMON • **S** = SEASONAL

LOONS AND GREBES
- ❑ Common Loon
- ❑ Red-throated Loon
- ❑ Pacific loon (s)
- ❑ Yellow-billed Loon (s,u)
- ❑ Horned Grebe
- ❑ Red-necked Grebe

SHEARWATERS AND PETRELS
- ❑ Fork-tailed Storm-Petrel
- ❑ Sooty Shearwater (u)

CORMORANTS
- ❑ Pelagic Cormorant
- ❑ Double-crested Cormorant

HERONS
- ❑ Great Blue Heron

WATERFOWL
- ❑ Surf Scoter
- ❑ White-winged Scoter
- ❑ Long-tailed Duck
- ❑ Barrow's Goldeneye
- ❑ Common Goldeneye
- ❑ Bufflehead
- ❑ Harlequin Duck
- ❑ Mallard
- ❑ Dusky Canada Goose
- ❑ Common Merganser
- ❑ Red-breasted Merganser

SHOREBIRDS
- ❑ Black Oystercatcher
- ❑ Semipalmated Plover
- ❑ Least Sandpiper
- ❑ Yellowlegs (Lesser and Greater)
- ❑ Red-necked Phalarope (s)
- ❑ Surfbird (s)
- ❑ Black Turnstone (s)
- ❑ Dunlin (s)
- ❑ Western Sandpiper (s)

GULLS/TERNS
- ❑ Glaucous-winged Gull
- ❑ Herring Gull
- ❑ Mew Gull
- ❑ Bonaparte's Gull (s)
- ❑ Black-legged Kittiwake
- ❑ Parasitic Jaeger
- ❑ Pomarine Jaeger
- ❑ Arctic Tern (s)
- ❑ Aleutian Tern (s,u)

SEABIRDS
- ❑ Tufted Puffin (s)
- ❑ Horned Puffin (s)
- ❑ Marbled Murrelet
- ❑ Kittlitz's Murrelet (u)
- ❑ Parakeet Auklet (u)
- ❑ Pigeon Guillemot
- ❑ Common Murre

RAPTORS
- ❑ Bald Eagle
- ❑ Peregrine Falcon

HUMMINGBIRDS
- ❑ Rufous Hummingbird (s)

KINGFISHERS
- ❑ Belted Kingfisher

PASSERINES
- ❑ Tree Swallow
- ❑ Violet Green Swallow
- ❑ Bank Swallow
- ❑ Chestnut-backed Chickadee
- ❑ Winter Wren
- ❑ Common Raven
- ❑ Northwestern Crow
- ❑ Black-billed Magpie
- ❑ Steller's Jay
- ❑ Hermit Thrush
- ❑ Varied Thrush
- ❑ American Robin
- ❑ Wilson's Warbler
- ❑ Orange-crowned Warbler
- ❑ Song Sparrow
- ❑ Fox Sparrow
- ❑ Savannah Sparrow

MAMMALS
- ❑ Humpback whale
- ❑ Minke whale
- ❑ Dall's porpoise
- ❑ Black bear
- ❑ Land otter
- ❑ Marmot
- ❑ Mink
- ❑ Weasel
- ❑ Killer whale
- ❑ Steller sea lion
- ❑ Sea otter
- ❑ Harbor seal
- ❑ Harbor porpoise
- ❑ Sitka black-tailed deer
- ❑ Brown bear
- ❑ Mountain goat
- ❑ Beaver
- ❑ Moose

WEATHER DATA

Forecasted to Help Improve Spill Prevention and Planning

A weather buoy near the Valdez Marine Terminal shows winds were mostly from the east in autumn and winter, transitioning to weak easterly and stronger westerly sea breezes during the summer months. *Austin Love/PWSRCAC*

BETSI OLIVER
PWS Regional Citizens' Advisory Council
eoliver@pwsrcac.org

Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) maintains two weather buoys in Port Valdez, one at Jackson Point close to the Valdez Marine Terminal and another near the Valdez Duck Flats. The mission of PWSRCAC is to support the safe transportation of oil in Prince William Sound. The buoys' data provide accurate information about weather and current trends to advise oil spill prevention and response planning.

The buoys have collected millions of hourly meteorological and oceanographic data points since their deployment in 2019, and will operate for at least five years. The buoys monitor temperature, wind speed, wind direction, and barometric pressure, as well as sea state information like surface current direction and speed, wave heights, and water temperature.

Dr. Robert Campbell of the Prince William Sound Science Center creates visuals and meaningful analyses from the data points. The report is available at www.tinyurl.com/PWSbuoys.

PWSRCAC partners with the National Oceanic and Atmospheric Administration to include the buoys' data in the PORTS® program. This program promotes navigation safety, improves the efficiency of U.S. ports and harbors, and ensures the protection of coastal marine resources. The City of Valdez provides maintenance funding for the buoys. More about the Council's weather monitoring: www.tinyurl.com/WeatherPWS

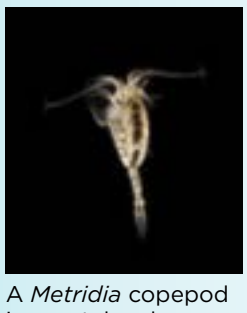
Are You Ready For Your Close-Up? Counting Plankton With Cameras

ROB CAMPBELL
rcampbell@pwssc.org
Prince William Sound Science Center

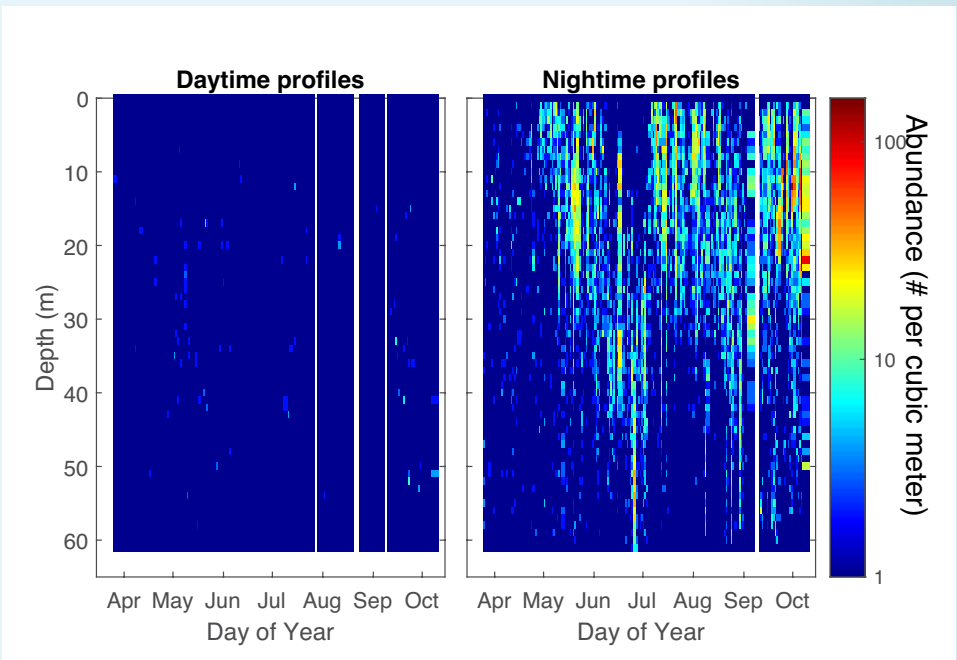
Plankton form the base of the marine food web: tiny single celled plant plankton (phytoplankton) grow and are consumed by animal plankton (zooplankton) grazers; zooplankton are food for larger animals like fish, birds, and whales. The amount and type of plankton present changes within and among years, and measuring them is not easy. New technologies, like underwater cameras, offer new ways to estimate plankton abundance.

PWSSC researchers have developed an underwater plankton camera and deployed it on an autonomous robotic profiler that is deployed from spring to autumn in central Prince William Sound (PWS). In 2021, the profiler did 338 separate profiles from 60 meters depth to the surface, and collected almost a half million individual plankton images.

Using Machine Vision methods developed by Google, we are able to automatically identify 43 different kinds of plankton, to an accuracy of about 90%. The images, along with other data collected by the profiler, are giving us an unprecedented picture of how the plankton ecosystem of PWS works, and how it is changing as the climate does.



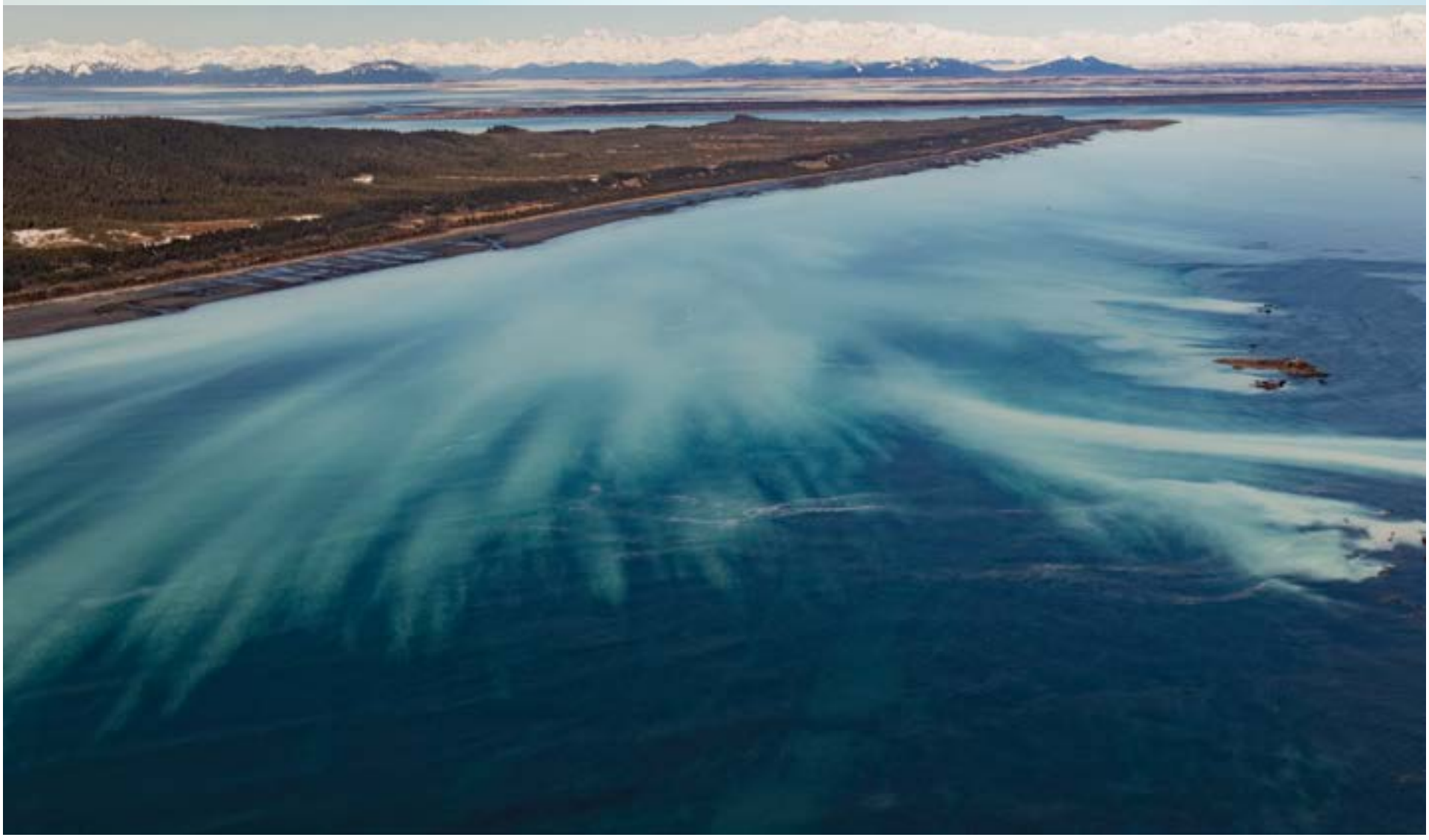
A *Metridia* copepod image taken by the camera in Prince William Sound. Copepods are a crustacean zooplankton, about the size of a grain of rice. The dark patch in the middle of its transparent body is the gut, full of phytoplankton it has eaten.



Abundance of *Metridia* copepods observed in 2021 during daytime (left) and nighttime (right). Hot colors indicate high abundances and cool colors indicate low abundances. *Metridia* is seldom observed during the day: it swims down to deep water to hide from predators. At night *Metridia* is much more common, but the depth it was observed at changes over the course of the year. We are investigating to see if this is driven by where their food occurs.

HAYLEY HOOVER
Prince William Sound Science Center
hhoover@pwssc.org

In the decades prior to 1990, there was a robust Pacific herring population in Prince William Sound (PWS) with a biomass of 130,000 tons. Not only are these forage fish a key link in the complex food web of PWS, but they once supported a lucrative early season commercial fishery that brought the communities of the Sound to life each spring. By 1993, that fishery had closed. Since then the herring population hovered around 20,000 tons but in recent years has experienced a rapid decline. The herring population in PWS experienced a record low biomass estimate of 4,000 tons in 2018. Fortunately, observations from aerial surveys in spring of 2019 during the annual spawning event suggest that that number has tripled. Still, researchers and fishermen alike wonder what is causing the herring to continue to struggle. The Herring Research and Monitoring (HRM) program has been exploring these questions since 2012. The program is a mix of monitoring studies that provide data necessary to understand changes in the PWS herring population and studies that address particular aspects of herring. These process studies help us understand why populations may change and or address assumptions in the population model that estimates the biomass of herring each year. The focus of the HRM program is on adult herring and the connections between herring condition, recruitment, and environmental factors. Measurements continue to be collected to detect changes in the PWS herring population, observe where herring go after spawning, and determine what role diseases play in limiting the herring population. Additional effort is being spent examining how the herring condition and recruitment is affected by environmental factors, predator populations, and prey availability.



Herring spawn event at Kayak Island during the 2021 ADF&G aerial surveys. *Photo credit: ADF&G.*

New Study to Investigate Interactions Between Pacific Herring and Pink Salmon

PETE RAND
Prince William Sound Science Center
prand@pwssc.org

KRISTEN GORMAN
University of Alaska Fairbanks
kbgorman@alaska.edu

Investigators from three different institutions (Prince William Sound Science Center, University of Alaska Fairbanks, and Sitka Sound Science Center) will begin a multi-year project to describe ways that Pacific herring interact with juvenile pink salmon in Prince William Sound. Past studies have examined some interactions (diet studies), but this will the first study of its kind to fully describe multiple interactions, including predation, competition for food, and disease by carefully tracking the early life history of pink salmon in western Prince William Sound and documenting interactions with Pacific herring in key habitats where they co-occur.

As indicated in the food web diagram (Figure 1), ecological interactions between herring and pink salmon, which can go both ways, take place in different habitats. Herring can feed on, compete with, and pass pathogens to juvenile salmon, and vice-a-versa. The research team will apply a combination of old and new sampling approaches to describe interactions and understand the implications for survival and recruitment of both species. Through traditional diet studies (examining gut contents under a microscope) and newer approaches using stable isotope and DNA fingerprinting analyses, the team will identify consumed prey. Many prey quickly break down in the guts of predators and are indistinguishable under a microscope, but these newer approaches provide an alternative approach for identifying prey. The team's observations over multiple years will be analyzed and integrated into a model to determine how important these processes are at the population and ecosystem level. An important, tangible result of this project is an annual abundance index of the number of juvenile Pacific salmon emigrating from Prince William Sound every spring that can be used to forecast returns to contribute to fishery management. This work will also provide new insight into factors that are preventing herring from recovering since the *Exxon Valdez* oil spill.

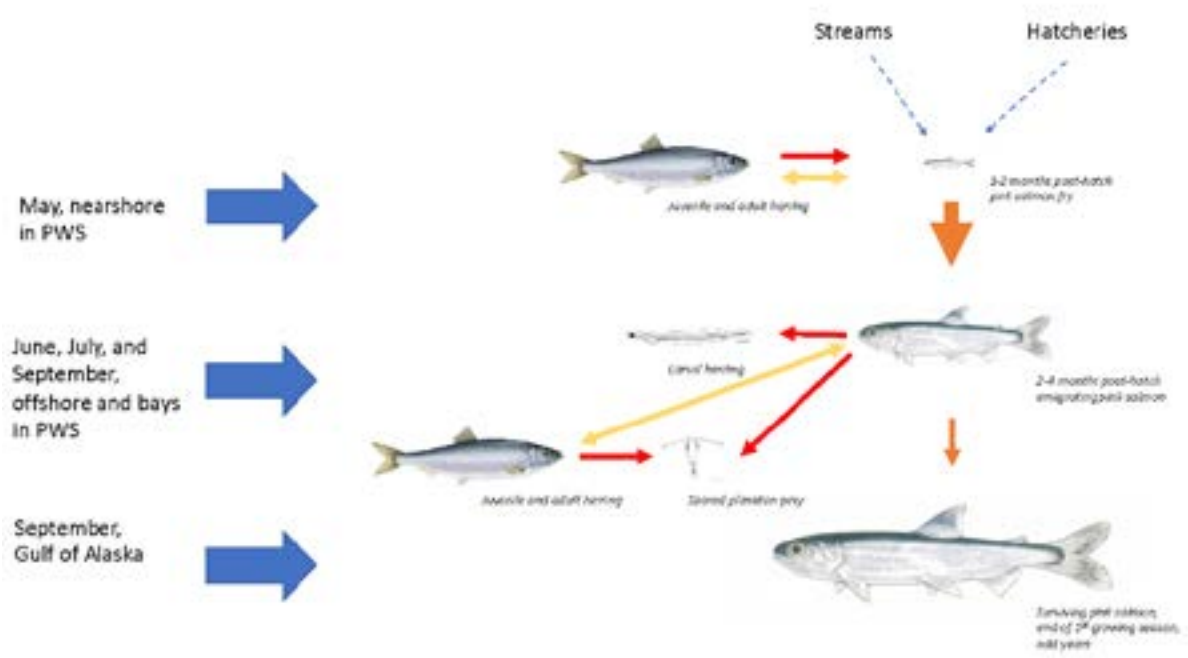
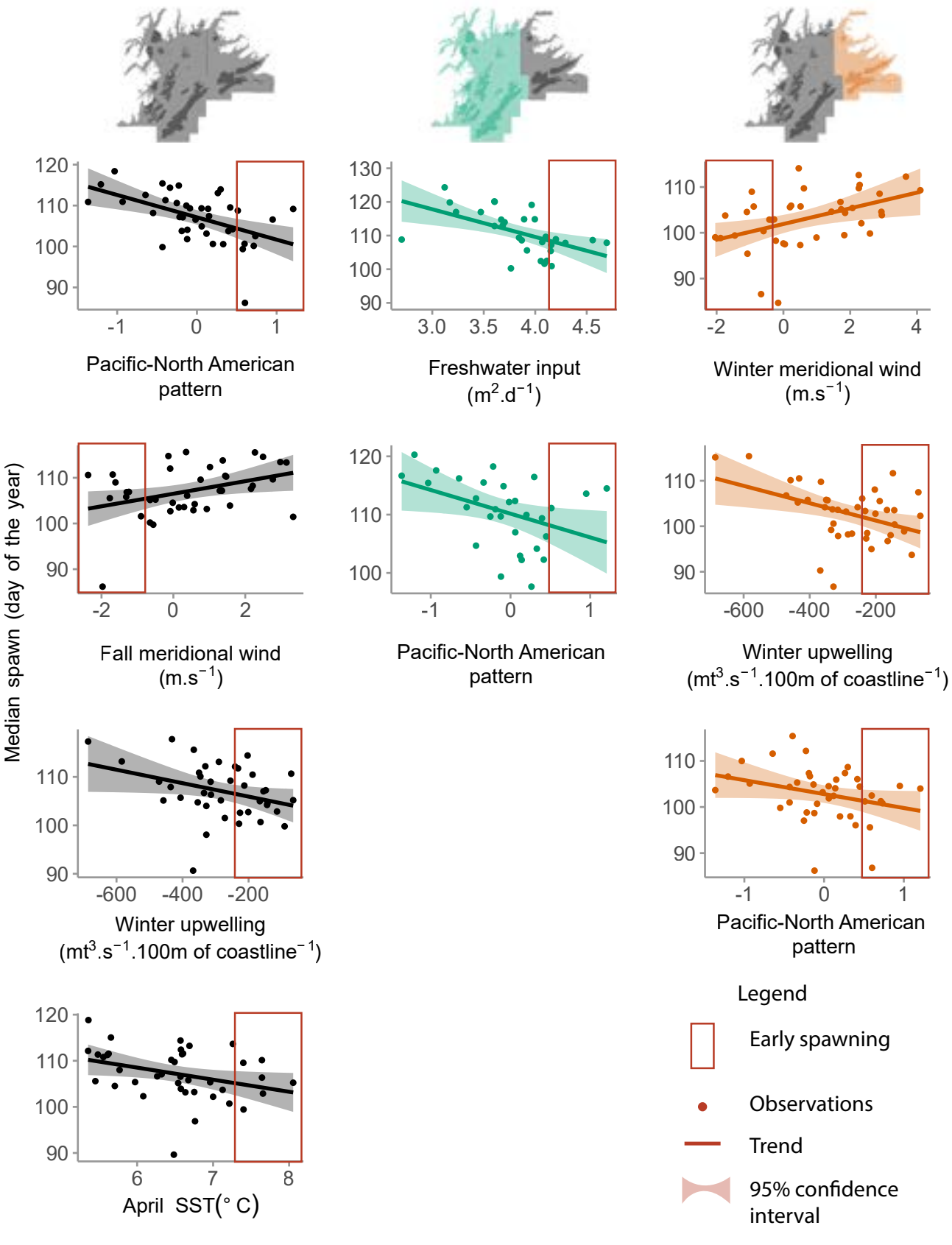


Figure 1. Interactions that may be taking place between Pacific herring and pink salmon in Prince William Sound. Red arrows indicate predation, yellow arrows indicate potential disease transmission, and orange arrows track the number of surviving juvenile pink salmon. This study tracks the early life history of pink salmon originating from hatcheries and natural streams from nearshore waters of Prince William Sound to the continental shelf of the Gulf of Alaska.

WHAT IS CAUSING HERRING EARLY SPAWNING?

BEATRIZ S. DIAS
University of Washington
University of Alaska Fairbanks
bdossantosdias@alaska.edu

Alaska Department of Fish & Game aerial surveys have found pronounced changes in the location and timing of herring spawning in Prince William Sound since the 1970s. Once widely distributed across the Sound, spawning has gradually contracted to waters primarily near Port Gravina and Port Fidalgo in the east and along the northern tip of Montague Island. This spatial variability explains why we see different environmental variables in western and eastern Prince William Sound. The boxes in figure 1 show the environmental and climatological conditions correlated to earlier spawning. Among them we have meridional (north-south) winds, April sea surface temperature, freshwater input, coastal upwelling, and the climatological Pacific-North American Pattern (PNA), which is measured by atmospheric pressure patterns strongly related to winds. When PNA is in the positive phase we can experience above average temperature for the North Pacific. Changing ocean conditions can bring additional complications for fish life history. Thus, a complex suite of factors, partly geographic, and partly environmental appears to have driven shifts in spawn location and timing, which is likely to impact the survival of herring in their first year of life.



Observed trends in aerial survey data and population, environmental, and climatological conditions.

EARLY RETURNS:

Do Herring Winter Near Their Spawning Grounds?

MARY ANNE BISHOP
Prince William Sound Science Center
mbishop@pwssc.org

Every spring, Pacific herring spawn in Prince William Sound. The high concentration of fish schools in relatively small areas provide a golden opportunity to tag herring. From 2017-2020 we captured and tagged over 700 adult herring on the spawning grounds from early to mid-April. We surgically inserted a small 8 or 9mm diameter acoustic tag into the herring's abdomen. The tags emit an individualized acoustic signal every 70-180 seconds that gets recorded when the tagged herring swims near an underwater acoustic receiver.

From the acoustic tags we have learned that after spawning, herring schools typically move to passageways such as Hinchinbrook Entrance where the Gulf of Alaska enters Prince William Sound. Some fish leave the Sound and may spend several months in the Gulf of Alaska before returning, while others go back and forth between the Gulf and the Sound until late winter.

Interestingly, by September some herring are already back on the spawning grounds and remain in the area until after spring spawning in April. While we have yet to determine if these overwintering fish are concentrated in a specific location, it is clear that some adult herring are partial migrants.

Temperature-Induced Disease Progression in Pacific Herring

JOANNE SALZER
(Conducted this experiment as an undergraduate student at Northeastern University)
USGS Western Fisheries Research Center
jsalzer@usgs.gov

MAYA GRONER
Bigelow Laboratory for Ocean Sciences
mgroner@bigelow.org

PAUL HERSHBERGER
USGS Marrowstone Marine Field Station
phershberger@usgs.gov

Example of an anemic Pacific herring with heavy ENV infection (top) compared to a healthy individual (bottom). Severe anemia from ENV is indicated by the pale gills. *Photo credit Paul Hershberger, USGS.*

Infectious diseases in Pacific herring can have population-level impacts, which are challenging to quantify in the wild. The marine environment fluctuates on seasonal, yearly, and decadal scales; and environmental conditions such as temperature can alter immune function or increase metabolic demands in fish, thereby mediating responses to infections. Health assessments of wild herring leave scientists with the following question: How do changing environmental conditions affect the progression of disease in herring? The answer requires controlled laboratory studies.

Erythrocytic necrosis virus (ENV) is a pathogen that infects many marine fish species and has been associated with mortality events in wild Pacific herring. Direct and indirect mortality results from red blood cell degradation, causing severe anemia and host death. Through seasonal surveys, peak prevalence of ENV in the NE Pacific Ocean has been observed in the summer months associated with higher temperatures. To study the effects of seawater temperature on disease progression in Pacific herring, we conducted a controlled experiment at the U.S. Geological Survey, Marrowstone Marine Field Station with ENV-exposed fish held at three different temperatures (6.9, 9.0, and 13.5 °C).

Blood and tissues were sampled throughout the course of the disease. After analyzing collected tissue, we determined that the disease onset was earlier and disease progression was faster at warmer temperatures. Ongoing work is evaluating the herring immune response to the disease in each temperature regime.

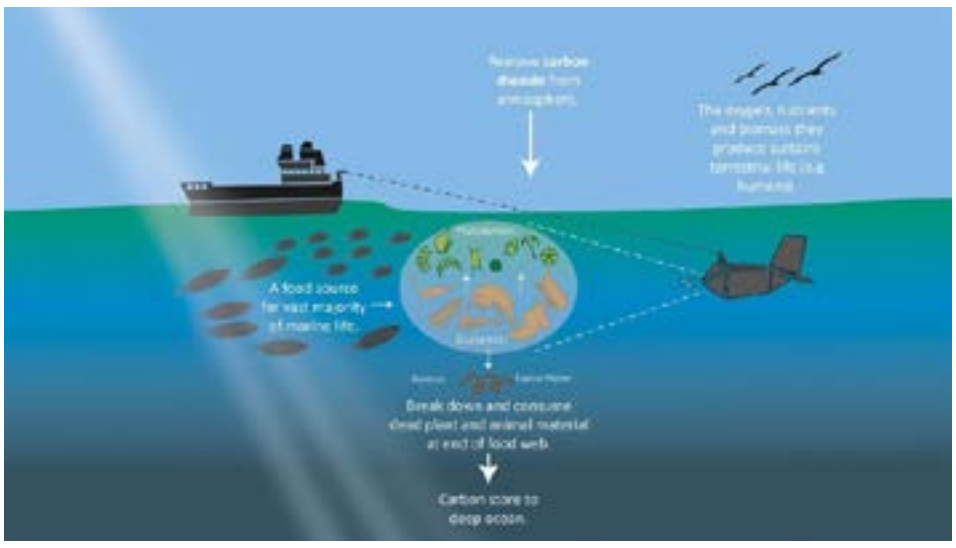
GULF WATCH ALASKA CELEBRATES A DECADE OF DATA!

DONNA ADERHOLD
Prince William Sound Science Center
daderholdPWSSC.ORG

How have the ecosystems affected by the *Exxon Valdez* oil spill fared since the spill? Many scientists have contributed observations to help explore that question. The Gulf Watch Alaska (GWA) long-term ecosystem monitoring program exists to help us understand the status of recovery from the spill. GWA was initiated by the *Exxon Valdez* Oil Spill Trustee Council in 2012, and the program turns 10 years old in 2022. Many of the projects that make up the program began before GWA, meaning we have invaluable datasets that range from 10 to an incredible 50 years long (representing one of several important sources of pre-spill data). The GWA program includes projects that collect data on oceanography, plankton, intertidal seaweeds and invertebrates, forage fish, sea otters, whales, and marine birds, capturing key parts of the Gulf of Alaska food web. We sample from beaches at low tide to the depths of the Gulf, from Prince William Sound to the Katmai coast.

Over time, data tell stories and boy do we have stories to tell! Enjoy the narratives on these pages, authored by GWA scientists and partners, that demonstrate the variety of scientific information available from GWA. For more information about the GWA program visit our website at www.gulfwatchalaska.org.

SCAN TO VISIT GULFWATCHALASKA.ORG



Schematic of the continuous plankton recorder (CPR) being towed by a volunteer ship, and some of the key processes that plankton are involved in.
Gemma Brice, Marine Biological Association

PLANKTON FEELING THE HEAT

CLARE OSTLE
Marine Biological Association
claost@mba.ac.uk

SONIA BATTEN
North Pacific Marine Science Organization
sonia.batten@pices.int

For over 20 years, volunteer ships have towed continuous plankton recorders (CPR) through the Gulf of Alaska. The route from Tacoma, Washington to Cook Inlet, Alaska is currently towed by the cargo vessel *Matson Kodiak*. This cost-effective and consistent way of sampling plankton has allowed scientists to investigate changes in the plankton over time in this highly productive area. Plankton are the base of the ocean food chain and important for sustaining whole fisheries as well as supporting almost all other marine organisms (including many seabirds and marine mammals). Plankton also play key roles in marine biochemical cycles and the variability in the environment is passed rapidly through them to their predators, making them good indicators of any changes in their environment.

During the recent marine heat waves in 2016 and 2019 in the Gulf of Alaska, this plankton time-series has seen significant changes. The warmer waters have created a bias towards plankton species that prefer warm conditions, and this likely has knock-on effects up the food chain as they tend to be smaller and may be a better, or worse, food source. These shifts in the food web could also influence the productivity of the ecosystem, which is why it is vital to maintain sampling in the area to better understand these changes.

For more details on these findings please refer to this paper or email the authors for access: Batten, S. D., Ostle, C., Hélaouët, P. and Walne, A. W.: Responses of Gulf of Alaska plankton communities to a marine heat wave, Deep Sea Res. Part II Top. Stud. Oceanogr., 195, 105002, doi:10.1016/j.dsr2.2021.105002, 2022.

Underwater Glider Makes First Ever Mid-Winter Voyage in the Gulf of Alaska

SETH DANIELSON AND HANK STATSCEWICH
University of Alaska Fairbanks
sldanielson@alaska.edu

ED FARLEY
NOAA

JOHN HORNE
University of Washington

Photograph of UAF glider technician Hank Statscewich alongside the glider that flew across the Seward Line in February 2022. *Photo by Seth Danielson*

Oceanographers from the University of Alaska Fairbanks (UAF) have collected hydrographic data at "Seward Line" stations since the 1970s. The Seward Line extends 150 miles from the mouth of Resurrection Bay to beyond the continental shelf break and into the deep Gulf of Alaska basin. Seward Line data provide Gulf Watch Alaska scientists with insight into the ecological functioning of the Northern Gulf of Alaska.

On February 12, 2022, an autonomous underwater glider launched in Resurrection Bay began the first-ever, mid-winter Seward Line sampling. The glider supported the International Year of the Salmon high seas survey, a multinational collaboration to document the North Pacific distribution of salmon. The data will also help Gulf Watch Alaska scientists better understand the oceanic "winter reset." Strong winter storms mix ocean waters and resupply surface layers with nutrients before the spring phytoplankton bloom. The spring bloom ultimately feeds the zooplankton, fishes, and marine mammals and birds that make their homes here.

The glider, about one foot wide and eight feet long, moves slowly (about 0.5 mph). It flies by adjusting its buoyancy, gliding forward and downward until the bottom of its dive, and then forward and upward toward the sea surface. Sensors measure water temperature, salinity, clarity, phytoplankton concentrations, and colored dissolved organic matter. Fish-finder acoustics on the glider collect backscatter from fishes and zooplankton.

The glider dove to 1,600 feet when in the basin and to within 60 feet of the seafloor while over the continental shelf. It surfaces every 2-3 hours to transmit data ashore via satellite communication and receive new flight instructions from the UAF-based glider pilots.

The glider mission was supported by the Alaska Ocean Observing System with funding from the National Oceanic and Atmospheric Administration's Office of Marine and Aviation Operations and the Integrated Ocean Observing System.

Adult black-legged kittiwake on nest with chicks. *Photo credit: Dan Roby*

Prince William Sound Kittiwakes Experienced Dramatic Decadal Differences in Population Trends, But All Collapsed in the MARINE HEAT WAVE (AKA, THE BLOB)

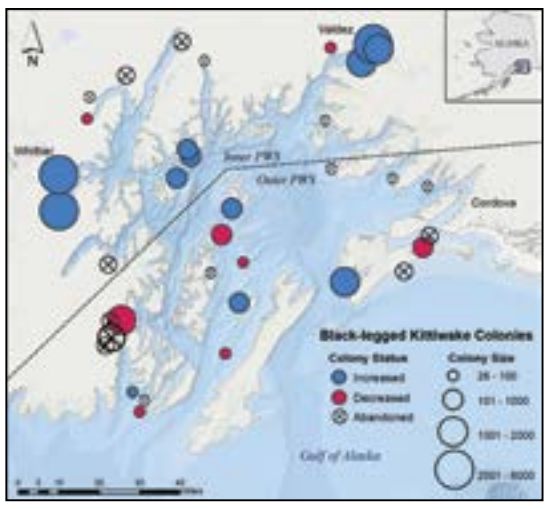
DAVID IRONS
ROBB KALER
USFWS Migratory Bird Management
robert_kaler@fws.gov

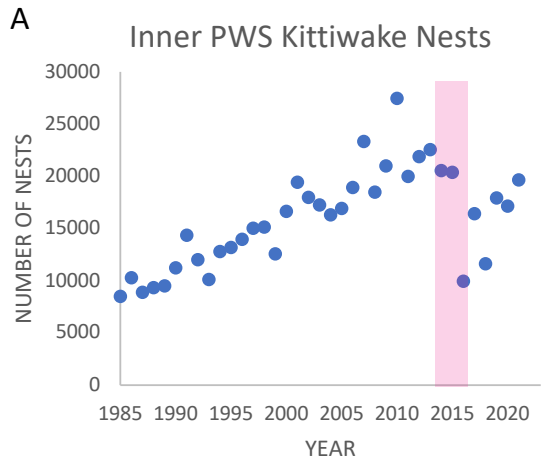
E.A. LABUNSKI
KATHY KULETZ
U.S Fish and Wildlife Service
kathy_kuletz@fws.gov

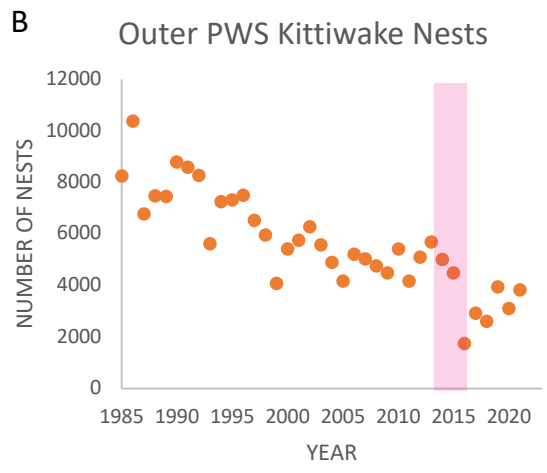
The Black-legged Kittiwake is a conspicuous fish-eating, ledge-nesting seabird that breeds throughout the world in northern latitudes, including in Prince William Sound (PWS). Most PWS boat tours include a visit to a seabird colony, where tourists may see thousands of kittiwakes nesting on vertical cliffs. In spring, kittiwakes often leave the cliffs all at once, flying a choreographed aerial dance - quite a spectacle!

People care about seabirds, both for the health of their populations, and as an indicator of the health of oceans on which seabirds and Alaskans depend. Globally, scientists are concerned about the overall decline in kittiwake numbers. We studied kittiwake colonies in PWS for over three decades and in total, kittiwake populations in PWS appear relatively stable; however, there are notable differences when we examine the data more closely. The colonies in the Outer Region, closer to the Gulf of Alaska, have decreased by 54%, with several large colonies having been abandoned. In contrast, colonies in the Inner Region of PWS have increased 130%. Sadly, the 2014-2016 'Marine Heat Wave' (aka, The Blob) caused colony decline for several years throughout PWS.

What are kittiwakes telling us? From a kittiwake's view, their grocery store in the Gulf of Alaska has some empty shelves. Warmer ocean temperatures reduce the abundance of small schooling fish on which they feed. As our climate and oceans are expected to continue warming, monitoring seabirds, like kittiwakes and other cold-water species, will provide important clues as to the overall health and productivity of the oceans. This will assist resource managers in making wise conservation actions.







Discovering Linkages Across Ecosystems with the Help of Long-Term Monitoring:

A Case Study of Brown Bears and Sea Otters Along the Katmai Coast

HEATHER COLETTI
National Park Service
heather_coletti@nps.gov

DANIEL MONSON
USGS Alaska Science Center
dmonson@usgs.gov

Sea otter populations are monitored across the northern Gulf of Alaska. We use several tools to assess populations such as surveys to estimate abundance, foraging observations to assess diet, and carcass collections to determine the population's age-at-death distribution (AADD). A stable population with adequate food should have an AADD comprised of mostly young or old, with few prime-age animals. Together, these pieces give us a sense of the status of the sea otter population.

In Katmai National Park and Preserve, surveys and foraging observations indicated that the sea otter population was near carrying capacity and stable. However, a conundrum arose: the sea otter carcasses we collected included a higher-than-expected number of prime-aged animals. If these carcasses were a representative sample of the dying population, then the living population should be in rapid decline, which was contrary to our findings from our other data.

Katmai is famous for its brown bears and the coast is no exception where they are an important component of the Katmai coastal ecosystem. We investigated bear predation as a potential cause of high prime-aged otter mortality by using camera traps at haulout sites. We documented brown bears successfully hunting sea otters. This suggests the sea otter population was not in steep decline but that prime-age animals were killed by brown bears when they hauled out and thus more likely to be found than otters that died of other causes. This novel observation highlights ecosystem linkages across land and sea.

Based on the article: Brown bear-sea otter interactions along the Katmai coast: Terrestrial and nearshore communities linked by predation by Daniel H. Monson, Rebecca L. Taylor, Grant V. Hilderbrand, Joy A. Erlenbach, Heather A. Coletti, Kimberly A. Kloecker, G. G. Esslinger and James L. Bodkin

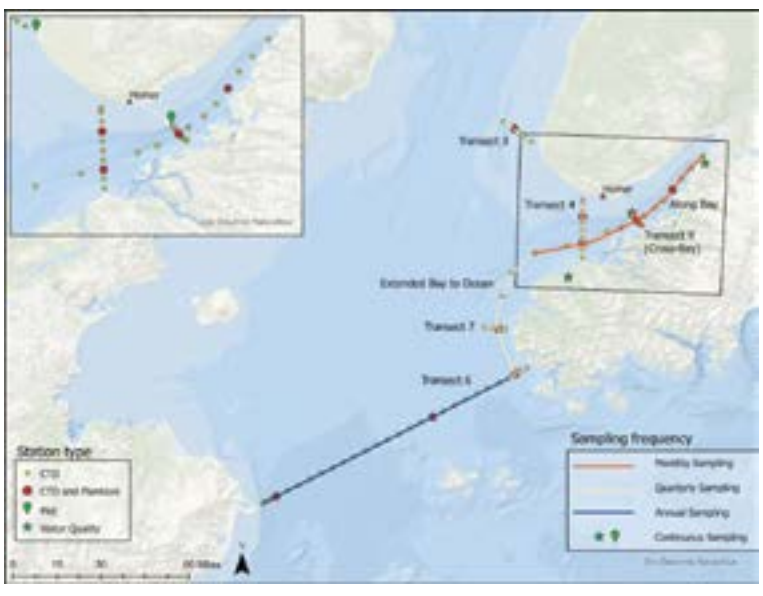
A brown bear with a recently killed sea otter taken at a haulout site in Katmai National Park and Preserve, Alaska, 2016. *The image was captured with one of the deployed camera traps.*

Warm Waters Have Impact on Tiniest Cook Inlet Residents

CAITLIN MCKINSTRY
Prince William Sound Science Center
cmckinstry@pwssc.org

From California to Alaska, the Pacific Ocean experienced unprecedented warm water from 2014-2016. This marine heatwave, known as "The Blob", caused widespread die-offs of seabirds and declines in fish populations, and brought marine life from more tropical regions of the Pacific to the Gulf of Alaska like skipjack tuna and ocean sunfish. How this warm water affected the tiniest animals in the ocean, zooplankton, was not clear. The mishmash of microscopic animals that make up this community form the base of the food web in most temperate and arctic coastal waters. This is especially true in the Northern Gulf of Alaska where zooplankton are important food for fishes, seabirds, and whales. In Cook Inlet and its main arm, Kachemak Bay, zooplankton have been collected for the past ten years. We looked at the individual species that make up zooplankton to see how this community was affected by the marine heatwave. We found that, like ocean sunfish and skipjack tuna, the abundance of copepods (shrimp like zooplankton smaller than a grain of rice) from warmer regions off the coast of California increased in numbers. One particular copepod species (*Corycaeus anglicus*) is a voracious predator of other zooplankton that could impact the "normal" community in the Cook Inlet region.

https://doi.org/10.1016/j.dsr2.2021.105012



THE GOOD AND BAD NEWS

About Salmon and Climate Change in Alaska

PETE RAND
Prince William Sound Science Center
prand@pwssc.org

How is climate change affecting Alaska salmon? Well, it's complicated. Two recent scientific papers published provide two very different perspectives.

Kara Pitman and colleagues describe in a *Nature Communications* article how melting glaciers will open up new habitat for salmon. Through an analysis involving maps of glaciers, land topography, and trends in glacial melting, the authors conclude that over 6,000 km (3,500 miles) of river habitat will become accessible to salmon by 2100. In some regions in southeast and southcentral Alaska, this represents a sizable fraction of the total amount of river kilometers currently available to salmon (+27% in some watersheds). Thus, there will be new habitat unlocked that salmon can readily colonize as our climate warms. That is the good news!

Another paper, authored by Vanessa von Biela and colleagues in *Fisheries Magazine*, provides a more sobering picture of what the future might look like. These authors document over 100 observations of adult salmon die-offs that occurred during the Alaska heatwave of 2019 across a large swath of the state. Different causes were identified, including exposure to warm water temperatures and declining river flow leading to suffocation or stranding (see photo). The authors described how the presence of glaciers in some watersheds buffered the negative effects from heat and drought, suggesting that salmon in some streams are more vulnerable than others.

To answer the question about the future of salmon as Alaska's climate changes, a fair response is, "It depends." We need to expect surprises and be able to adapt to them. Following the publication of these papers, there has been constructive dialog on creating "on-line observation networks" to help summarize river conditions across the state. This is a worthy cause, and could provide a more definitive answer to this important question.

Image of a pink salmon premature mortality observation consisting of a large number of carcasses in Hogan Creek (Hogan Bay), Knight Island, Prince William Sound, Alaska, in early September 2019 during a field study conducted by the Prince William Sound Science Center. *Photo credit: Brad von Wichman, Babkin Charters.*

PAPER REFERENCES:

Pitman, K.J., J.W. Moore, M. Huss, M.R. Sloat, D.C. Whited, T.J. Beechie, R. Brenner, E.W. Hood, A.M. Milner, G.R. Pess, G.H. Reeves, and D.E. Schindler. 2021. Glacier retreat creating new Pacific salmon habitat in western North America. Nature Communications 12:6816. https://www.nature.com/articles/s41467-021-26897-2

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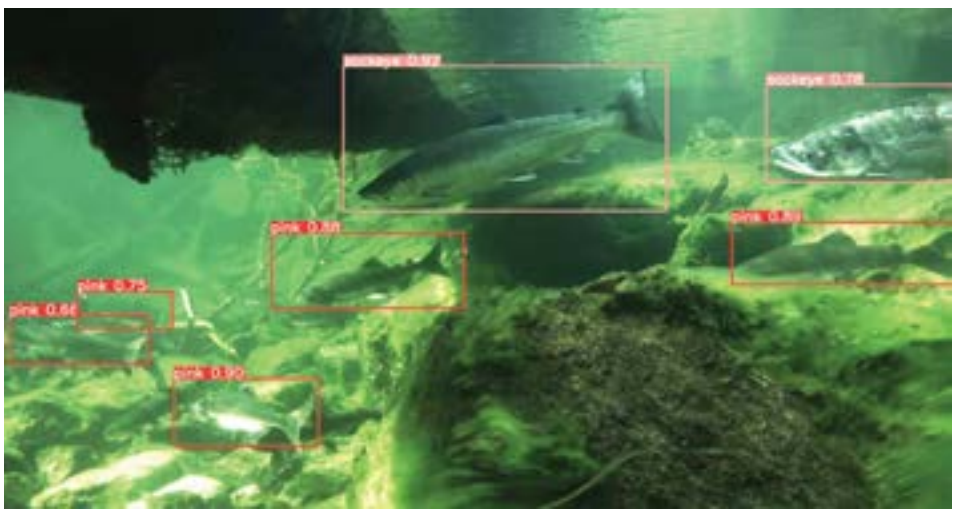


A video frame from the 2021 deployment in Eshamy Creek with computer tracking and identification boxes superimposed. The type of fish is labeled in the box, and the number indicates the confidence of the computer classifier in the species identification (a scale from 0 to 1). The computer is remarkably successful at discriminating pink salmon from sockeye salmon.

In-water Fish Counting Computers

ROB CAMPBELL
Prince William Sound Science Center
rcampbell@pwssc.org

PAUL L. ROBERTS
Guatek Inc.

The State of Alaska uses fish passage estimates to manage numerous fisheries throughout the state. An important management goal is a certain amount of "escapement" – fish that have moved out of the ocean into spawning streams and have "escaped" the fishermen. For many fisheries the escapement is estimated by setting up a barricade in the stream (called a weir) and counting fish as they are allowed to pass through it.

Weirs require several technicians to run safely and effectively, and cost tens of thousands of dollars per year to run. Several weirs have been unfunded in recent years due to budget cuts by the State.

In 2021 we developed an in-water camera system with an onboard computer that we are training to count and identify salmon as they pass. The camera was deployed in Eshamy Creek, Prince William Sound, to collect video of salmon passage. We are now using the collected video to train computers to identify the salmon from the videos.

In 2022 we will again deploy the cameras in Eshamy Creek, they will be located upstream of a weir run by the Alaska Department of Fish and Game. They will count salmon as they pass, and we will compare the camera counts to the weir counts and see if they are comparable.

A USFS fisheries biologist retrieves a datalogger that measures both temperature and dissolved oxygen from a pond on the Copper River Delta. *Luca Adelfio/USDA Forest Service*

Have You Diversified YOUR WATER PORTFOLIO?

KATE MORSE
Copper River Watershed Project
kate@copperriver.org

There is no denying that salmon are a cold-water species. While their life stage development is tied to the accumulation of temperature units, with warmer temperatures increasing the rate of development, there is a threshold at which warm water turns lethal. If evidence is needed, look back no further than 2019, where record warm water temperatures resulted in pre-spawning die-offs in salmon populations across Alaska.

Fortunately, the news isn't all bad for Copper River salmon when it comes to water temperature, as they have a diversified water portfolio. The Copper River watershed has a range of hydrologic regimes, including dynamic glacial-fed and precipitation-driven systems, and more stable spring-fed systems. For example, the Klutina River runs silty to its confluence with the Copper River, fed by the Klutina Glacier and with peak flow during high melting events. However the Gulkana River emerges year-round from underground springs in its headwaters that stay at a more constant temperature and flow rate.

It's likely that these different hydrologic regimes have influenced life history strategies of salmon living in sub-watersheds. In Cordova, some streams host spawning salmon late into the winter, while Long Lake salmon in the interior have been observed spawning as late as April! It's the diversity between these sub-populations of salmon that will hopefully help to buffer salmon from changes in water temperature into the future.

The Copper River Watershed Project is working with partners to coordinate and expand temperature monitoring in the watershed. An improved understanding of thermal regimes in the watershed will help identify cold-water refugia important for sustaining salmon during warm weather events. It will also help track how different hydrologic regimes change with a warming climate and how sub-populations of salmon respond to these changes. Supported by a diversified water portfolio, we're hopeful that Copper River salmon are resilient to the uncertain changes that lie ahead.

TO LEARN MORE ABOUT TEMPERATURE MONITORING IN THE COPPER RIVER WATERSHED, contact Kate Morse, kate@copperriver.org, (907)424-3334.

RIGHT: Dr. Steve Wondzell, an ecologist with the Pacific Northwest Research Station, installing water temperature data loggers into the streambed at Upper Ibeck Creek on the Copper River Delta to monitor water temperature where salmon eggs incubate. *Luca Adelfio/USDA Forest Service*

Studying the Ecological Impact of SALMON SHARKS in the Northeast Pacific

ALEXANDRA MCINTURF
Oregon State University
mcintura@oregonstate.edu

No matter where you live, it's likely that you have heard of, seen, or even tasted salmon. They are important fish in many ways – economically, culturally, and ecologically. As a result, much research focuses on making sure we can fish them sustainably; that is, without causing so much damage to the population that it cannot recover. However, natural ecosystems are complicated and can be hard to predict. For some salmon populations, conservation strategies work quite well, while other populations don't respond as we might expect. This may be because while we can control our own actions (i.e. by limiting our fishing), there are other factors affecting salmon populations that we need to consider. Key among these is predation.

Starting in January 2022, researchers at Oregon State University, with partners at the University of Alaska Fairbanks and NOAA, are studying a potentially impactful salmon predator: the salmon shark. Salmon sharks can be found from California to Alaska, and their presence seems correlated with that of salmon. However, very little is known about the salmon shark, including what it eats, how often, and where. For the next two years, this study aims to fill these gaps. Researchers will examine stomach contents of deceased individuals, take tissue samples to see what the sharks are eating over long periods of time, and use biologging tags (like animal FitBits) to determine how much prey salmon sharks need to consume to compensate for their energy use. This information will be used to assess the impact of this large predator on salmon populations in Alaska, Oregon, and Washington. Ideally, it will also allow managers to consider the impact of predators like the salmon shark when making decisions about sustainable fishing.

Salmon shark illustration by Jess Schulte.

INTERESTED IN CONTRIBUTING TO THIS STUDY? Please contact the author.

63°N
62°N
61°N
60°N
59°N
Paxson
Talkeetna Mountains
Talkeetna
Gakona
Gulkana
Glennallen
Mendeltna
Tazlina
Copperville
Copper Center
Kenny Lake
Chitina
Wasilla
Chugach
Valdez
Anchorage
Unakwik Inlet
Tatitlek
Portage
Whittier
Eaglek Bay
Bligh Reef
Port Gravina
Simpson Bay
Cordova
Alaganik
Blackstone Bay
Prince William Sound
Eshamy Bay
Knight Is.
Egg Is.
Hinchinbrook Is.
Copper River
Hinchinbrook Entrance
Chenega
Montague Is.
Seward
Resurrection Bay
Montague Strait
Middleton Is.
N
25
50
Miles
150°W
148°W
146°W

PRINCE WILLIAM SOUND SCIENCE CENTER

Map and design by Kristin Link

Highways

Trans Alaska Pipeline

USA-Canada Border

entasta Lake

Slana

ochina

Wrangell Mountains

Mt. Wrangell
14,163 ft

Kennecott Copper Mine

McCarthy

na

Chitina River

ountains

Copper River

Bagley Icefield

Mt. St. Elias
18,008 ft

Bering River

Bering Glacier

Icy Bay

Flats

Yakutat Bay

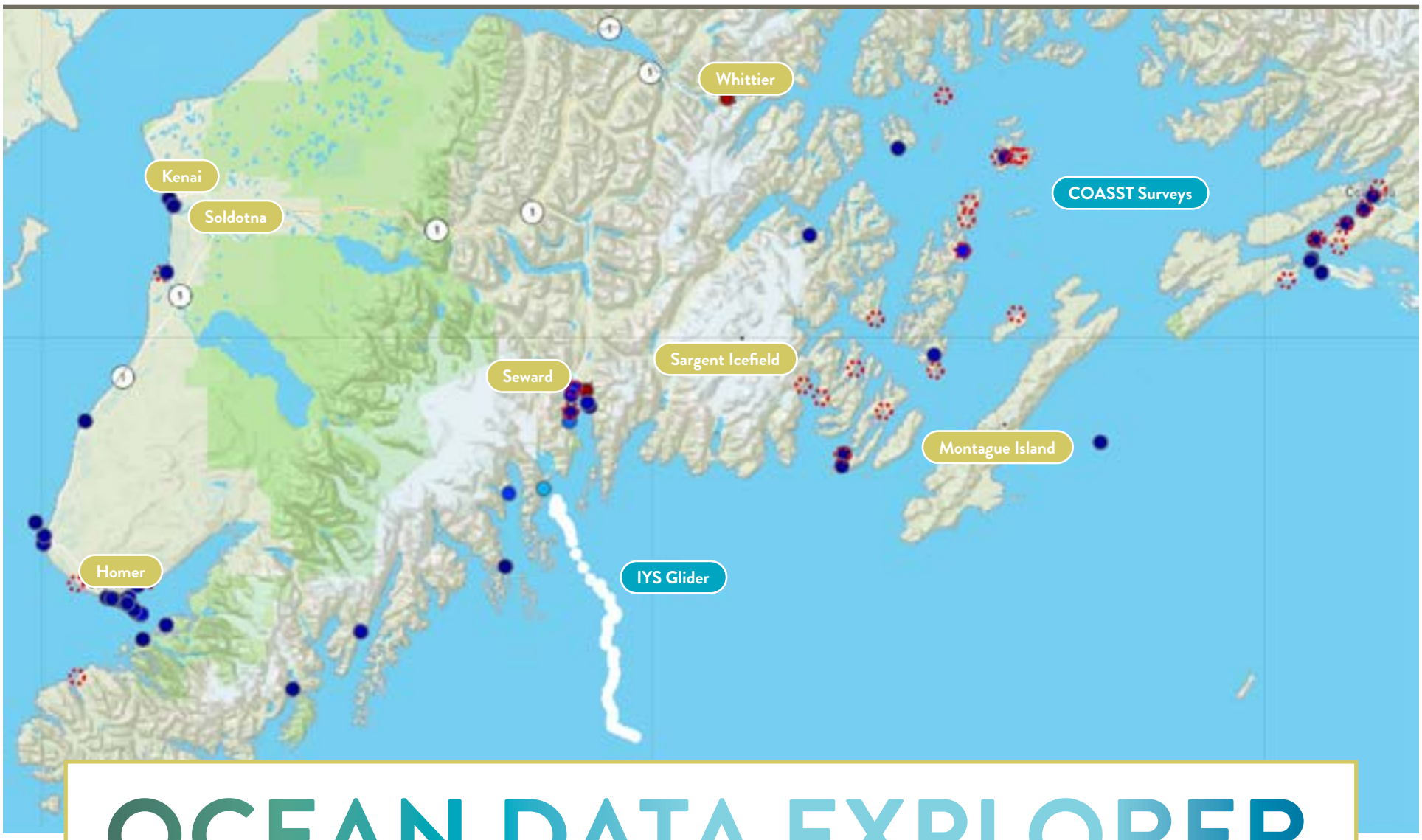
Yakutat

Kayak Is.

Gulf of Alaska

144°W

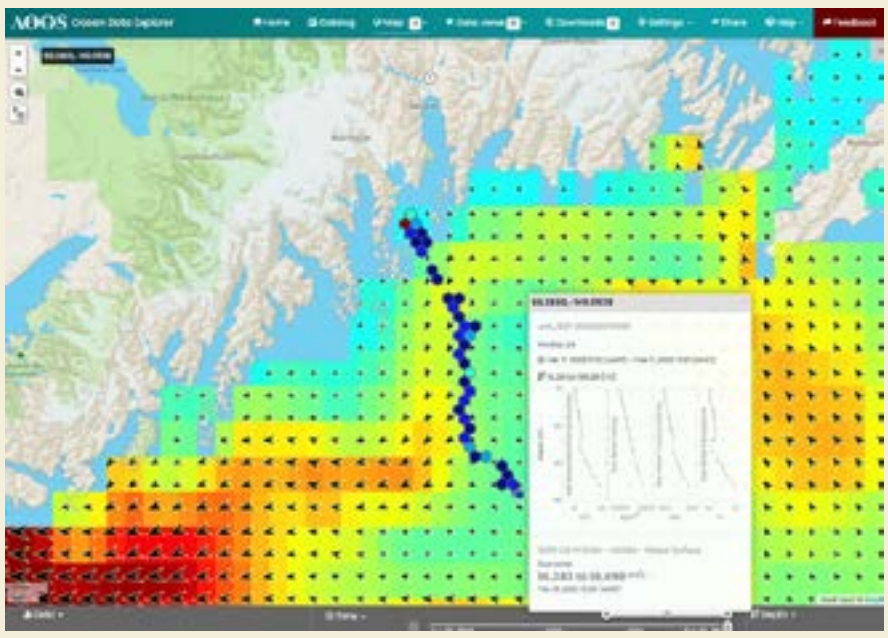
142°W



OCEAN DATA EXPLORER

The Ocean Data Explorer portal, the largest catalog of ocean data for visualization and download for the Alaska region, contains scientific and management information including real-time sensor feeds, oceanographic and atmospheric models, satellite observations, and GIS datasets that describe the biological, chemical, and physical characteristics of Alaska and its surrounding waters. The portal's visualization map offers many new updated features that build upon the existing data system, including:

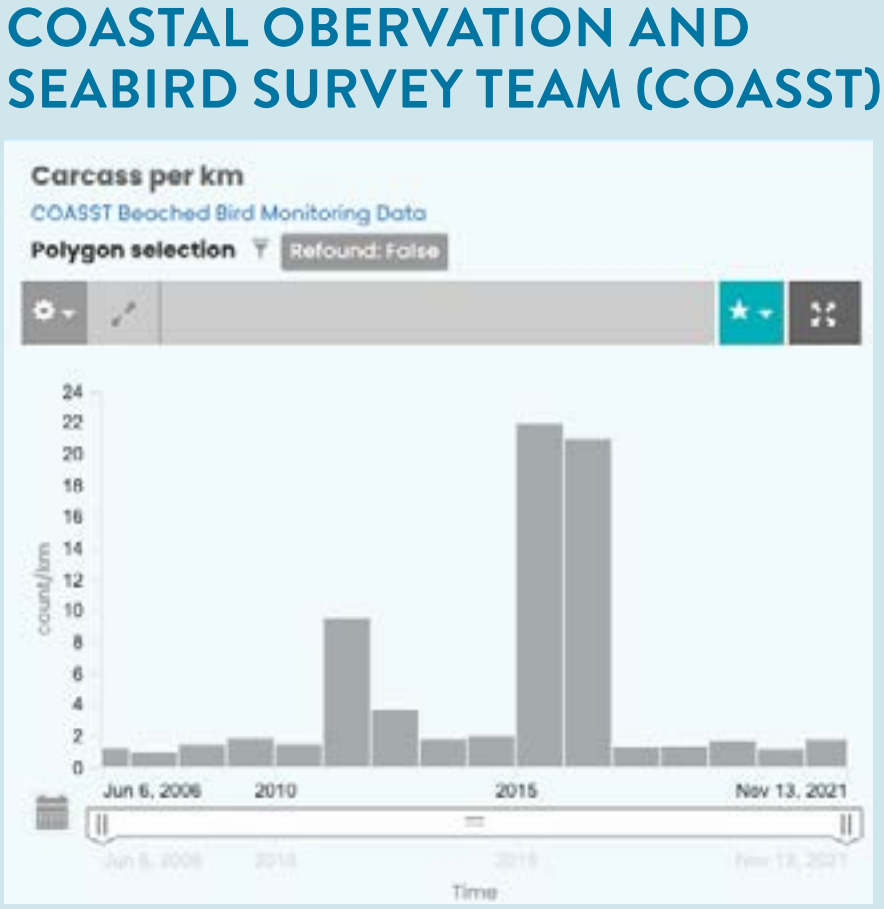
- Data comparison and charting functions
- Featured data views
- Advanced charting features, including climatologies and anomalies
- Station and source level metadata pages
- Shareable custom data views



INTERNATIONAL YEAR OF THE SALMON (IYS) GLIDER

The Ocean Data Explorer portal presents several datasets generated by autonomous underwater vessels (AUVs) also called gliders. The portal map at the top of this page shows the track (in white) of a glider deployed from Seward on February 11, 2022. AOOS funds the University of Alaska Fairbanks (UAF), the University of Washington, and Axiom Data Science to expand the sampling capability of this autonomous underwater glider to provide near real time ecosystem monitoring in support of NOAA's International Year of the Salmon (IYS) field surveys. The glider collects several types of data including conductivity, temperature, and salinity throughout the water column. The image above was also generated from the portal and shows the glider track in blue along with surface current data from the Hybrid Coordinate Ocean Model (HYCOM) overlaid on the map. The glider dataset can also be visualized in chart form (inset of above image). UAF Principal Investigator (PI) Seth Danielson says, "This display interface is going to be absolutely key to helping us make good glider piloting decisions."

COASTAL OBERVATION AND SEABIRD SURVEY TEAM (COASST)



The Ocean Data Explorer portal presents many biological datasets generated through several monitoring techniques. Seabird mortality trends are a valuable indicator of marine ecosystem health, and unusual mortality events are on the rise. The portal map at the top of this page shows data collected by the Coastal Observation and Seabird Survey Team (COASST), an established citizen-science volunteer monitoring effort of beached seabird abundance in Alaska between April 2012 and November 2021. The blue dots indicate survey sites where at least one carcass was observed and the red dotted circles show survey sites where no carcasses were observed. The image above was also generated from the data portal visualizing these data as a histogram chart.

AOOS Alaska Ocean Observing System

AOOS is a stakeholder driven, science-based organization working to identify and fill observing gaps, provide easy access to data, develop information products and tools to meet stakeholder needs, and coordinate private sector, local, state, and federal agency efforts.

LEVERAGING FUNDING

AOOS leverages funding for many research efforts to "go the last mile" in funding ensuring that critical gaps in ocean observational data are filled.

- The Seward Line is a long-term time series of physical, biological, and chemical oceanographic conditions in the Gulf of Alaska and within Prince William Sound to understand climate variability and ecosystem change. AOOS is part of a consortium formed to maintain support of the Seward Line and has been funding this multi-disciplinary monitoring of the Gulf of Alaska ecosystem since 2009. Visit https://aoos.org/project-page/ecosystems/seward-line/ for more information.

- AOOS is one of several funders contributing to ecosystem moorings in the Chukchi Sea and Gulf of Alaska. These moorings contain multiple instruments collecting observations on physical, biological, chemical, and geological oceanographic conditions, greatly contributing to our understanding of these complex ecosystems. These are the beginning phases to AOOS's plan to establish sentinel ecosystem moorings in each of the Large Marine Ecosystems (LMEs) in Alaska, the Gulf of Alaska, the Bering Sea, the Chukchi Sea, and the Eastern Beaufort Sea. Visit https://tinyurl.com/2p94e38a and https://tinyurl.com/kusw2cfa for more information.
- AOOS is one of several funders supporting the Prince William Sound Science Center's Prince William Sound Ocean Tracking Network which has been tracking fish movements in Prince William Sound for more than 10 years using underwater acoustic receivers. Visit https://tinyurl.com/ymfkf3xj for more information.

COLLABORATING

AOOS collaborates with organizations and stakeholders in a key role. Because we are policy neutral, we are a trusted broker for bringing groups of stakeholders together, or for serving as a central hub for information.

Alaska Ocean Acidification Network

- AOOS established the Alaska Ocean Acidification Network (AOAN) in 2016 and continues to provide coordination and facilitation for a very diverse group of stakeholders. The mission of the AOAN is to engage with scientists and stakeholders to expand the understanding of OA processes and consequences in Alaska, as well as potential adaptation and mitigation strategies. Visit the OA Network website for more information.
- AOOS coordinates the Alaska Harmful Algal Bloom (AHAB) Network formed in 2017 to provide a statewide approach to HAB awareness, research, monitoring, and response in Alaska. AHAB coordinates a diverse group of coastal stakeholders to address human and wildlife health risks from toxic algal blooms. Visit the AHAB Network website for more information.
- The Alaska Water Level Watch (AWLW) is a collaborative group established by AOOS in 2018 and coordinated by the State of Alaska Division of Geological & Geophysical Surveys working to improve the quality, coverage, and accessibility to water level observations in Alaska's coastal zone. AWLW is made up of state and federal agencies, local governing entities, non-profits, private businesses, and community members. Visit the AWLW website for more information.

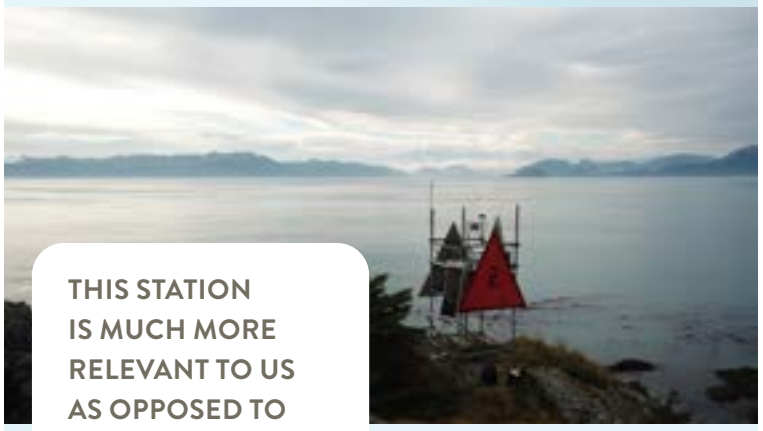
Alaska HAB Network

FILLING GAPS

AOOS works to fill existing gaps in ocean data. These gaps are identified through workshops and meetings with stakeholders with the goal of providing easy to access and pertinent data for mariners, scientists, fishermen, and many others.

- High Frequency Radar (HFR) systems are shore-based radar systems that are used to map ocean surface current speeds and directions in real time. Initial HFR sites were installed on the northwest coast of Alaska in 2009. These data are available in real-time for operational applications including hazardous material spill response, marine forecasts, marine operations, and search and rescue missions. AOOS is working with partners at UAF to expand the original network of four installations to fill observational gaps by adding installations in the Bering Strait region. Future plans include HFR systems in the Aleutians, Cook Inlet, and the Gulf of Alaska.

THESE STATIONS ALLOW FOR GOOD FEEDBACK TO BRIDGE TEAMS REGARDING ACTUAL CONDITIONS IN A PILOTING AREA. PARTICULARLY USEFUL IN A PORT FOR DECISION MAKING ON APPROACH FOR BERTHING. *—Barry K. Olver, Marine Pilot*



THIS STATION IS MUCH MORE RELEVANT TO US AS OPPOSED TO THE NWS STATION ON THE WHITTIER BREAKWATER. THE WIND CONDITIONS ARE VERY DIFFERENT IN THE TWO LOCATIONS EVEN THOUGH ONLY A FEW HUNDRED YARDS APART.
– Gar M. Henning, Master M/V Aurora

- AOOS's partner Marine Exchange of Alaska has installed and maintains over 150 shore-based vessel tracking stations using AIS (Automated Information System) receivers positioned across the state. Over the last 10 years, AOOS has supported adding weather stations to these AIS installations which then communicate weather directly to mariners over the system. Visit https://tinyurl.com/4x78cp5e for more information.
- Wave information is critical for maritime domain awareness, safe navigation, and for laboratory and analytical research into the physics of wave generation, propagation, and transformation. Gaps in real time wave information were identified through stakeholder outreach and AOOS has responded by maintaining three wave buoys near Kodiak, Lower Cook Inlet, and Nome.

TUFTED PUFFINS:

Where to Winter?

ANNE SCHAEFER & MARY ANNE BISHOP
Prince William Sound Science Center
aschaefer@pwssc.org, mbishop@pwssc.org

KRISTEN GORMAN
University of Alaska Fairbanks
kbgorman@alaska.edu

Many seabird species breeding at subarctic and Arctic latitudes head south for the winter where daylight hours are longer and food is more available. At one end of the migration spectrum, the Arctic Tern makes an epic journey from Alaska to Antarctica and back every winter, while at the other end of the spectrum, the Whiskered Auklet stays year-round near its breeding colony.

Monthly locations over two years (July 29, 2018 – June 26, 2020) for Tufted Puffin #BP587. Arrows show the direction of the trackline.

Until recently, one seabird whose wintering areas had yet to be determined was the Tufted Puffin. We wanted to solve the mystery of where Tufted Puffins wintered in the Gulf of Alaska. For two summers we deployed light-level geolocators on bands affixed to the lower legs of Tufted Puffins nesting at Middleton Island. Located approximately 80 miles southwest of Cordova, Alaska, Middleton is home to over 20,000 puffins that breed there during the summer season. When we recaptured the puffins the following summer, or even two years later, we removed the geolocator and analyzed the ambient light-level data to determine where each puffin wintered in the Gulf of Alaska.

Tufted Puffin #BP587 was a male we initially captured in late July 2018 while he was brooding his chick, and then was recaptured two years later in June while incubating an egg. Both of BP587's movements to and from his wintering ground location were typical for many of the puffins that we tracked. In September this puffin left Middleton Island and headed to waters beyond the Continental Shelf. By March of both years (when waters are coldest) this puffin was wintering offshore of Canada's Haida Gwaii Archipelago. Our work confirms, for the first time, complete at-sea winter distribution of individual puffins off the continental shelf in the deeper waters of the Pacific Ocean.

The brow of the female Semipalmated Plover (left) is brighter, longer, and more distinct compared to that of the male (right).

SEMIPALMATED PLOVERS

Bolder Eyebrows Reveal the Sex

MARY ANNE BISHOP
ANNE SCHAEFER
Prince William Sound Science Center
mbishop@pwssc.org;
aschaefer@pwssc.org

Semipalmated Plovers, named for the partial-webbing between their toes, are small plovers that breed across the Arctic and sub-Arctic, and winter along both coasts of North and South America. The Prince William Sound Science Center has been capturing and color-banding a population of these plovers that breed on an uninhabited island on the Copper River Delta to determine their annual survival rates.

Survival rates can often vary by sex. While sex in some shorebird species can be determined based on the size of the bill or weight (with females often larger than males), at first glance it appears that male and female Semipalmated Plovers look alike.

Interestingly, one measurement that can be used to help identify the sex of a Semipalmated Plover is its eyebrow! Female Semipalmated Plover eyebrows are typically bolder, longer, and much more distinct than the shorter, often faded eyebrows of the males. When we tested the difference between eyebrow length of males and females using DNA-confirmed sexing results, average eyebrow length for a female was 10.7 mm versus only 6.9 mm for the males, or 1.5 x longer.

Focus on Wintering Seabirds and Oil Tanker Traffic

ANNE SCHAEFER
MARY ANNE BISHOP
Prince William Sound Science Center
aschaefer@pwssc.org,
mbishop@pwssc.org

Every month, approximately 19 oil tankers enter Prince William Sound (PWS) destined for the Alyeska terminal in Valdez. These tankers, some up to 1000 feet, are required to use a well-defined shipping lane in and out of PWS and be escorted by a tugboat. In 1989, the oil laden *M/V Exxon Valdez* tanker strayed from the tanker lane and caused what was then the largest oil spill in history. The spill occurred during late winter and had devastating consequences for marine bird populations: more than one-third of overwintering marine bird species were identified as injured by the spill.

After the spill, the PWS Regional Citizens' Advisory Council (PWSRCAC) was created to promote environmentally safe operation of the Alyeska terminal and associated tankers. Recently, PWSSC researchers Mary Anne Bishop and Anne Schaefer began working with PWSRCAC to identify important marine bird habitat in areas in and around the tanker escort lane. The project aims to document where sensitive bird resources and habitats are located before a spill occurs so responders can prioritize protection of areas before they are damaged.

Results from the first year of surveys emphasized the importance of protected nearshore habitat for marine birds during the winter. Areas warranting priority protection in the case of an oil spill included the bays around Hinchinbrook Entrance, where tankers first enter the Sound from the Gulf of Alaska, and around the Alyeska terminal, where the oil is loaded. Continued monitoring in and around the tanker escort lane are important for understanding marine bird vulnerability to environmental change and anthropogenic disturbance and can be used to inform oil spill response efforts during the nonbreeding season.

Surveying for marine birds in Port Valdez on a calm winter day. *Photo by Anne Schaefer.*

An Exciting Addition to PWSSC's REMOTELY OPERATED VEHICLES

LAUREN BIEN AND NICOLE WEBSTER

Prince William Sound Science Center
lbien@pwssc.org, nwebster@pwssc.org

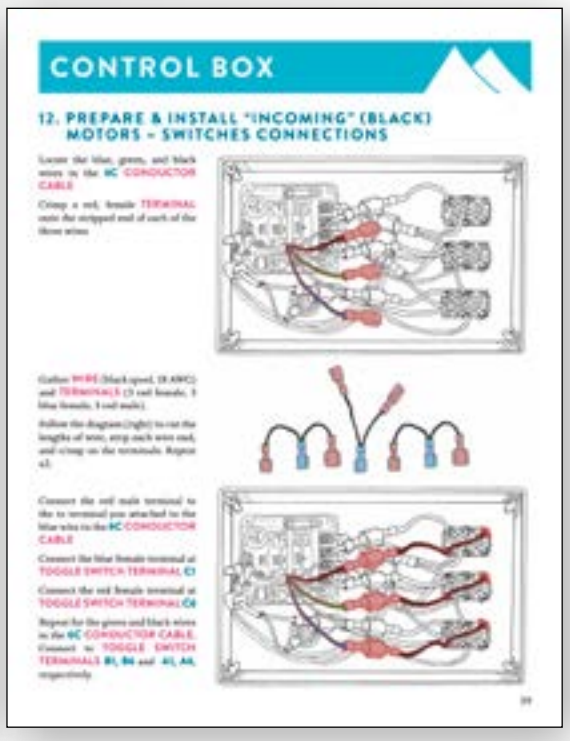
The Remotely Operated Vehicle (ROV) Mock Oil Spill Challenge is a hallmark of PWSSC's STEM-education programs. During the ROV Challenge, students are provided with a kit of materials to construct a unique underwater robot, or ROV. Students use the included PVC pipes and joints to create the ROV's frame, then attach a pre-built system of motors, controls, and battery to the frame. Teams finish the challenge by navigating their ROV through underwater tasks designed to simulate oil spill response.

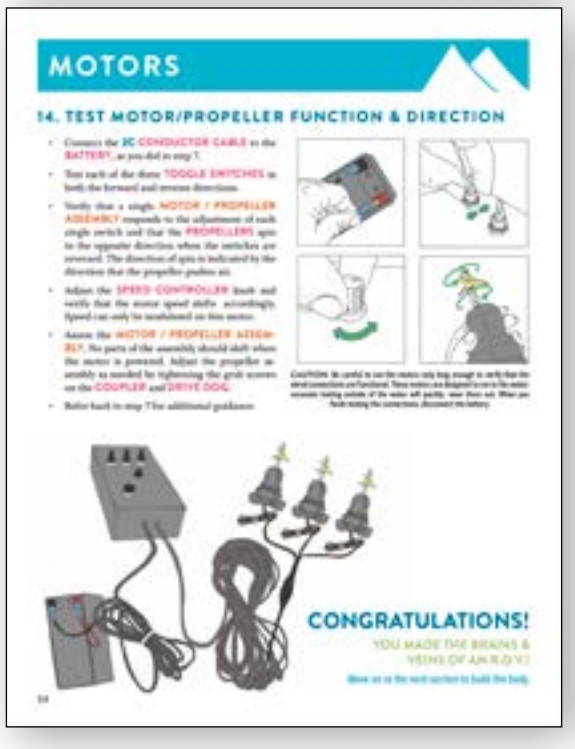
Since 2009, PWSSC has helped hundreds of students design, build, and test ROVs. The ROV Challenge is offered locally to Cordova's sixth graders each year, around the state in remote communities, and is a fixture at an annual statewide science competition in Seward.

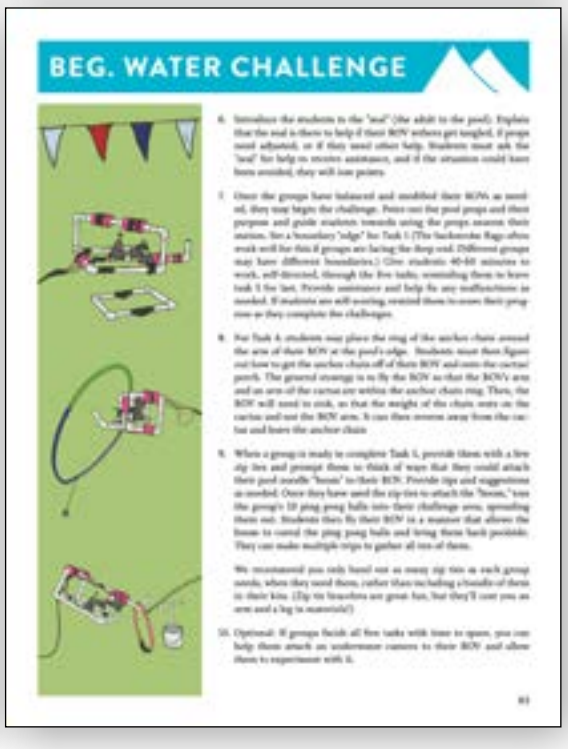
Our educators enjoy bringing the ROV Challenge to communities far and wide and love to cheer on students through the engineering excitement and ocean obstacles. However, the number of participants in the challenge is limited by the capacity of our staff; we can only offer as many challenges in a year as our schedule allows. So, why not provide students and educators with an opportunity to build their own ROV kits? Hence, the exciting new addition to our ROV program – the ROV Kit Build-Guide!

The Guide is not only a practical solution, but also an incredible extension to this program. With the ROV Kit Build-Guide, educators and students can be more hands-on during the engineering phase of ROVs. The Guide walks users through every material and tool we use and shows, step-by-step, how to construct a simple, classroom-ready ROV kit for students. With this Guide, we are excited to reach more classrooms and inspire more students with the ultimate hands-on, STEM opportunity.

This program is generously supported by Prince William Sound Regional Citizens' Advisory Council and Oil Spill Recovery Institute.







Cordova's NOSB team, the GeoSchmucks, in Seward. *Photo by Lauren Bien.*

THE FUTURE IS WATER AND THE YOUTH THAT STUDY IT

LAUREN BIEN
Prince William Sound Science Center
lbien@pwssc.org

If the future is water, we need young people that will continue to ask questions and seek answers about the marine environment, marine life, and the humans that harvest and subsist from its resources. Many of those young Alaskans were in Seward in February for the Tsunami Bowl, Alaska's regional competition of the National Ocean Sciences Bowl (NOSB). NOSB is an academic competition that engages high school students in a quiz bowl focused on all-things-ocean to prepare them for science-related and other STEM careers and help them become knowledgeable, well-informed citizens.

Alaska's Tsunami Bowl is unique in that it additionally requires teams to complete a research project, consisting of a paper and oral presentation, on a topic of their choosing within a larger theme. Each team devotes months of their time – usually after school, on weekends, or during lunch breaks - to research, write, and prepare their project. The completed projects are a testament to the passion these students have for the health and future of the ocean.

This year's theme was Climate Change Mitigation and topics ranged from carbon sequestration through kelp mariculture, solutions to coastal erosion, and creative ideas to reduce carbon emissions such as hydropower, geothermal energy, and cattle feed additives. These students fully immerse themselves and become experts in their chosen topic. It is an awe-inspiring and impressive scene to witness - high school students presenting to their peers and a panel of scientists about unique, local solutions to a global crisis. It truly gives one hope for the future. Not all of these students will enter the field of marine science, but they have fostered a deep understanding and appreciation for the ocean, its diversity, its complexity, and its awesomeness. The future is water and the youth that study it: the future looks bright.

Work accomplished on the Heney Ridge Trail last year using GAOA funds. *Photo by USFS.*

Chugach National Forest Benefits from the Great American Outdoors Act

DAVE ZASTROW
USFS Chugach National Forest
david.zastrow@usda.gov

The Great American Outdoors Act (GAOA) has given the USDA Forest Service increased opportunities to deliver benefits to the American public through investments in recreation infrastructure, public lands access, and land and water conservation.

The Forest Service currently administers more than 370,000 miles of roads, 13,800 bridges, 159,000 miles of trails, 1,700 dams and reservoirs, 1,500 communications sites, 32,000 recreation sites, and 40,000 facilities. Forest Service infrastructure supports more than 300 million recreationists, first responders such as wildland firefighters, and other users of Forest Service roads. Each year, national forests visitors contribute almost $11 billion to the U.S. economy, which sustains more than 148,000 jobs.

GAOA allows national forests and grasslands to address the deferred maintenance backlog for roads, bridges, visitor centers, campgrounds, and other facilities with authorized funding under the Legacy Restoration Fund annually through fiscal year 2025.

GAOA also helps the Forest Service to continue supporting rural economies and communities by contributing to economic growth and job creation. Forest Service economists estimate that projects funded with these dollars will support roughly 4,400 jobs and contribute $420 million to the gross domestic product.

The Chugach National Forest received funding in fiscal year 2021 for projects across all three districts including Cordova, Glacier, and Seward. Cordova Ranger District obtained funding for seven projects and began planning and implementing work on all of them through partnerships, contracts, and Forest Service staff. In the summer of 2022, the district will continue working on several GAOA funded projects including Eyak River Boating Site Rehabilitation, Martin Lake Cabin Reconstruction, Heney Ridge Trail Complex Bridge Replacement, Lake Elsner Trail Deferred Maintenance, McKinley Lake Trail Deferred Maintenance, Sand Trail Deferred Maintenance, and Cordova Trail Deferred Brushing Maintenance.

Projects are accomplished in partnership with local businesses and contractors, non-profit organizations, Tribal partners, volunteers, and national non-profits.

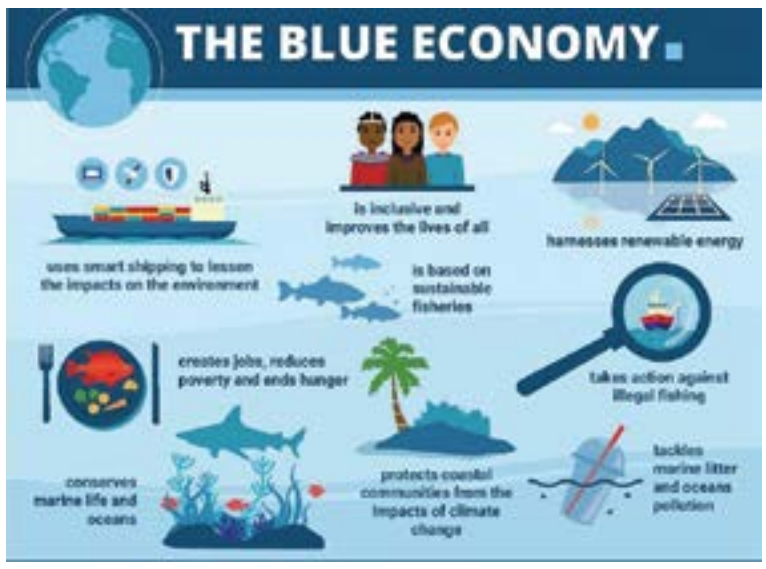
If you'd like to learn more about USDA Forest Service GAOA work, visit the GAOA website at fs.usda.gov/managing-land/gaoa

Prince William Sound fishing boat setting its purse seine net for pink salmon. *Photo by Jeremy Talbott, City of Valdez Harbor Master.*

VALUING OUR BLUE ECONOMY

LINDSEY HAMMER
PWS Economic Development District
programmanager@pwsedd.org

With a striking 3,800 miles of coastline, the communities of Prince William Sound are sustained by their waters. A true natural treasure, home to a diverse range of fish and wildlife, the "inland sea" of Prince William Sound supports traditional lifestyles and numerous ongoing and developing industries. Fishing, mariculture, research, recreation, transportation, tourism, subsistence: the blue economy encompasses everything that makes PWS communities tick. It is the provider of year-round jobs and economic opportunities, and it is our greatest resource. The 1989 *Exxon Valdez* oil spill proved just how precious, and precarious, the balance of our blue economy is. The wake of its destruction painfully showed the necessity of deep sustainability and prioritizing environmental preservation.

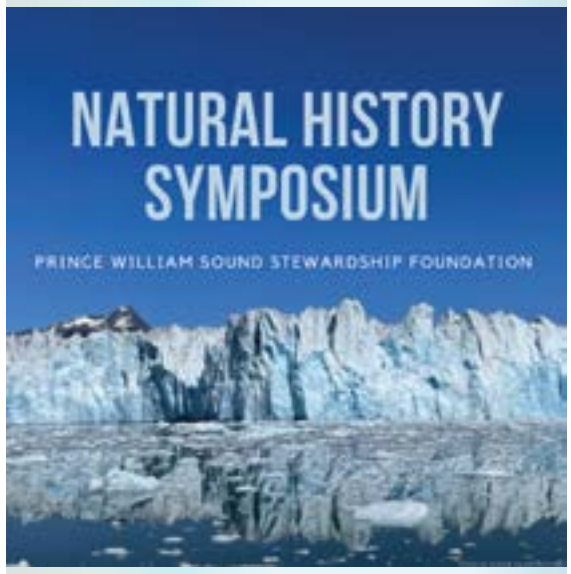


Ocean based industries are considered by many to be 'the last frontier', with huge potential for development, but it must come in a socially, environmentally, and economically sustainable way to have true value. That is the foundation of a blue economy's aim: to ensure the preservation of its future value, a blue economy promotes economic generation from our coast that maintains or improves its natural system. Prince William Sound has a long history of sustainability and a commitment to preserving this balance. We have some of the best managed fisheries in the world, research facilities continuously monitoring our ecology, and a deep, self-evident appreciation for the sound's natural beauty. As we continue to grow our blue economy, we must take care to sustain it as it sustains us. This means engaging in an ongoing process of creatively viewing and reassessing what our coastline and ocean has to offer us, broad research and investment into environmentally sustainable economic production methods, and the application of innovation and new technology. Helping our blue economy to realize its full potential positions us to continue to enjoy the bounty of Prince William Sound for years to come.

Natural History Symposium

CHARLA HUGHS
PWS Stewardship Foundation

The Prince William Sound Stewardship Foundation is thrilled to announce that we will kick off our summer season with our fourth annual Natural History Symposium. What started as an offering to local tour guides and naturalists has grown into a major community event in just a few short years. In 2020 and 2021, the pandemic led us to move the Symposium online. While we are looking forward to gathering in person in Whittier this spring, we will continue the online streaming option to welcome more attendees from across the Sound, the state, and the world.



On May 23, our free day-long event will bring together the latest news and research from the Sound; recordings of all presentations will be available on our website in June. Whether you attend live or view the recordings, you're sure to enjoy learning about topics ranging from kelp farming and aquaculture to unique wildlife like the Kittlitz's Murrelets and what's being done about invasive species. We'll also be introducing our "Student Strand," a selection of presentations highlighted for youth.

In addition to the latest in science, culture, and land management news, the Symposium offers information on how to get involved in stewardship in the Sound, including participating in the Leave It Better marine debris campaign, volunteering with beach clean-ups or trail work, and joining citizen science initiatives. The Natural History Symposium and all these summer projects speak to the heart of the Foundation's mission — helping keep Prince William Sound healthy, clean, and wild, for all to enjoy.

We are grateful to our community business and individual sponsors who make our work possible, and we would like to extend a special thanks to The Tatitlek Corporation, the Exxon Valdez Oil Spill Trustee Council and the PWS Regional Citizens' Advisory Council for their generous support of the Natural History Symposium.

To catch videos of this and past symposia or to register for the live May 23 event, visit princewilliamsound.org. If you're an educator and interested in hosting a watch party or using the symposium in your course materials this semester and/or next year, email info@princewilliamsound.org for more information.

SHELL ACIDIFICATION

CLIMATE CHANGE IS ACIDIFYING OUR OCEANS — AND FAST. IN THIS EXPERIMENT, YOU'LL BE ABLE TO SEE ONE OF THE PROBLEMS IT CAUSES TO MOLLUSKS.

TIME: 1 DAY • **DIFFICULTY:** MEDIUM

WHAT YOU NEED

- Egg shell
- 2 glass jars (no lids needed)
- Tap water
- Vinegar
- Marker
- Paper towels

MAKE IT

1. Crack the egg and rinse the shell. Egg shells are made of the same compound as marine mollusk shells (like clam shells).
2. Place one half of the shell in each of the glass jars.
3. Label each of the jars, one with "vinegar" and one with "water".
4. Fill the jars with enough liquid so that the shells are submerged.
5. Leave them to sit overnight.

TEST IT

Remove the shells from the jars. Place them on a paper towel and then scratch them with your fingernail. Does one seem softer than the other? Now, bend each one and try to break them. Does one break easier than the other?

EXPLAIN IT

Vinegar (acetic acid) is acidic, whereas water is neutral on the pH scale. What this means is that vinegar releases a higher concentration of free hydrogen ions (H+) than water. Mollusk shells, like your egg shells, are made of a compound called calcium carbonate ($CaCO_3$). This chemical is basic, or the opposite of acidic. This means that once this basic compound comes in contact with the acidic vinegar, they undergo a chemical reaction which releases a gas. The vinegar erodes the shell, making it weaker and easier to break.

OBSERVE IT

Climate change is slowly acidifying the ocean, due to the ocean taking in higher levels of carbon dioxide (CO_2) from the atmosphere. Although the ocean will never increase to the acidity of vinegar, it is definitely slowly acidifying now. This could have drastic impacts over time on soft-shelled mollusks. They use their shells for protection, and if the shells are weakened, they won't be useful any more.

GO FURTHER

Put your shells back in the same jars they came from. Leave them there for another day, another week, or even another month. Record your observations every day. What happens to them?

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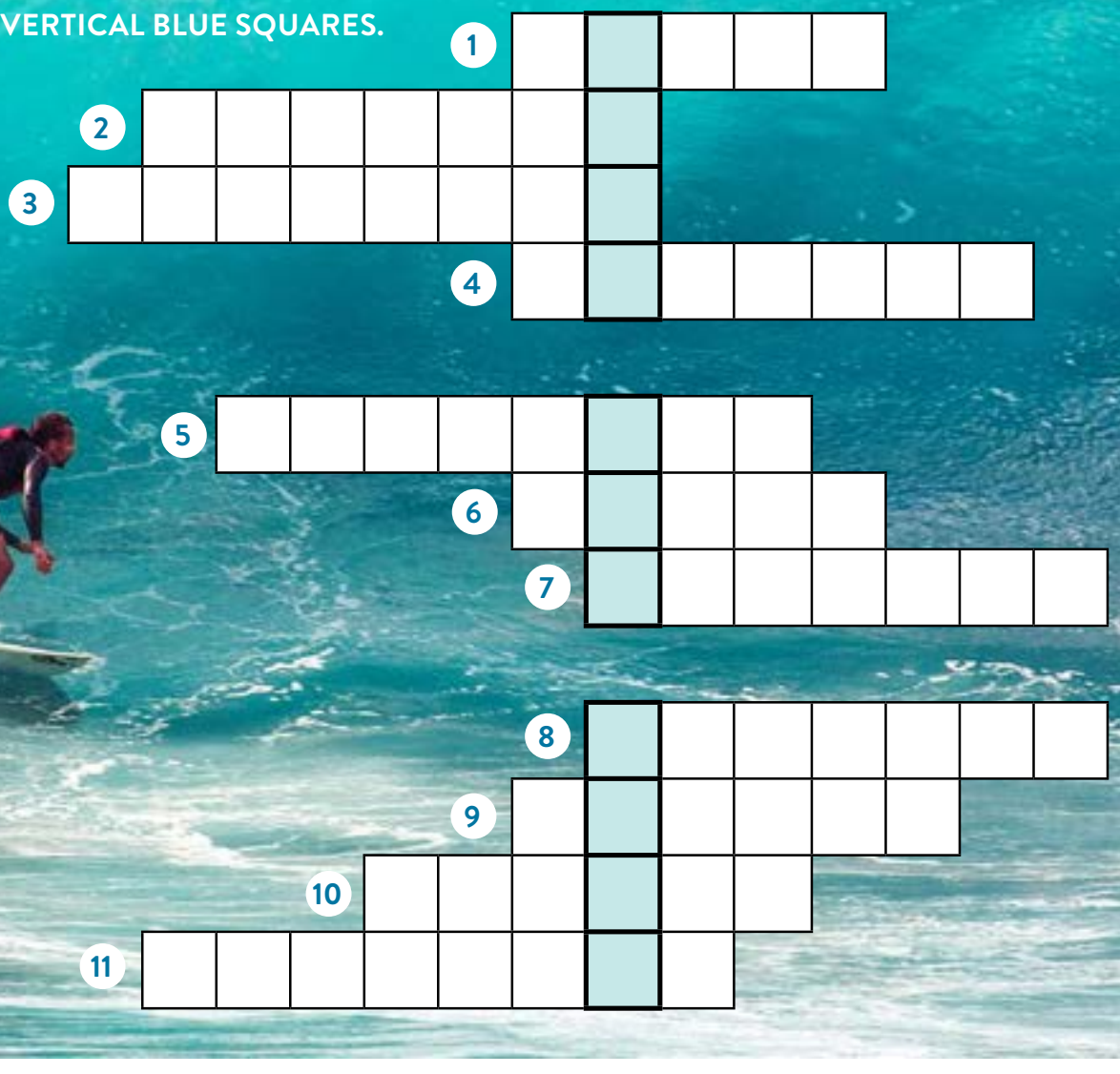
THE FUTURE IS WATER: MYSTERY PHRASE

- FIND ANSWERS TO THE CLUES THROUGHOUT THE PUBLICATION.
- WRITE YOUR ANSWERS HORIZONTALLY IN THE GRID.
- REVEAL THE MYSTERY PHRASE IN THE VERTICAL BLUE SQUARES.

CLUES

1. What kind of bear is pictured on page 7?
2. This academic competition is named after the Japanese word for tidal wave (p16)
3. Complete this term "Remotely _____ Vehicle" (p15)
4. This fish is a key link in the Prince William Sound food web (p4)
5. These critters are "feeling the heat" (p.6)
6. Salmon predator (p9)
7. Blue _____ (p17)
8. What type of buoy is pictured on page 3?
9. What fish is featured on page 8?
10. These birds have brows! (p14)
11. Ocean Data _____ (p12)



OCEAN ACIDIFICATION AND KELP

In the Shell Acidification project, you learned that oceans play a large role in absorbing carbon dioxide (CO_2) from the atmosphere. Because of increased CO_2, the ocean water is becoming more acidic. Fortunately, there are ways we can work towards reversing this problem, one which involves kelp.

Kelp can help improve the ocean's health – and it's good for your health, too!

Sugar kelp and ribbon kelp, both a type of brown algae, are being farmed right here in Prince William Sound! Read on to learn some of their key benefits.

WATER QUALITY ENHANCER: Oxygenates water & balances pH

Kelp counters ocean acidification locally, which benefits people and entire marine ecosystems. It also outputs tons of oxygen through photosynthesis.

CREATES HABITAT: Kelp could enhance fisheries

Kelp provides critical habitat for a variety of forage fish species, like herring, at multiple lifecycle stages.

NATURAL SUPERFOOD: Outstanding health benefits

Kelp is a rich source of Vitamins A, B12, C, D and E, as well as necessary minerals like zinc, iodine, magnesium, iron, potassium, and calcium. Kelp contains 7-12 grams of protein per pound, depending on species.

**Information provided by Noble Ocean Farms/nobleoceanfarms.com*

BLANCHED KELP SALAD

FROM NOBLE OCEAN FARMS

DIRECTIONS:

Chop fresh sugar kelp into thin slices or soak dried kelp before chopping. Boil water and add your sliced kelp to the pot. Watch the kelp turn bright green as it blanches, and remove after 30 seconds. Transfer to a bowl.

Now you can get creative by adding a mixture of any of the following ingredients!

- Sesame oil or soy sauce
- Rice wine vinegar
- Minced garlic
- Diced scallions/green onions
- Dried chili flakes
- Toasted sesame seeds

Bren Smith of GreenWave cranks up a longline of sugar kelp *(Saccharina latissima)*
Photo credit GreenWave.org

SEA OTTER KELP CRAFT

SEA OTTERS CAN OFTEN BE FOUND IN KELP BEDS EATING ONE OF THEIR FAVORITE FOODS — SEA URCHINS! URCHINS LOVE TO GRAZE ON KELP. HAVING SEA OTTERS AROUND HELPS THE KELP GROW HEALTHY AND ABUNDANTLY BY KEEPING THE SEA URCHIN POPULATION LOW.

DOWNLOAD A TEMPLATE AT **PWSSC.ORG/HOME-2/DELTA-SOUND-CONNECTIONS**

GATHER YOUR SUPPLIES:

- Brown paper bag
- Newspaper to stuff the paper bag
- Rubberband
- White printer paper and brown crayon or brown printer paper (optional if printing the sea otter template)
- Scissors
- Glue
- Tissue paper (green, brown)
- Backdrop: flat piece of cardboard painted blue or covered in blue paper

DIRECTIONS

1. Stuff a brown paper lunch bag about 2/3 full with newspaper or other material (shredded paper, etc.)
2. Gather the bag together below the stuffing and rubber band it together Cut the bottom of the paper bag (below the rubber band) into two, creating two sea otter feet.
3. Print out the templates. If printing it out on white paper, color your sea otters brown.
4. Cut out the head, arms, and feet.
5. Glue them onto your stuffed paper bag.
6. Make kelp using tissue paper. Cut long strips of green tissue paper and twist them. Glue to your backdrop.
7. Add some details to your sea otter craft with the baby sea otter.

Adapted from Buggy and Buddy (https://buggyandbuddy.com/sea-otter-craft/)

MYSTERY PHRASE KEY:

1. BROWN
2. TSUNAMI
3. OPERATED
4. HERRING
5. PLANKTON
6. SHARK
7. ECONOMY
8. WEATHER
9. SALMON
10. PLOVER
11. EXPLORER

RIDE THE WAVE

RIDE THE WAVE

The time has finally arrived. The Prince William Sound Science Center will be moving into our new home in summer 2022.

This once-in-a-generation project has been years in the making, and we are excited to have you join us in our new waterfront campus. We'll generate knowledge on important issues, including: climate change, fish, birds, mammals, new industries such as mariculture, a sustainable economy for the region, and science education. This work will happen through carefully planned collaborations, and we'll share our hard-earned knowledge with many people, including scientists, managers, regional community leaders, and school districts around the state.

The Copper River Watershed Project (CRWP), another local nonprofit with whom the Science Center collaborates, received title to over 120 acres of adjacent property whose future uses are restricted to conservation and recreation. Together with other community partners, we are creating a research, education, recreation, and conservation district that will provide community benefits for generations to come.

Good facilities are foundational to understanding this remarkable region, home to Copper River salmon and the world's richest waters. Fundraising for the new campus continues as we finish phase 1 of the campus (the main building) and proceed to future phases, including installation of a seawater system and seawater heat pump for research, education, training, and industry support purposes. Will you support the PWSSC's continuing progress as well as our important mission to advance ecosystem research, science education, and community resilience?

With your help, our work as a nonprofit in one of the world's last, great natural regions will continue for years to come. Ride the wave of success with us!

DONATE NOW

VISIT

PWSSC.ORG/SUPPORT/NEW-BUILDING

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