2019-2020

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 LONG VIEW

On the edge of Vitus Lake, looking north towards Bering Glacier. *Credit: Teal Barmore.*

In 1989, our founders turned an idea into action when they started the Prince William Sound Science Center. The concept of an institute that would build an understanding of the incomparable ecosystems here among the world's richest waters had been batted around for a while, but it was still a risky one. After all, we were incorporated just one month after the *Exxon Valdez* oil spill. The region was in the throes of an environmental, social, and economic trauma that, as it turns out, would continue to have impacts for decades. Research dollars were hard to come by at first. But still, our region was unmatchable when it came to the potential for building an understanding of the way things work in natural systems that are both regionally important and globally relevant.

KATRINA HOFFMAN
President & CEO
Prince William Sound Science Center

The opportunity to accomplish something meaningful was so powerful that our first employees came aboard when nobody quite knew where the money would come from for anybody's paycheck. Yet everybody involved knew that this place was worth studying…not for a few weeks or a month, but over the long haul, because the resilience of our region matters.

We are positioned among thousands of miles of coastline, and adjacent to 700,000 acres of wetlands on the Copper River Delta, the northernmost extent of the coastal temperate rainforest, the largest ice field in the northern hemisphere outside of Greenland, hundreds of salmon-bearing rivers and streams, and some of the fastest moving tidewater glaciers on earth. The Science Center is the only place-based research institute set within the rich lands and rich waters of Prince William Sound and the Copper River Delta, and it is through monitoring and investigations that we have been able to build a body of knowledge and share understanding of how these ecosystems function, how they are changing, why they are so important to the resilience of the communities of our region, and why they matter in the world.

Much of what we do isn't obvious to the casual passerby. For example, we have cameras and instruments moored in the ocean that collect terabytes of data every year and ping it to our office via cell towers so we can track ocean productivity in near-real time. These devices help us detect events such as the Warm Blob, a multi-year ocean heat wave that had cascading effects on the plankton, fish, birds, and mammals of the region. We have a team tagging Tufted Puffins on a remote island in the northern Gulf of Alaska—and when they recapture the geolocator tags, they will learn for the first time where these birds go when they are not in their breeding colony. This information, in turn, may allow us to better understand why the Tufted Puffin population in Alaska appears to be declining. And every year, our education staff engage hundreds of Alaska's youth in hands-on and outdoor science education programs that get them unplugged from devices and charged up by programs that require observation skills, teamwork, and creativity.

Now, after 30 years of impact, we find ourselves looking forward to what the future may hold. It's a time of great changes in ecosystems—changes that are driving unpredictable outcomes for the things that matter to people and the planet. We're taking the long view, because we're deeply invested in this place—one of the last, best places on earth. We hope by reading this publication that you'll become more knowledgeable about and invested in this place, too. If so, please consider making a donation to the Science Center so we can continue to play a role in the region's resilience for a long time to come.

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This tiny copepod (3 mm) stores fat in its orange lipid sac. This fat will allow the copepod to survive during the dark winter months when its food (phytoplankton) is scarce. The photograph was created with a microscope using a technique called focus stacking. *Credit: Caitlin McKinstry*

HOW IS A COPEPOD LIKE A BEAR?

BY CAITLIN MCKINSTRY
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As a skinny bear wakes from his long winter torpor in the spring, there is only one thing on his mind: food. The goal of eating rich and nutritious meals will consume this large mammal for the next eight months. Then, as the days get shorter and food becomes scarce, the bear will return to his secluded place in the woods to sleep through the harsh winter nights relying on his hard earned fat to see him through.

If we bring out our or magnifying glasses and turn our gaze into the ocean, we can see a similar story playing out in the tiniest of ocean creatures. In the spring, millions of tiny (2-8 mm), shrimp-like animals called copepods are waking up from their own unique winter naps to feed on the spring bounty.

Just like bears, copepods "sleep" when food is scarce. This can start in the summer, after all the food produced during the spring phytoplankton bloom is devoured, or in the fall for those lucky copepods that found food throughout the summer. Either way, the harsh dark winters prevent their main photosynthetic source of food from growing. To get through these periods of scarcity, copepods undergo a period of rest scientists call diapause. During diapause, copepods find their own quiet place in the deepest parts (400-1000 m) of Prince William Sound and the Gulf of Alaska. They hunker down and expend as little energy as possible relying on their hard earned fat reserves (see photo) they accumulated until the next spring phytoplankton bloom begins. Environmental cues (e.g. longer days/more sunlight) let these little critters know when it's time to wake up and start the feast. After copepods have filled their bellies with phytoplankton, they molt into adulthood to produce the next generation of zooplankton.

NEW CITIZEN SCIENCE

OPPORTUNITY IN THE WILDERNESS STUDY AREA

Popular camping areas like this beach in Blackstone Bay often show changes in the amount and type of vegetative cover. *Credit: Barbara Lydon*

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The Chugach National Forest has updated protocols for monitoring the condition and distribution of dispersed recreation sites in western Prince William Sound. The updated methods align with the latest national protocols and open new opportunities for citizen science.

Dispersed recreation sites are beaches and other areas where human use has created physical impacts such as cut trees or reduced vegetative cover. Monitoring sites in the western Sound began in the mid-1990s with separate efforts by Chugach National Forest managers and Alaska Pacific University, led by Paul Twardock.

Data have helped describe visitor trends and inform the Forest Service about conditions in the Nellie Juan-College Fjord Wilderness Study Area, which comprises nearly 2 million acres around the western Sound.

Previous methods used paper forms, site sketches, and a potentially subjective rating system, which were later entered into electronic format. The new protocol is more streamlined and objective and uses ArcGIS Collector software loaded onto a phone or tablet. Data are automatically synched to a GIS layer and a Microsoft Access database. The new process enables greater participation by citizen scientists.

The Chugach National Forest thanks Matt Quinn for spearheading the effort. Matt performed the work during a fellowship offered through the Society for Wilderness Stewardship, a national organization providing support for federal wilderness and wilderness study areas.

PRINCE WILLIAM SOUND 2018 CLIMATE SUMMARY

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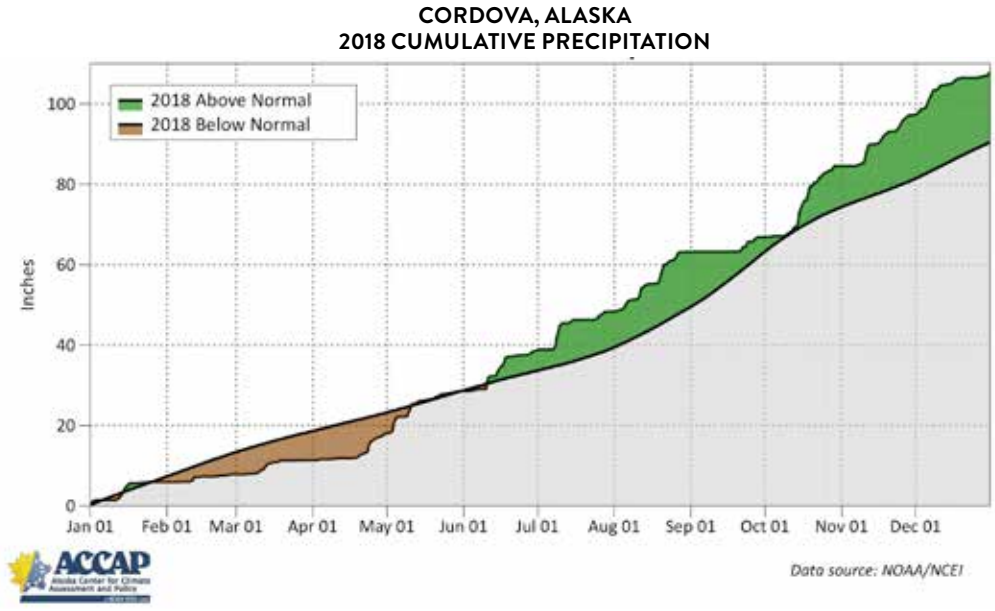
Overall, 2018 was a wet year around the region, with total rain and melted snow generally 10%-20% above normal. At the Merle K. (Mudhole) Smith Airport in Cordova, total rainfall of 108 inches (9 ft) was the most for any year since 1993. While the year as a whole was wet, the biggest monthly highlight was the very dry September. The Cordova airport reported the driest September since observations began in 1945.

Snowfall was also way below normal in 2018. In spite of near-normal snow in December, Valdez reported less than half of normal snowfall for the year. The April 1 snowpack at low and moderate elevations was generally only 40%-75% of normal, and in the autumn, snow packs were established later than usual. By New Year's Eve, the snowpack was again only 40%-75% of normal.

Like the rest of Alaska, temperatures averaged warmer than normal. The annual average temperature at the Cordova airport was 41.1°F, 1.5°F above the 1981-2010 normal.

MERLE K (MUDHOLE) SMITH AIRPORT
CORDOVA, ALASKA
2018 CUMULATIVE PRECIPITATION



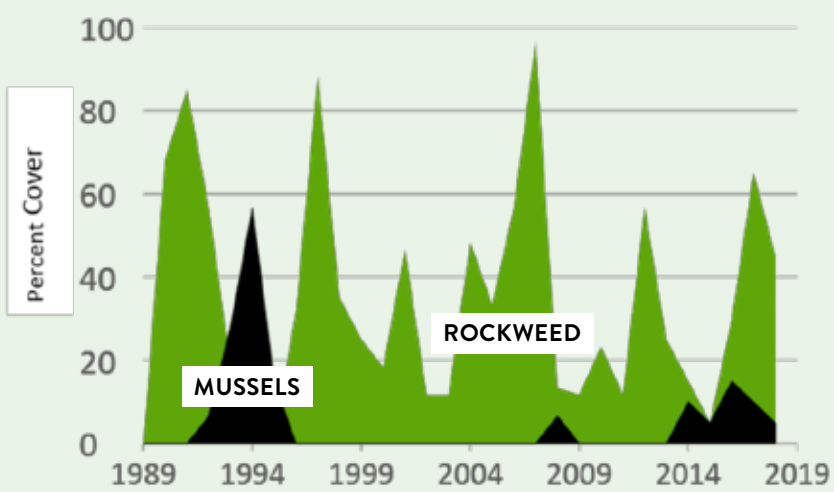
Mearns Rock, photographed over the past 29 years. *Credit: Alan Mearns*

FIND YOUR ROCK

PHOTO MONITORING TRACKS DRAMATIC YEAR-TO-YEAR VARIABILITY OF MARINE LIFE ON SHELTERED ROCKY SHORES

ALAN J. MEARNS
NOAA, retired

Since 1989, during summer low tides, NOAA scientists, contractors, and volunteers have been visiting and photographing more than a half dozen shoreline sites in western Prince William Sound. Individual photos don't reveal much, but when collected together over several decades, these annual images reveal dramatic variations in the abundance of dominant marine life: namely the cover of seaweeds, mussels, and barnacles. The composite collection from one such site in Snug Harbor, Knight Island—affectionately named "Mearns Rock" by a colleague—shows 29 consecutive annual photos spanning nearly 30 years.



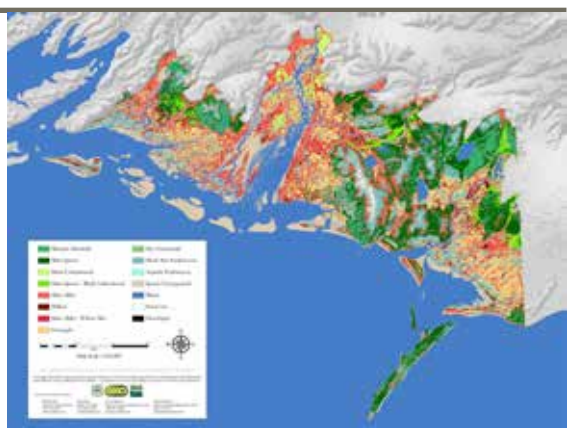
Rough estimates of the percent cover of common rockweed and mussels from 1989 to 2018.

Rough estimates of the percent cover of common rockweed and mussels for each year are shown in the graph. The graph, and certainly the photos, indicate the "common" species are not always abundant: Rockweed cover varied between "big years" (such as 1991, 1997, 2006 and 2017) and "poor" years (such as 1994, 2002/2003, 2007/2008, and 2015.) Mussels had only three periods of abundance at this site: 1993-94, 2008, and 2014-17.

Given this variability, what is "normal"? Looking at the graph, the "mean" or "average" rarely occurs. Perhaps what is normal is simply the natural range of variation itself. But you won't know that unless you watch and better yet, photograph, over many years.

The Prince William Sound Science Center (PWSSC) is seeking annual photos, like these, for other sites in the Sound. Do you have a favorite shoreline or location that you visit, especially during summer low tides? Maybe a family site or a school field trip location? If so, think about starting your own annual photo series and sending the photos to Dr. Scott Pegau at the PWSSC! In short, find your own rock!

Special thanks to David Janka, Auklet Charter Services; Scott Pegau and Rob Campbell, OSRI/PWSSC; and over a dozen other volunteers.



Copper River Delta vegetation map.

MAPPING VEGETATION IN EASTERN PRINCE WILLIAM SOUND

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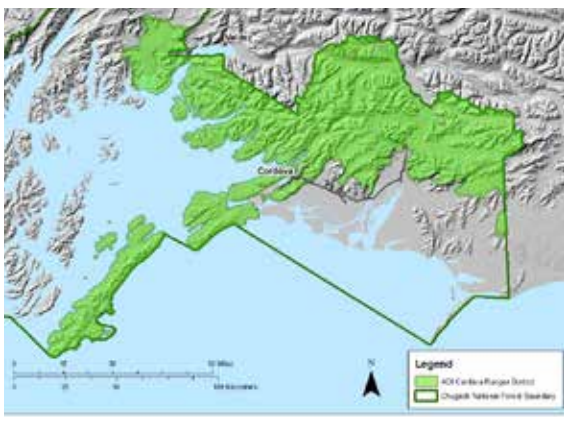
Maps of existing vegetation support resource management by informing project-level planning efforts with vegetation data that can be used in numerous applications. For example, an existing vegetation map was completed for the 1.1 million acre Copper River Delta project area in 2011 (above). It has been used to determine locations and quantities of suitable moose habitat to identify areas that may benefit from enhancement activities. Other uses of this map have included identifying rare and sensitive species habitat and climate change analysis.

The U.S. Forest Service, in coordination with other land owners in eastern Prince William Sound, seek to expand this vegetation mapping effort to include an additional 2 million acres across eastern Prince William Sound and north to the USFS boundary in the Copper River watershed. The project area will also include Columbia Bay within the Nellie Juan-College Fjord Wilderness Study Area (below).

This project will use remotely sensed imagery captured from the 2011 mapping effort to initially identify patterns in the vegetation that would define different plant community types. These patterns can be elucidated both visually and through modelling spectral signatures (i.e. the measurement of the wavelengths of light, both visible and invisible, given off by an object). The Copper River Delta effort mapped a total of 15 land cover types with 11 vegetation classes.

Once map classes have been determined for this effort, plots representing these classes will be identified for visual field confirmation known as "ground truthing." In the summer of 2019, crews will hike into these sites or inspect them visually from the air to determine their dominant plant species. This ground truthing effort will span two field seasons, producing data that will be fed into computer models to generate a final vegetation map of the area. The final map product is anticipated to be completed in 2022.



Cordova Ranger District vegetation mapping area. Columbia Bay is located in the upper left of the area of interest.

COMPUTERS TO IDENTIFY PLANKTON IMAGES FROM PRINCE WILLIAM SOUND

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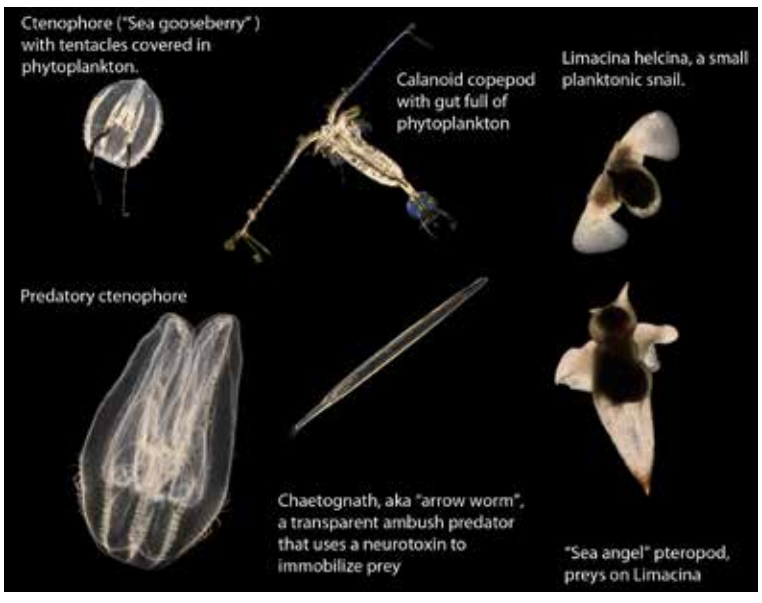
Plankton form the base of the marine food web. Tiny single-celled plant plankton (phytoplankton) grow and are consumed by animal plankton (zooplankton) grazers; zooplankton are food for larger animals like fish, birds, and whales. The amount and type of plankton present changes within and among years, and measuring them is not easy. Going out and collecting them from ships costs thousands of dollars per day for the ship; taxonomists must manually identify everything that is in the sample. But new technologies, like underwater cameras, offer new ways to estimate plankton abundance.

In 2016, an in-water plankton camera was developed and installed on an autonomous robotic profiler that is deployed every year in central Prince William Sound from spring to autumn. From over 1000 twice-daily profiles from 60 meters to the surface done so far, over 2 million images of individual plankters have been collected. Current work is using Deep Learning techniques similar to those used by Google to automatically identify images on the internet, to identify the different kinds of plankton and what they are doing (e.g if they are feeding). At present the computer can identify plankton from 34 different classes to an accuracy of about 90 percent.



RIGHT: A selection of images of plankton captured by the plankton camera.

Researchers collect fecal samples from gulls that congregate on the docks in Cordova to understand the prevalence of avian influenza in wild bird populations.
Credit: Anne Schaefer

SAMPLING POO FOR AVIAN FLU

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Infectious diseases that can be transmitted or shared by animals and humans are known as zoonotics. One zoonotic that you may be familiar with is avian influenza, or bird flu. Although birds can host many influenza strains, only a few strains pose a risk to humans.

Gulls and shorebirds are vectors for influenza reassortment, meaning they can develop new influenza strains by recombining genetic material. Dr. Mary Anne Bishop of the Prince William Sound Science Center has been working with Drs. Jon Runstadler and Nichola Hill of Tufts University to study the prevalence, transmission, and evolution of influenza viruses in shorebirds and gulls in Cordova and on the Copper River Delta.

One method researchers use to study influenza prevalence in wild birds is by fecal sampling. Each year, hundreds upon hundreds of fresh droppings are collected on cotton swabs and then preserved in special viral transport media, frozen, and sent to Dr. Runstadler's lab where the samples are screened for influenza.

Researchers begin sampling in April when gulls and shorebirds migrate north for the breeding season, continues through the summer when gulls congregate on the docks and rooftops of Cordova, and ends in October after birds have flown south for winter.

The fecal samples, combined with samples collected from captured wild birds, abundance survey data, and mark-resight data from banded birds, will help researchers understand the factors that are important to the evolution of new viral strains and potentially enable researchers to predict when and how outbreaks of zoonotic pathogens may occur.

RESOLVING THE ANNUAL PELAGIC DISTRIBUTION OF TUFTED PUFFINS IN THE GULF OF ALASKA

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The Tufted Puffin is one of Alaska's most iconic seabirds. Populations of Tufted Puffins throughout the Gulf of Alaska, numbering well over 150,000 birds, have historically been considered at least stable or increasing. However, recent research suggests that these Tufted Puffin populations are declining and are predicted to continue to do so in the future.

From 2014 through 2016, the Gulf of Alaska experienced rapid environmental change due to a persistent marine heatwave, which included a significant die-off of other seabirds such as Common Murres. Resolving little known aspects of the ecology of Tufted Puffins is important for better understanding the species' vulnerability to rapid changes in the marine environment. While much is known about Tufted Puffin breeding ecology, the migratory routes and wintering areas of the species in the Gulf of Alaska are currently not known.

In 2018, researchers at Prince William Sound Science Center initiated a two-year study to examine the at-sea distribution of Tufted Puffins during the non-breeding season. Our study is being conducted at Middleton Island, 70 miles offshore in the middle of the Gulf of Alaska at the edge of the continental shelf where thousands of Tufted Puffins breed. In late July 2018 during the chick-rearing period, we captured adult puffins at their nest burrows. Each puffin was weighed and measured, and blood and feather samples were collected for carbon and nitrogen stable isotope analysis.

Lastly, each puffin was leg-banded with an archival geolocator tag that measures ambient light levels. This summer, researchers will recapture these tagged puffins at their burrows to remove geolocators and download the data, which will reveal the geographic locations of Tufted Puffins during winter. Stable isotope values of feather and blood samples will provide a measure of food web interactions occurring during early spring (feathers) and early summer (blood).

Future analyses will investigate the relationship between the non-breeding season location data obtained from the geolocator tags and stable isotope values derived from the blood and feather samples.

Research assistant Anne Schaefer poses with a Tufted Puffin on Middleton Island, July 2018. *Credit: Kristen Gorman*

(Left) Upclose shot of a geolocator and tag. (Right) Geolocator and tag on a Tufted Puffin. *Credit: Anne Schaefer*

TAKE ONE, LEAVE ONE

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Fresh gull eggs are a traditional food for many native Alaskans. On the Copper River Delta, gull eggs can be legally harvested between May 1-31 by residents of Cordova that have obtained a subsistence permit from either the Native Village of Eyak or the USDA Forest Service Cordova Ranger District.

Glaucous-winged Gulls, the most abundant gull on the Delta, typically lay a three-egg clutch. What happens when eggs are collected from the nest? It depends on the timing. If eggs are harvested during the egg-laying period, the female will continue to lay replacement eggs until the clutch is again complete. However, if the clutch is removed after incubation has begun, the female must wait 12 to 13 days for follicle development before she can lay a replacement clutch.

So how can a subsistence egg gatherer be sure to get a fresh egg and minimize disruption to nesting gulls? The best advice is to take a single egg from a two-egg nest. This ensures that the egg is fresh, and importantly, reduces the likelihood of nest abandonment. An egg collector can also doubly confirm egg freshness by gently placing the egg in a clear container with lukewarm water. If the egg sinks to the bottom and lays flat, or if the larger round end floats upwards at an angle of 25° or less, it is fresh. However, if the egg floats vertically or is suspended in the water, that means an embryo is developing inside and the egg should be returned to the nest.

Glaucous-winged Gulls typically lay a clutch of three eggs in nest scrapes lined with grass, moss, or seaweed. *Credit: Kirsti Jurica*

INVASIVE
AQUATIC PLANT STUDY

U.S. Forest Service researches the invasive aquatic plant, *Elodea*, on the Delta. *Credit: USFS*

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Introduced into Eyak Lake near Cordova, *Elodea* is the first invasive aquatic plant established in Alaska. Thought to be introduced from an aquarium dump into the lake prior to 1982, *Elodea* has spread though flooding and floatplanes to major waterbodies, ponds, and side sloughs across the Copper River Delta.

The U.S. Forest Service (USFS) Chugach National Forest, in collaboration with researchers at USFS Pacific Northwest Research Station, Loyola University, U.S. Geological Survey, and University of Notre Dame have been studying the effects of several small-scale herbicide treatments on native aquatic plants, macroinvertebrates, water chemistry, and fish. The USFS is also exploring the ecological role of this invasive aquatic plant on the Delta.

Treatment of three ponds and a small slough near Eyak River were completed from 2016 to 2018. Preliminary results on impacts to aquatic organisms will be available in 2020 following an additional year of monitoring. In 2019, USFS will begin treatments in a pond west of Alaganik Slough harboring species of salmon to determine effects of herbicide treatment of *Elodea* on fish. A final report on the feasibility of eradication and effects of treatment, as well as the effects of *Elodea* on native aquatic organisms where the invasive plant continues to thrive is expected in 2022.

Footage of a female Dusky Canada Goose leading her brood of eight away from the nest site (seen just behind in the sweet gale).

THE DUSKY DILEMMA

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The primordial call of the Sandhill Crane and the gregarious chatter of geese are signs of spring on the Copper River Delta. Dusky Canada Geese (hereafter, Duskys) are large, white-cheeked geese that breed almost exclusively on the Copper River Delta. Over the years, the number of Duskys returning to the Delta has decreased due to habitat and subsequent predator changes.

Since the Good Friday earthquake of 1964, Sitka spruce and black cottonwoods have increased across the landscape providing elevated perches for avian predators such as Bald Eagles. Eulachon (a.k.a. hooligan, a small, anadromous fish) are the preferred food source of Bald Eagle, but eulachon numbers fluctuate throughout the spring and summer.

When eulachon numbers are low, Bald Eagles turn their attention to other food sources, such as eggs. In 2018, the U.S. Forest Service and U.S. Geological Survey, launched a project to investigate predator influences on Dusky nest success. Time-lapse cameras were deployed on 78 nests to monitor success or failure and identify nest predators. The camera footage provided a glimpse into the life of a nesting Dusky on the Delta.

Though the footage was disheartening at times it was also very insightful. Eagles, coyotes, and bear were all caught with their paws (and talons) in Dusky nests. Eagles, however, were the main culprit of nest failure. Although some nests were destroyed, many of them survived. Over half of the Dusky nests monitored on the Delta in 2018 hatched goslings! Time-lapse cameras will be deployed again in 2019 to further pinpoint patterns influencing Duskys.

A group of Bald Eagles take turns destroying a Dusky Canada Goose nest.

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)

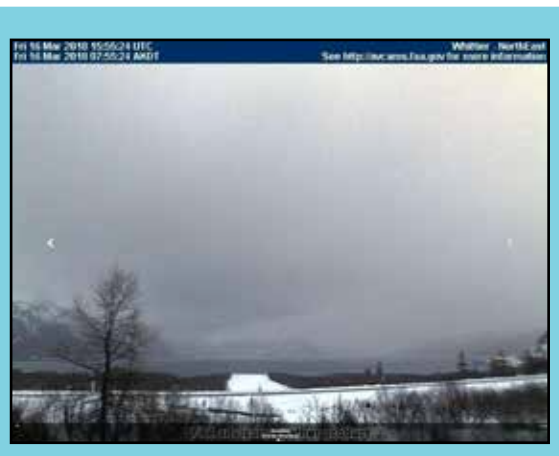
KINGFISHERS
- ❑ Belted Kingfisher

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

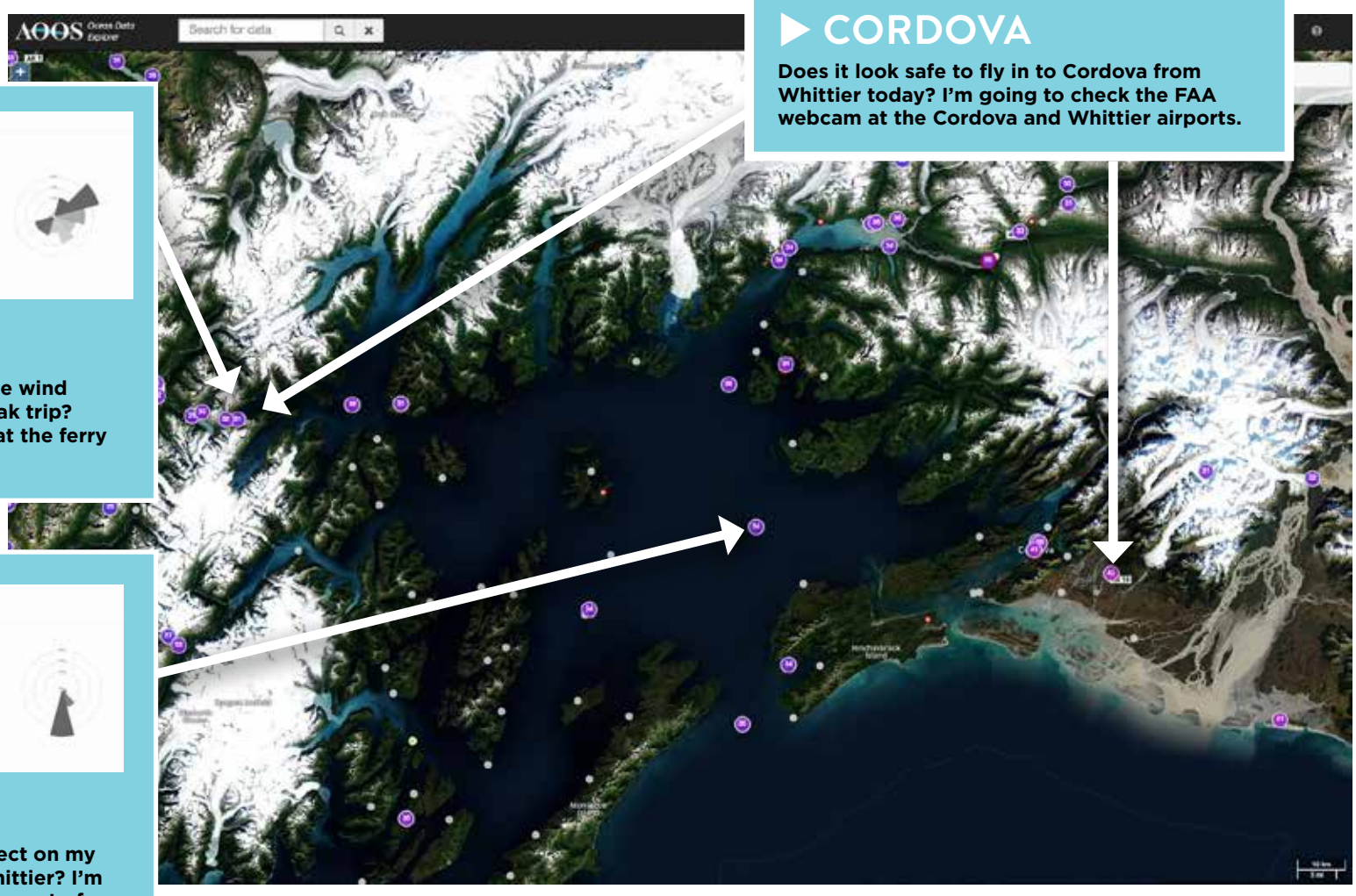
OCEAN DATA EXPLORER

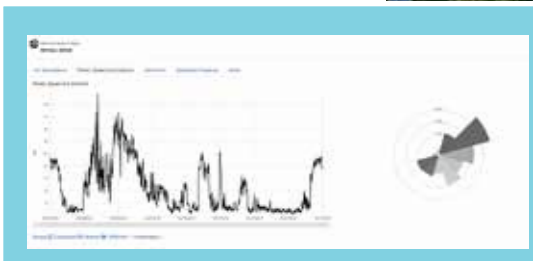
The Ocean Data Explorer (ODE), the Alaska Ocean Observing System's (AOOS) data portal, uses cutting-edge technology to deliver data and information about the oceans and coasts of Alaska to stakeholders. The ODE allows the user to search for current, recent, and historical information, that can then be viewed as a "layer" overlaid on a map or in the form of a graph or chart. The information can also be downloaded directly for sorting or use in its raw form. Data is all around us and important resources have been used to collect this information; the AOOS data portal provides a way for users to find what information they need and helps them use it to make decisions.



▶ CORDOVA

Does it look safe to fly in to Cordova from Whittier today? I'm going to check the FAA webcam at the Cordova and Whittier airports.





▶ WHITTIER

What speed and direction is the wind blowing in Whittier for my kayak trip? I'm going to check the sensor at the ferry dock in Whittier.

▶ BOAT TRIP

What kind of waves can I expect on my boat ride from Cordova to Whittier? I'm going to check the wave buoy west of Orca Bay.

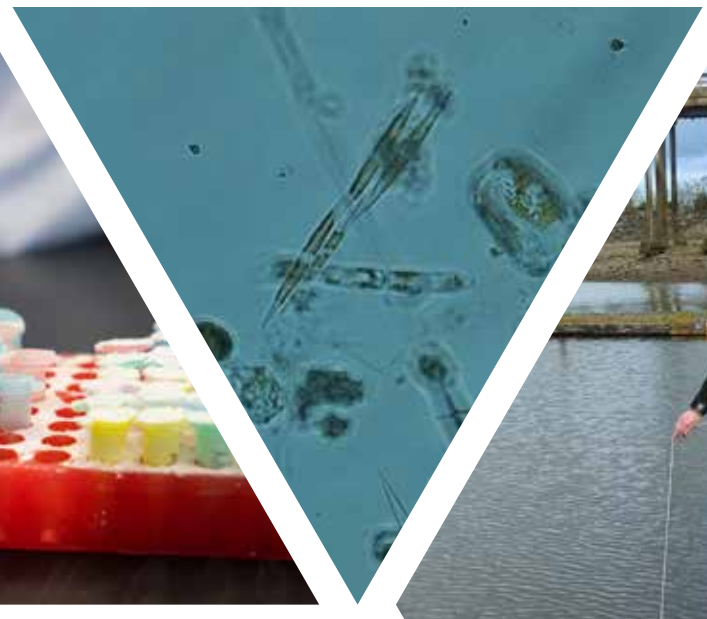
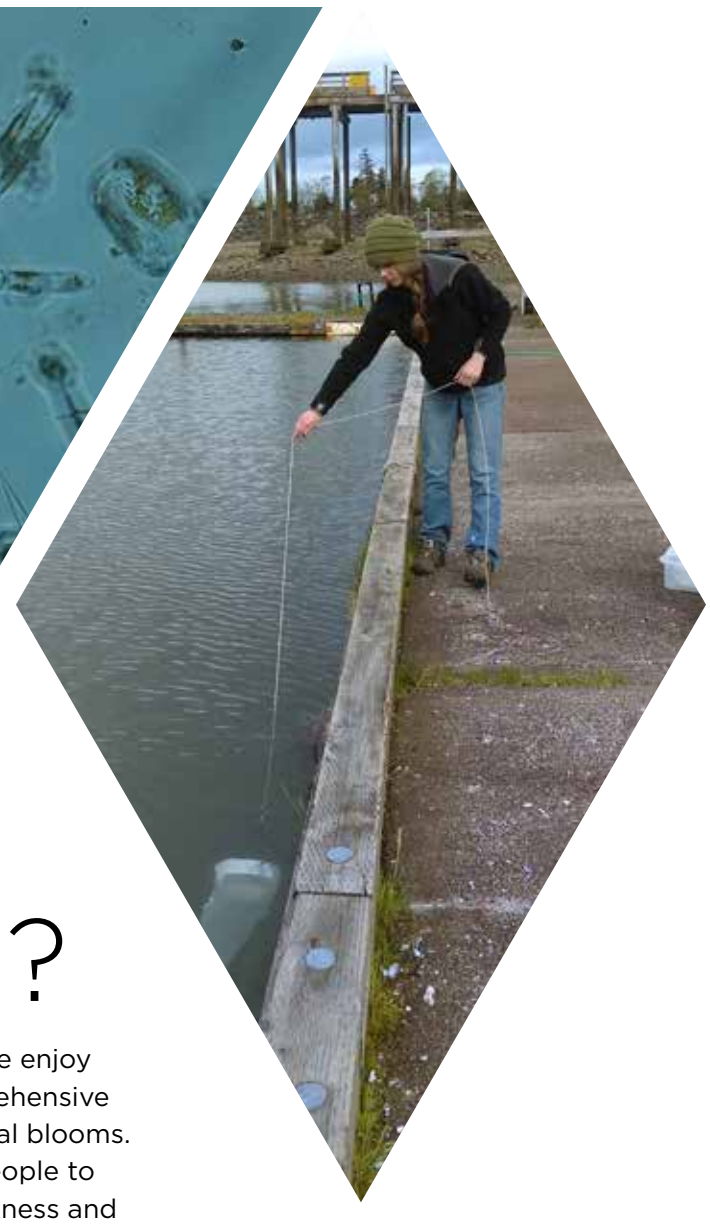
FILLING GAPS IN WATER LEVEL INFORMATION

Accurate and timely water level information is critical for the people of Alaska whose lives depend on the ocean for fishing, shipping, and subsistence. AOOS hosts the Alaska Water Level Watch working group combining resources from many agencies in Alaska to create an integrated water level observation network. The group produced a report identifying where the most critical gaps in information exist including up to six areas in Prince William Sound that need better coverage. The Alaska Water Level Watch working group is finding resources to fill these gaps.

AOOS has developed unique partnerships with two organizations to use GPS reflectometry to collect high quality water level data, with no need to put sensors in the water. AOOS is working with ASTRA, a private company that uses GPS receivers for space weather research and UNAVCO, a private research organization that uses GPS/GNSS receivers to measure ground movements for earthquake research to apply the same technology to measure water levels. Once this technology has been proven effective and efficient it could be used to fill gaps in water level information in Prince William Sound.

Alaska Department of Natural Resources employee Jacqueline Overbeck using a water level measuring instrument.



Alaska
Harmful Algal Bloom Network

IS IT SAFE TO EAT THE CLAMS?

This is a common question in Alaska, where shellfish are plentiful and many people enjoy wild food. However, unlike much of the Lower 48, Alaska does not have a comprehensive state-sponsored shellfish monitoring program to test for toxins from harmful algal blooms. Consequently, no beach is officially "safe" for recreational harvest. This leaves people to harvest shellfish at their own risk, and harmful algal blooms have periodically caused sickness and occasionally death. Commercially sold shellfish is tested and deemed safe before sale.

▶ WHAT ARE HABS?

Algal blooms are caused by phytoplankton—microscopic, plant-like organisms that form the basis of the marine food chain. When phytoplankton are exposed to the right conditions they can "bloom", or multiply extremely rapidly. In general, more phytoplankton means more food and oxygen for everything else in the ocean, but occasionally plankton blooms are hazardous to human or marine life. These are known as "Harmful Algal Blooms" or HABs. Paralytic Shellfish Poisoning is caused by an algal bloom that produces a toxin ingested by shellfish.

▶ THE DANGERS OF HABS

HABs can impact humans and other marine species, and they come in a variety of forms. Some produce toxins that directly poison humans, marine mammals, shellfish, or fish. Some algal types have sharp spines that harm fish gills. In especially dense blooms of other phytoplankton species, opaque or dark-colored cells can make it difficult for marine predators to find prey. Poisoning in humans usually comes from eating a contaminated organism such as clams, mussels, or other shellfish. Symptoms of HAB poisoning include nausea, vomiting, diarrhea, skin or throat irritation, and breathing difficulties. Because HABs are more likely with warmer water temperatures, blooms in Alaska are most common in the summer.

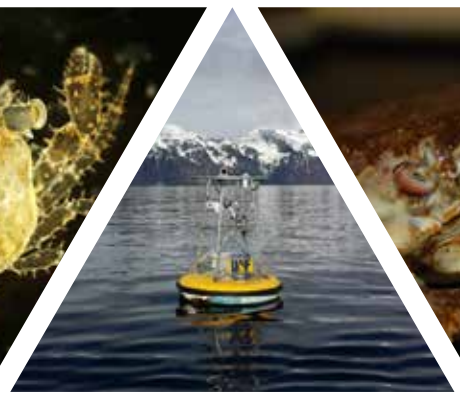
▶ BUILDING A STATEWIDE NETWORK

The Alaska Harmful Algal Bloom Network (AHAB) was formed in 2017 to provide a statewide approach to HAB awareness, research, monitoring, and response in Alaska and to better inform recreational harvesters and prevent poisoning. AHAB coordinates a diverse group of coastal stakeholders to address human and wildlife health risks from toxic algal blooms. Among AHABs members are research institutions, public health and resource management agencies, tribes, and local communities. While monitoring efforts do not span the entire state, efforts are growing. Current monitoring takes place in specific beaches in Southeast, Kachemak Bay, Kodiak, and parts of the Aleutian islands. Visit the AHAB website to learn more and view recent monitoring results. aoos.org/alaska-HAB-network

OCEAN ACIDIFICATION UPDATE

Alaska Ocean Acidification Network

AOOS established the Alaska Ocean Acidification Network in 2016 to engage with scientists and stakeholders to expand the understanding of ocean acidification (OA) processes and consequences in Alaska.


WHAT IS OCEAN ACIDIFICATION?

Scientists estimate that the ocean is thirty percent more acidic today than it was 300 years ago, traceable to increasing levels of atmospheric carbon dioxide (CO_2) generated by humans. As CO_2 is released into the atmosphere by human activities, about half of it stays there and much of the rest is absorbed by the ocean. This lowers the pH and increases the acidity of seawater, changing the environment for the organisms that live there.

WHY IS OCEAN ACIDIFICATION A CONCERN FOR ALASKA?

Some of the species most susceptible to OA often include the basis of the food chain, so researchers expect the effects of OA to be felt throughout the marine ecosystem. This could dramatically affect the lives and livelihoods of Alaskans, including many who rely on wild foods and the $5.8 billion Alaska seafood industry. OA in Alaska is expected to happen faster than in other regions due to its cold water, which can absorb more CO_2. Since Alaska is already close to the tipping point due to natural factors, an increase in ocean acidification could have major impacts.

HIGHLIGHTS:

▶ New State of the Science Report Published: The Alaska Ocean Acidification Network published its first annual "State of the Science" report in November 2018. The report provides clear and understandable information explaining the process of OA, what Alaskan species are affected and how, the combined effects of OA and warming oceans, and types of monitoring being used in Alaska.

▶ Ocean Acidification in the Classroom: High school teachers in Alaska can now borrow ocean acidification kits to conduct hands on experiments in their classrooms. The kits are adapted from the C-MORE science program curriculum and allow students to produce and track measurable results. Additional curriculum resources can be found on the new "For Educators" page on the Alaska OA Network webpage.

▶ Ferry for Science: The state ferry *M/V Columbia* has just completed one year of OA data collection during its weekly run between Bellingham, Washington and Skagway, Alaska. This partnership between research entities and the Alaska Marine Highway System provides a unique window into nearshore water chemistry and seasonal trends and will give scientists the opportunity to identify local hotspots. Keep an eye out for results!

▶ Tribal involvement: Native Alaskans depend on wild food for nutrition and culture and are becoming key players in OA monitoring efforts. Tribes in Lower Cook Inlet, Prince William Sound, and Southeast Alaska are taking water samples near their communities and sending them to Alutiiq Pride Shellfish Hatchery in Seward or the Sitka Tribe of Alaska lab in Sitka for analysis. These samples will help build an understanding of baseline conditions and local influences that can help Tribes plan and respond. The Alaska Ocean Acidification Network recently launched an OA Tribal Research Working Group to help spread community monitoring efforts to other parts of the state.

▶ Species response: How will Alaska species respond to more acidic conditions? Research in this area is expanding. The NOAA Lab in Kodiak has been involved in multi-year studies looking at crab, and for the last two years University of Alaska researchers have done experiments on clams at the Alutiiq Pride Shellfish Hatchery in Seward. Starting this summer, NOAA's Kasitsna Bay Lab in Kachemak Bay and the Sitka Sound Science Center will be studying species response as well. Most species studied so far have shown negative affects to acidified waters, but scientists except there to be winners and losers. One of the big questions is the ability for Alaska species to adapt.

Herring Bay was a heavily oiled bay during the spill and still has small pockets of subsurface oil but has largely returned to its pristine profile. *Credit: Mandy Lindeberg*

30 YEARS SINCE THE *EXXON VALDEZ* OIL SPILL:

AN ERA OF SCIENTIFIC RESEARCH AND MONITORING THAT HAS CHANGED OUR UNDERSTANDING OF OIL SPILL IMPACTS

Sampling persistent *Exxon Valdez* oil in 2002 to look at its chemical composition and how well it is weathering in the environment. *Credit: Mandy Lindeberg*

Heavily oiled beach in 1989. *Credit: Mandy Lindeberg*

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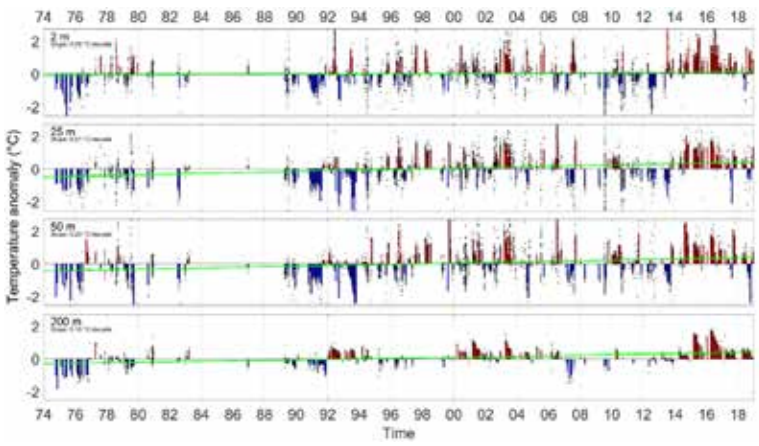
Clean-up crews preparing boom before washing an oiled beach. *Archive photo provided by ARLIS.*

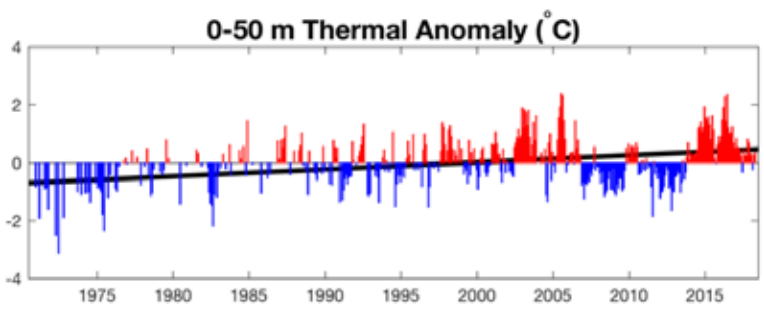
Thirty years ago, on March 24, 1989, the *Exxon Valdez* ran hard aground on Bligh Reef, Prince William Sound. This is long enough ago that much of the public has a hard time relating to the spill. For the spill-affected and scientific communities, the three decades since the spill represent a legacy of change on many levels. To set the stage, think about the technology scientists had in 1989: Intel introduced the 486 processor, Windows 2.11 MS-DOS was released, there was only dial-up access to the internet, no World Wide Web, no cellular phone service in Prince William Sound, and GPS navigation was in its infancy. Still not ringing a bell? Maybe this will—Nintendo introduced the first Gameboy.

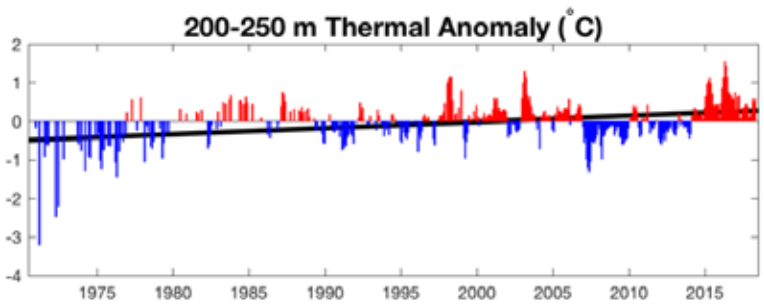
Initially, scientists came to the spill with the expectation of conducting short one to two year injury assessment studies, but for some it became an entire career as they tried to disentangle spill effects from ecosystem variation.

It eventually became clear that a new, holistic approach was needed to understand what resources were injured and whether they would recover. With help from spill affected industries and communities, the scientific approach prevailed and the *Exxon Valdez* Oil Spill Trustee Council established a rigorous structure for assessing impacts and monitoring ecosystems based on two key restoration objectives: 1) restoration should contribute to a healthy, productive, and biologically diverse ecosystem within the spill area that supports the services necessary for the people who live in the area, and 2) restoration will take an ecosystem approach to better understand what factors control the populations of injured resources. This framework and approach was very forward thinking in the 1990s, but has become the benchmark for studying how a changing marine environment affects commercial fisheries in Alaska, as well as oil spill recovery.

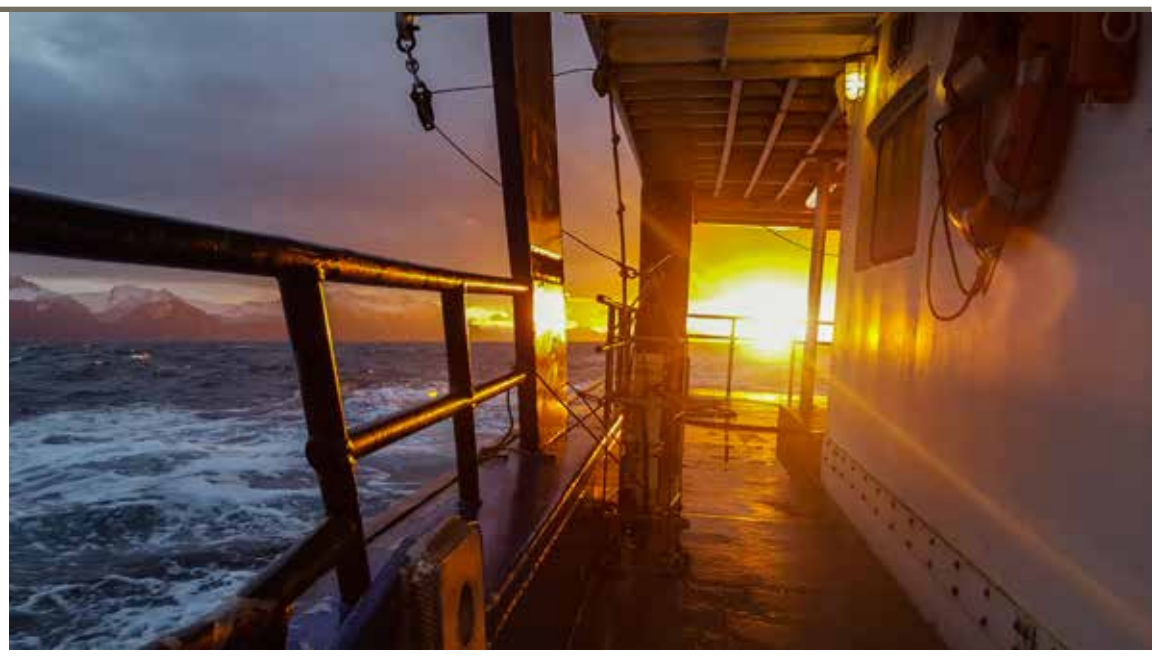
Scientists studying the effects of the *Exxon Valdez* oil spill on the environment have learned about the long-term persistence of oil in contaminated habitats, the many ways toxic substances can impact marine life, the prolonged duration of ecological damage, and the socioeconomic and human health effects. A wealth of information now lies in the scientific literature documenting these novel findings, but after three decades, the system has still not recovered fully, and more work needs to be done. Ultimately, research conducted by scientists in the wake of the *Exxon Valdez* oil spill forms the basis of our contemporary understanding of oil spill effects and is the gold standard for other such efforts around the world.







Temperature anomaly plots for the Prince William Sound mooring (top) and the Gulf of Alaska Shelf near Resurrection Bay (GAK1 mooring) for different water depths. Warmer than normal temperatures are shown in red, and colder than normal temperatures are shown in blue. The green line in the Prince William sound plots and the black lines in the GAK1 plots show the temperature trend over time.



A conductivity-temperature-depth profiler waits on deck for the next sampling point as the sun sets over Kachemak Bay. *Credit: Jim Schloemer, Kachemak Bay National Estuarine Research Reserve*

WHAT DOES THE FUTURE HOLD FOR THE GULF OF ALASKA?

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Can science predict the future for Prince William Sound and the Gulf of Alaska ecosystem? No…but by studying how the ecosystem responds to current and previous climate events, we can narrow down the range of possibilities. Climate and ecosystem forecasts are roughly similar to the weather forecasting models that you rely on every day. (Yes, those model forecasts that are the subject of countless daily conversations, often with a not-so-well-deserved negative reputation.) But keep in mind that weather forecasting has greatly improved over the decades and forecast models produce a range of possibilities—yet we are often only presented with a single value. Also, we tend to remember when predictions were wrong and spoiled our outing rather than the many times the predictions were correct.

The accuracy of weather forecasting has greatly improved for three main reasons: 1) massive increases in observational data from weather stations and citizen scientists, to radar, aircraft, ships, and satellites; 2) models are much more advanced and can assimilate the new data streams; and 3) computing power has greatly increased.

All of the same applies to climate forecasts and anticipated ecosystem response. Were climate models accurate in predicting the recent heatwave affecting Alaska? Yes and no. Yes, the range of warming was predicted, but no, not so soon! Ocean climate will continue to exhibit periods of cooling and warming, including likely more frequent heatwaves. Long-term ecosystem monitoring projects like Gulf Watch Alaska provide critical local data streams for understanding and forecasting how local populations, including commercially important species, will respond to the anticipated climate changes.

COLOR THE LINGERING OIL INTERTIDAL ZONE

TRACKING WATER LAYERS IN THE OCEAN

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Gulf Watch Alaska scientists Seth Danielson (left) and Russ Hopcroft (right) draw water samples from Niskin bottles at oceanographic station GAK1, which is located at the mouth of Resurrection Bay near Seward, Alaska. The conductivity-temperature-depth (CTD) instrument is lowered through the water to just above the 270 meters deep (885 feet) seafloor. It continuously collects data on temperature and salinity stratification and brings discrete water samples back to the surface. Water samples are analyzed for nutrients and phytoplankton biomass.

Stratification: it is the layering of ocean waters with different densities. Heavy, cold, and salty waters sink below waters that are light, warm, and fresh. Ocean stratification is important to understand because it helps regulate the exchange of nutrients between the dark depths and sunlit surface waters. All fishes, whales, and seabirds ultimately depend on food produced by photosynthetic plankton, which in turn rely on sunlight and sufficient nutrients.

Ocean monitoring in the Gulf of Alaska, Prince William Sound, and Cook Inlet is showing multiple changes in stratification due to alterations in coastal temperatures and salt content. During the warm "Blob" in 2014-2016, Gulf Watch Alaska scientists observed much warmer and fresher surface waters. Long-term observations show that surface waters are warming faster than subsurface waters and becoming fresher, because melting glaciers are increasing river runoff into the Gulf of Alaska.

What might stratification changes mean for the Gulf of Alaska ecosystem? New ocean conditions might favor growth of different phytoplankton species, which in turn affects their predators, their predators' predators, and so on. These food web changes will be difficult to detect at first, but Gulf Watch Alaska scientists are using observations of ocean stratification to help provide early signals of change and clues to look in the right directions.


63°N
62°N
61°N
60°N
150°W
148°W
146°W
Paxson
Chist
Talkeetna Mountains
Gakona
Gulkana
Glennallen
Talkeetna
Mendeltna
Tazlina
Copperville
Copper Center
Kenny
Lake
Chitin
Wasilla
C h u g a c h
M
Valdez
Anchorage
Unakwik Inlet
Tatitlek
Portage
Whittier
Eaglek Bay
Bligh Reef
Prince
William
Sound
Blackstone Bay
Simpson Bay
Cordova
Alaganik
Eshamy Bay
Knight Is.
Egg Is.
Hinchinbrook Is.
Copper River
Hinchinbrook
Entrance
Chenega
Montague Is.
Seward
Montague
Strait
Middleton Is.
N
25
50
Miles


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
Chitina River
Copper River
Bagley Icefield
Mt. St. Elias
18,008 ft
Bering River
Bering Glacier
Icy Bay
Flats
Yakutat Bay
Kayak Is.
Yakutat
Gulf of Alaska
144°W
142°W

EFFECTS OF WARMER WINTERS ON SALMON INCUBATION

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We know that chicken hens sit on their eggs to keep them warm, but what determines the temperature for salmon eggs? Female salmon bury their eggs in the streambed, where the water flowing through the gravel controls the temperature. The slightest iincrease in winter water temperature can speed up egg development, causing juvenile salmon to hatch earlier in the spring. Earlier emergence may trigger cascading effects on juvenile growth and the timing of seaward migration that can have lifelong impacts on survival. The average winter air temperature is increasing in Alaska, changing precipitation and streamflow patterns.

To better understand how these changes influence water temperature and salmon egg development, the Chugach National Forest uses low-cost data-recording thermometers to continuously monitor water temperatures at 40 spawning sites across the Kenai Peninsula, Prince William Sound, and the Copper River Delta. Interestingly, we see significant differences in the response of water temperature to rising air temperature. Streams fed by upwelling groundwater maintain uniform temperatures year after year. In contrast, streams flowing out of shallow lakes are highly sensitive to changes in climate. As land managers, this information is important because it identifies which spawning sites are most vulnerable to climate change.

Salmon eggs incubate in streambed gravel. Based on water temperature data, we determined that juvenile Coho Salmon on the Copper River Delta emerged from the gravel, on average, two months earlier than normal during the pervasive and record-setting warm spell that affected Alaska from June 2013 through September 2016. *Credit: Luca Adelfio*

GAINING UNDERSTANDING OF FISH COMMUNITIES WITHIN KACHEMAK BAY

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Alaska's forage fish species, like Pacific herring, saffron cod, and Pacific sand lance, play a crucial role as food for predators like adult salmon. Understanding the abundance and habitat needs of these forage fish becomes increasingly important as salmon populations respond to warming oceans.

The Kachemak Bay National Estuarine Research Reserve (Reserve), in Homer, has long recognized that coastal river mouths and adjacent beaches within the Kachemak Bay estuary offer vital rearing habitat for juvenile salmon, forage fish, and other species living within the nearshore environment.

Working with KBNERR research technician and University of Alaska Fairbanks graduate student Chris Guo, the Reserve has undertaken a study to quantify ecological variations on species abundance within these nearshore habitats.

Commonly caught fish species during sampling within Kachemak Bay.

During the summer of 2018 and again in 2019, Reserve staff, under Guo's guidance, are seining (netting) forage fish and juvenile salmon and collecting zooplankton samples for identification from seven identified riverine estuaries within Kachemak Bay.

Additionally, water chemistry data (such as temperature, salinity, and pH), and physical parameters (including slope, substrate and rates of freshwater flow) will be collected. The resulting data will yield a deeper understanding of important habitat parameters and related fish communities within Kachemak Bay.

SPATIAL PATTERNS

OF CAPELIN IN THE GULF OF ALASKA

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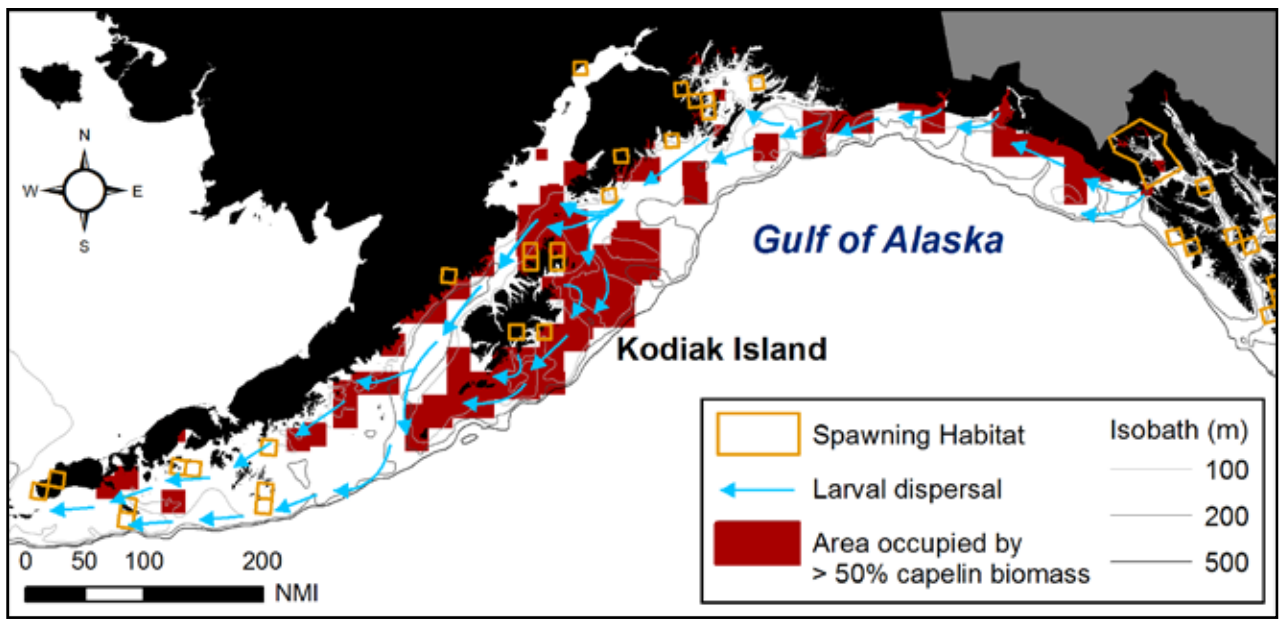
Capelin are abundant, small pelagic fish that serve a critical, middle role in marine food webs; they are consumers of zooplankton and prey for marine mammals, seabirds, and commercially important fishes. Each year, capelin migrate from the Gulf of Alaska (GOA) to beaches within bays and fjords along the Alaska coast to spawn and die. Shortly afterwards, their larvae are primarily dispersed offshore over the continental shelf, where they remain for several years feeding on abundant zooplankton, before returning to coastal waters to complete their life cycle.

Spatial patterns of the GOA capelin population were examined over the past two decades by integrating multiple, independent data sources with habitat and larval dispersal models that show potential connections between spawning areas and offshore foraging grounds over the shelf. Capelin are patchily distributed across the GOA, but consistently concentrate over the shelf near Kodiak Island (see above). Favorable currents near shallow banks (<100 meters) east of Kodiak function as a catcher's mitt to retain larvae spawned locally and upstream from as far away as Southeast Alaska. This improved understanding of capelin spatial patterns aids monitoring efforts to detect changes in their abundance that potentially affects their availability to predators.



Conceptual diagram of modeled spawning habitat, simulated larval dispersal, and areas of the GOA that are consistently occupied by capelin.

Suturing a herring after acoustic transmitter implantation. *Photo by Ben Gray.*

TIME TO SPAWN!

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There is a well-known Alaskan t-shirt complete with a human skull and crossed salmon that says "Spawn till you die." In contrast to this dire reproductive finale of many salmon species, many fish, including Pacific herring, spawn several times during a lifetime—a strategy known as iteroparity.

In April 2017, the Prince William Sound Science Center installed an underwater acoustic receiver array at Port Gravina. We then captured over 100 adult herring just before they spawned and surgically implanted them with acoustic transmitters that have a battery life of two years. Those transmitters have afforded us the first opportunity to determine when herring begin to return to their spawning grounds. Interestingly, we found that some herring begin to frequent the spawning grounds as early as four months before they spawn. Some herring wintered in other areas, such as Montague Strait, and did not return until right before spawning. By April 2018, we also detected some herring moving over to a different spawning area from where we initially tagged them the previous year. Future tagging efforts will continue to reveal movements to and between these important herring spawning grounds.

PING! TRACKING FISH USING PASSIVE ACOUSTIC TECHNOLOGY

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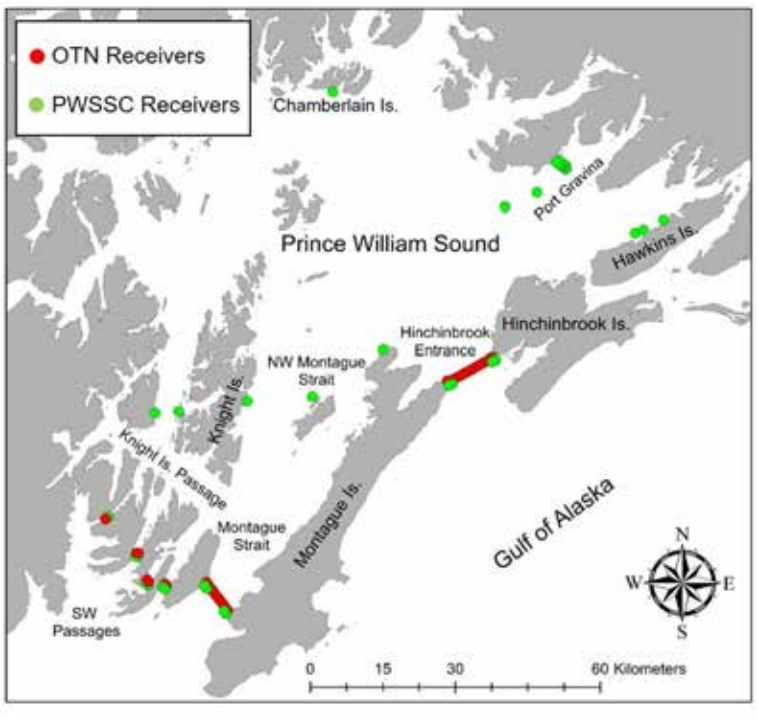
In 2007, scientists at the Prince William Sound Science Center began deploying underwater acoustic receiver arrays to track select fish species as part of the Pacific Ocean Shelf Tracking project. Since then, with funding from Canada's Ocean Tracking Network and the *Exxon Valdez* Oil Spill Trustee Council, acoustic coverage within the Sound has increased from less than 20 receivers in 2007 to about 85 receivers. The receivers are strategically located in fish migration corridors and at major entrances between Prince William Sound and the Gulf of Alaska (see map). Acoustic transmitter technology has improved alongside receiver coverage allowing researchers a view into the multi-year movements of fishes as small as 100 grams (about 3.5 ounces).

The way it works is that a transmitter, or tag, is surgically implanted into a fish. The tags are programmed to emit unique coded "pings" that are detected, decoded, and stored by the acoustic receivers. Researchers then upload the data either by hovering over and connecting to the receivers via a transducer hung over the side of the boat, or by popping up receivers that have built-in release devices. Uploading trips happen multiple times throughout the year, allowing researchers to determine where fish are during different seasons. Currently the Science Center has over 300 Pacific herring tagged with implanted transmitters that have a life of 8 or 25 months. This study will provide new insight into herring ecology and their seasonal movements.



HERRING RESEARCH AND MONITORING

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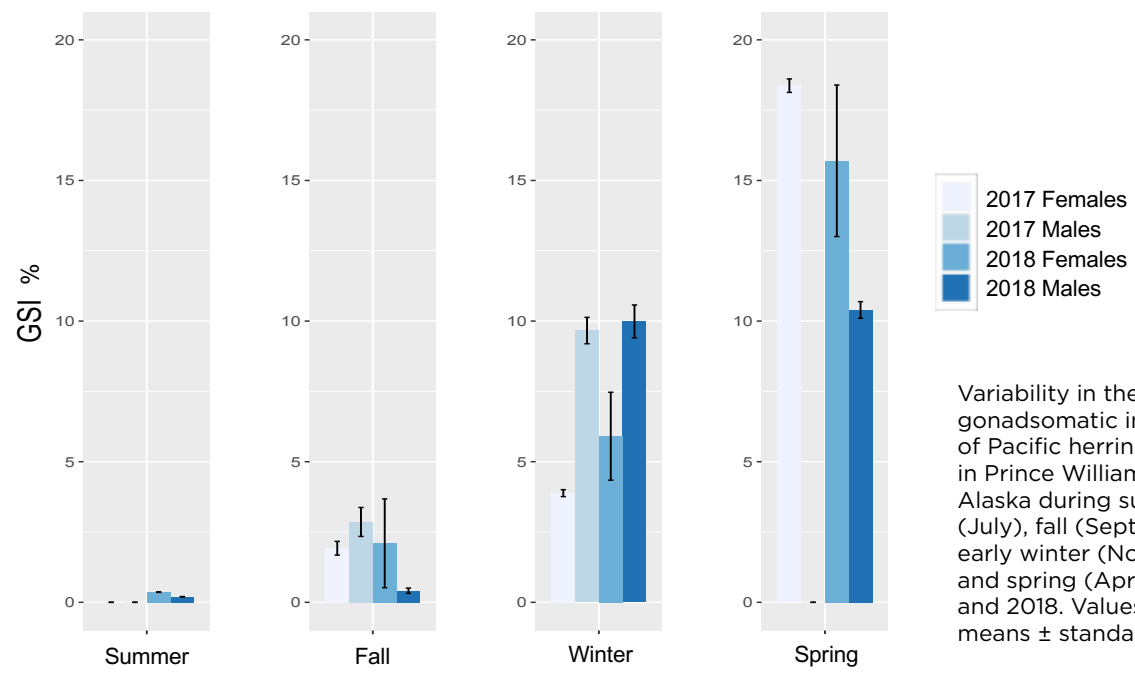
In the decades prior to 1990, there was a robust Pacific herring population in Prince William Sound (PWS) with a biomass of 130,000 tons. Not only are these forage fish a key link in the complex food web of PWS, but they once supported a lucrative early season commercial fishery that brought the communities 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 current herring population in PWS has dropped to a record low of around 3,000 to 4,000 tons. This raises the question of what is causing the herring to struggle and ultimately what is contributing to the recent intensity in decline. Fortunately, the Herring Research and Monitoring (HRM) program has been exploring these questions for the last six years.

The Herring Research and Monitoring 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 conditions.

Measurements continue to be collected to detect changes in the PWS herring population, observe where herring go after spawning, and determine when herring mature and become part of the spawning population. Diseases continue to be examined to determine their role in limiting the herring population. Additional effort is being spent examining how the herring condition and recruitment is dependent on environmental factors, such as food availability, predator populations and climate change.



Variability in the gonadsomatic index (%) of Pacific herring caught in Prince William Sound, Alaska during summer (July), fall (September), early winter (November), and spring (April) in 2017 and 2018. Values are means ± standard errors.

VARIABILITY

IN SEASONAL GONAD DEVELOPMENT OF HERRING

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One important factor fundamental to the persistence of any population is successful reproduction. More specifically, information on the age structure and reproductive maturation of herring might help predict annual recruitment strength. Pacific herring are iteroparous, meaning that these forage fish reproduce, or spawn, multiple times throughout their life. The development of gonads (ovaries and testes) in preparation for spawning occurs over a nearly six-month period between the fall and spring each year. A standard measure of investment in gonads for fish is called the gonadosomatic index (GSI), which is the ratio of the weight of the gonad to the weight of the whole fish expressed as a percentage. As Pacific herring prepare to spawn, the GSI increases as gonads sequester energy and nutrients for reproduction. Although the relative seasonal timing of gonad development by Pacific herring is fairly well known, variability between years in this process is less well understood.

During 2017 and 2018, adult Pacific herring were captured in PWS throughout the year and their investment in gonads measured. Not surprisingly, herring caught during spring spawn had large, well-developed gonads, while fish caught during summer following the spawning season had small, undeveloped gonads (right). However, our study documented differences in gonad maturation between years (see figure above), particularly for herring caught in fall and winter, when gonads are developing rapidly. These results suggest that the timing of gonad development by females and males is variable between years and may be influenced by the abundance and timing of food availability.

BELOW: The image on the left shows a fully mature Pacific herring ovary during spring spawning. The image in the right shows an immature gonad that looks like a thin ribbon of tissue running along the dorsal region closer to the spine.

Large, mature ovary during spring spawning.

Small, immature gonad during summer.

CHANGES IN FORAGE FISH

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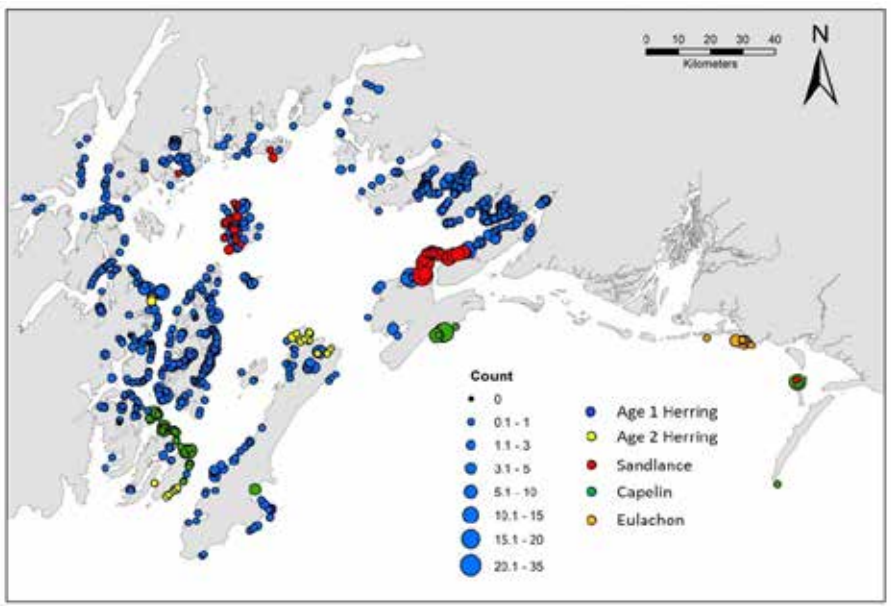
Aerial surveys flown during June each year provides an indication of changes in forage fish populations. Forage fish are the small fish that eat oceanic plankton and in turn are eaten by fish, birds, and mammals. Not all forage fish can be observed from the air, but herring, capelin, and sandlance form schools that are dense enough to be seen.

The primary forage fish in the region is herring, which can be observed along the coastline throughout Prince William Sound. In June, the fish observed are typically one-year olds, but schools of adults are also seen. The number of schools of one-year old herring has fluctuated between 170 schools in 2014 and over 2,100 schools in 2013. We are trying to use the number of schools of one-year olds to predict recruitment into the herring spawning population as three-year-old fish.

Sandlance tend to be found in fewer locations than herring and haven't shown as large of fluctuations in population. Capelin are the least common of the forage fish in recent years but are often in very large schools when they are observed. During the warm ocean conditions in 2015 and 2016, capelin were rare or totally absent. Larger numbers of schools were observed again in 2018, after cooler water temperatures were present.

The presence of forage fish provides an indication of the health of Prince William Sound and the aerial surveys allow us to track their population in a manner that will help us understand how the fish depend on different oceanic conditions.



Map of forage fish schools from June of 2018. The distribution of young herring throughout the Sound is in contrast to the more restricted areas where other forage fish are observed.

MILE-DAYS OF MILT

PWS herring spawn event observed during 2018 aerial surveys. *Credit: Shane Shepherd*

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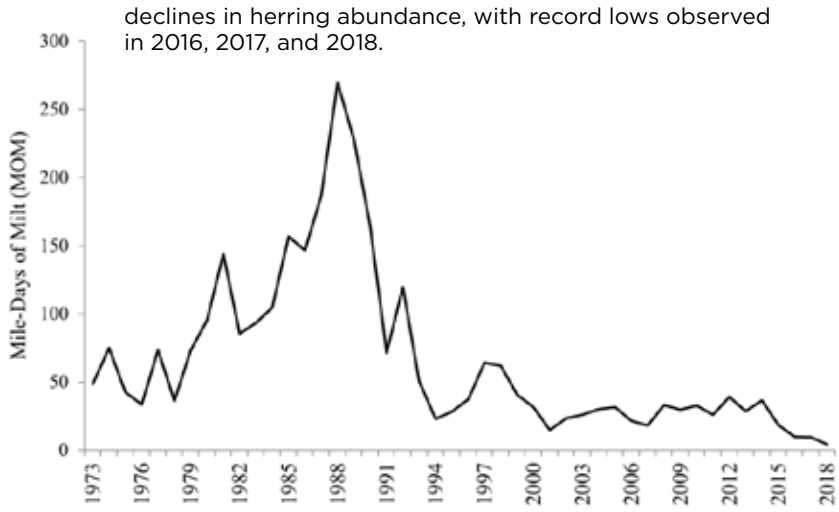
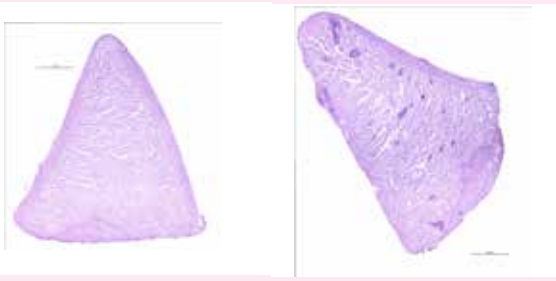
Pacific herring in Prince William Sound (PWS) aggregate in large spawning groups in March and April. These spawning events are highly visible due to milt broadcast (see photo). Because spawning aggregations consist of a large proportion of the mature herring population, and the spawning events are visible to the naked eye, aerial surveys are an effective and repeatable way to monitor the abundance of herring populations over time.

Recent aerial MOM observations indicate continued declines in herring abundance, with record lows observed in 2016, 2017, and 2018.



Aerial surveys measure and sum the linear extent of milt from all spawning events observed during a single year resulting in an annual index of abundance known as mile-days of milt (MOM). ADF&G began aerial MOM surveys in PWS in 1973 to support sustainable management of PWS herring fisheries.

The results of this long-term monitoring program, made possible in recent years by the *Exxon Valdez* Oil Spill Trustee Council, now compose the longest and most complete record of the abundance of herring in PWS. These data provide critical inputs to more detailed investigations of factors relating to the collapse and lack of recovery of the PWS herring population.



Figures depict the contrast between healthy herring heart tissue (left) and diseased herring heart tissue (right).

'ICH-Y' DISEASES IN PACIFIC HERRING

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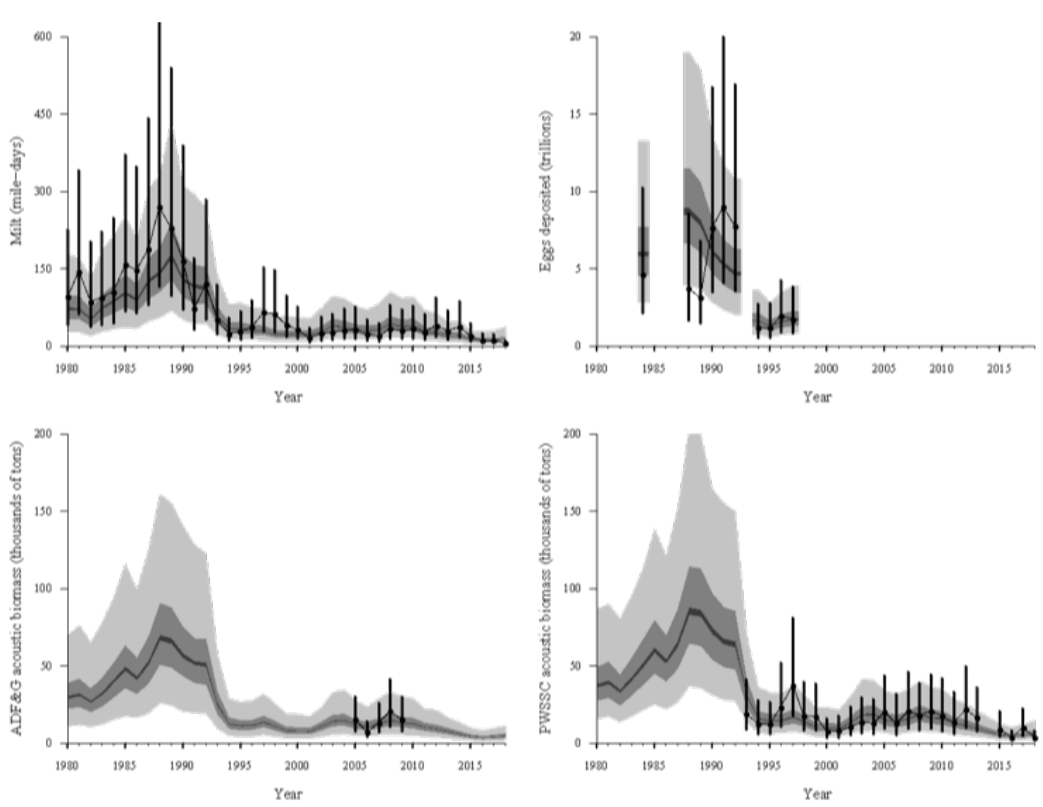
Diseases are common for Pacific herring, but their impacts on populations can vary, just like our common flu—in most years the flu is an inconvenience, but in others, it can be deadly (like the 1918 Spanish flu). Diseases can switch from slow progressing 'chronic' states to more lethal 'acute' states. *Ichthyophonus* sp., or 'Ich' for short, is a common pathogen that frequently infects Pacific herring. The disease caused by Ich infections, Ichthyophoniasis, typically progresses slowly. Studies conducted by Paul Hershberger at the U.S. Geological Survey's Marrowstone lab suggest that herring can maintain infections in their hearts and livers for years without dying. In some cases, however, Ich infections can be highly lethal. An epidemic off the coast of Sweden caused mortality of more than 300 million Atlantic herring in 1991, approximately 10% of the population.

It is unclear what causes this switch from chronic to acute infections. Could it be added stress from changing environmental conditions? A new strain of Ich? Poor condition in a few year classes of herring? In order to understand these questions, historical samples of herring from Sitka Sound and Prince William Sound are being examined. Trends in the patterns of disease across fish age suggest that, in Sitka Sound, but not Prince William Sound, there may have been increased mortality due to Ich infections beginning around 2013. We are examining the amount of infection occurring in herring from 2009 through 2019 in order to see if higher levels of infection are occurring and might indicate higher levels of mortality. We will fit these data to population models to estimate the impact of this disease on both populations.

HERRING MODELS: WHY AND HOW THEY ARE USED?



Stock assessment estimates (black line surrounded by shaded regions) of four different survey datasets (the individual points with black error bars up and down showing the 95% confidence intervals) that count Prince William Sound herring. If the points lie within the shaded region, the model fits the data well and provides accurate estimates. The model includes the most recent data (2018) and shows that the PWS herring continue to remain at their all-time low.

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"Counting fish is just like counting trees — except that they are invisible and keep moving."

— **JOHN SHEPHERD,**
University of South Hampton.

Anybody who has been to a river, lake, or ocean knows that you cannot simply look into the water and see all fish for reasons best said by Dr. Shepherd. Scientists have developed many different ways to count fish; with nets, from planes, with sonar, and directly by diving and counting themselves. Each method is prone to its own set of errors due to limitations with equipment, timing, and coverage in space that provide incorrect estimates. In other words, no single survey is typically enough to "count" fish.

This is where models come into play. For herring, management agencies use a certain type of model called a stock assessment. A stock assessment is a framework of mathematical equations that calculate how the population changes based on scientific knowledge of herring biology (e.g. births, deaths, maturation), catch records, and how well the predictions from these equations match the data (i.e. how big is that error described before?). Stock assessments can produce fish count estimates using many different data but must use rigorous and sometimes very complicated statistical theory to make sure that the maximum amount of correct information is extracted from the data. Researchers improve and run the stock assessment for Prince William Sound herring every year using data from many other herring studies shown in Delta Sound Connections to provide a state-of-the-art tool that critically assesses the population's status.

TAKING THE LONG VIEW

THINKING AND ACTING ON A WATERSHED SCALE

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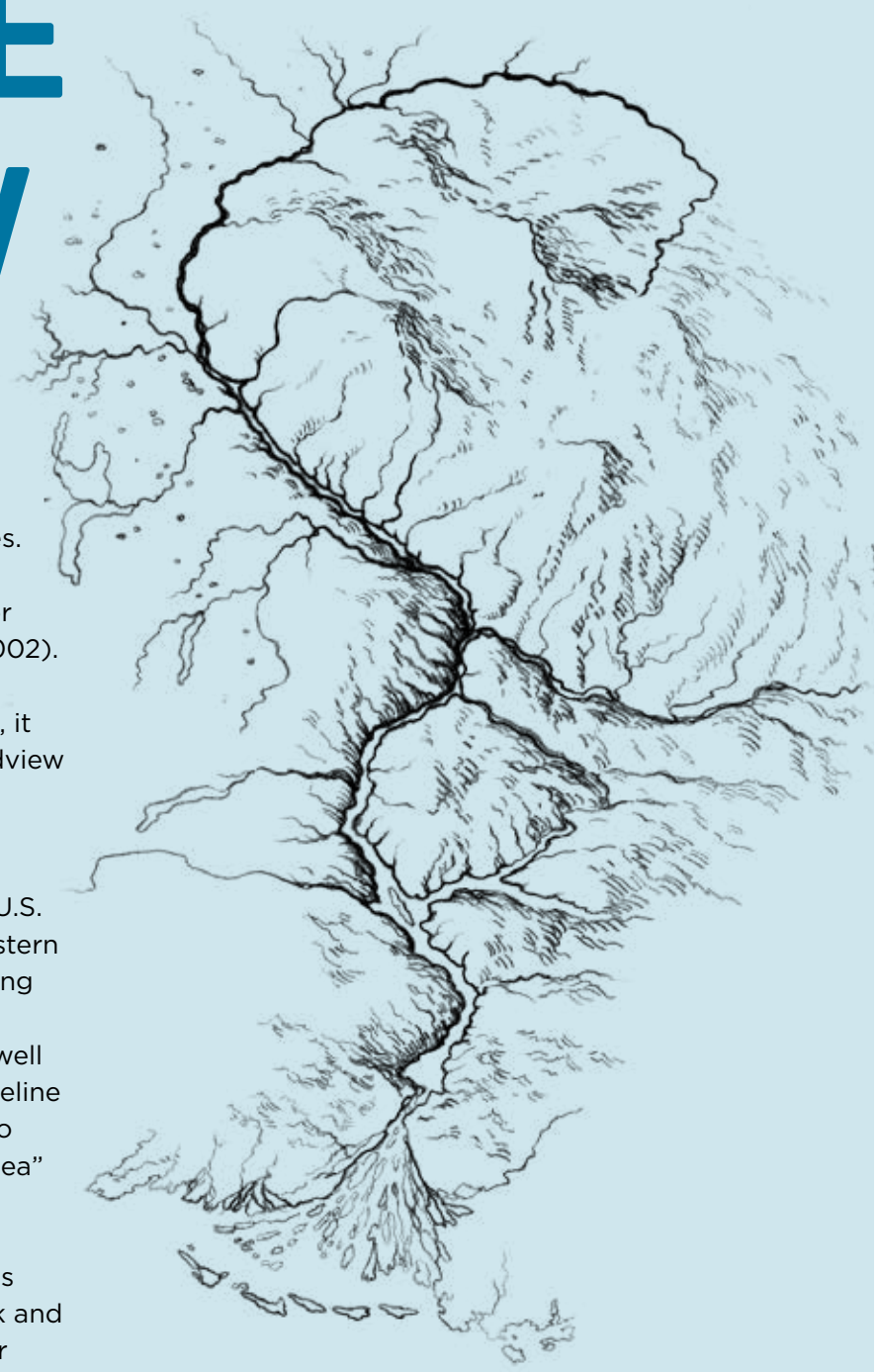
From source to sea, the main stem Copper River churns and flows almost 300 miles. This expansive system with its many tributaries is the key to its success—all those feeder streams branch out for spawning adult salmon and the next generation of juveniles. Shaping the watershed began over 60,000 years ago, when today's Copper River Basin was filled by Lake Atna. Sequential ice dam releases drained the lake, with the remnant river carving through the Chugach Mountains to the Gulf of Alaska. As glaciers retreated, salmon moved upriver.

Salmon have been a critical resource for Ahtna Natives in the Copper River basin for at least 1,000 years. They were abundant, predictable in their seasonal arrival, and arrived at a time of year when food was scarce. The Ahtna people had place names for most fish streams and their salmon stocks: "All major streams are named . . . that have some useable resources. A stream name often is derived from the name for a nearby hill or mountain" (Simeone and Kari, 2002). The Copper River's force and its salmon not only shaped the land, it shaped the Ahtna people's worldview and the language they used to communicate.

Just over 100 years ago, Major John Wesley Powell offered the U.S. Senate a radical approach to western development. He proposed settling the West based on watersheds rather than surveyor's grids: "Powell understood that a mountain ridgeline determined the flow of water into larger rivers and finally into the sea" (Ross, Smithsonian.com, 2018).

For the Copper River, we're advocating the same approach as others that came before us: think and act on a watershed scale. Copper River salmon migrations benefit those who harvest salmon with fish wheels, dip nets, fishing rods, and drift gillnets, and feed a complex web of wildlife throughout the drainage. We're working to keep it intact and thriving for a long time to come.



Encircled by three mountain ranges (Alaska Range to the northwest, Wrangell Mountains on the east, and Chugach Mountains to the south), the Copper River flows almost 300 miles into the Gulf of Alaska along the southcentral coastline. *Line art illustration of the Copper River watershed by Cordova artist Jen-Ann Kirchmeier.*

PWS STEWARDSHIP FOUNDATION

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The Prince William Sound Stewardship Foundation is a nonprofit that formed in late 2017 with a mission to help maintain the Sound's "wilderness character," especially within the Nellie Juan-College Fjord Wilderness Study Area. Under the tagline "Keeping Prince William Sound healthy, clean and wild," the group uses volunteers, fundraising, and partnership development to increase the capacity of agencies and others in caring for resources.

During the 2018 summer, the Foundation used its volunteer network to assist with several Chugach National Forest projects, including recreation site restoration in Blackstone Bay, beach clean-ups in the Eaglek and Unakwik areas, and a first-ever mollusk bio-blitz in Whittier, which documented local distribution of invasive European black slugs.

The group is now working with the Chugach National Forest and PWS Regional Citizens' Advisory Council to bring a one-day guide symposium to Whittier on May 20, 2019. The event will provide guides and other educators working in the sound with the latest information on salmon, wildlife, climate change, and other topics. The all-day event will be free and open to the public.

This summer, the Foundation also plans to assist Chugach National Forest managers and others with restoration, trash removal, citizen science, and other work, predominantly in the western Sound. Visit the group on Facebook, or join their new "Prince William Sound Forum," also on Facebook.

Camping in alpine vegetation above Prince William Sound. *Credit: Barbara Lydon*

INSPIRING

FUTURE LEADERS THROUGH PLACE-BASED EDUCATION ADVENTURES

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Every summer since 2009, ten high school students from the Copper River watershed have embarked on a field-based learning adventure as part of the Copper River Stewardship Program (CRSP). Some of the first program participants reflected on their experiences as they were finishing college and preparing for their next life adventure.

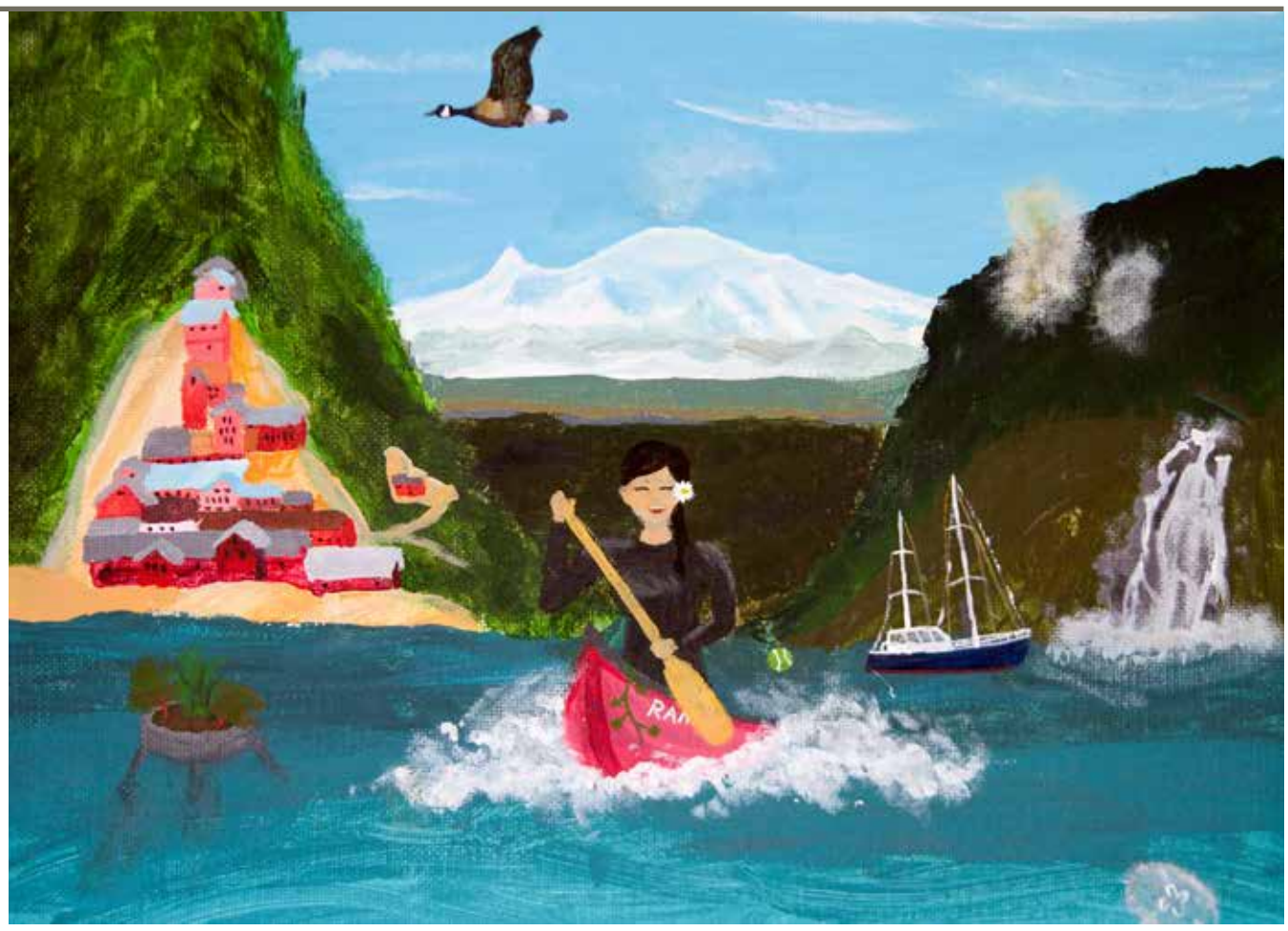
"[The CRSP] really helped me understand the scope of the watershed as a natural resource . . . it's important to understand that fish support many communities in multiple ways. They feed families and traditions further upriver than many of us in the CRSP had ever gone. This program is a powerful lesson in sharing resources, and understanding the watershed and its many connections . . . For me, personally, the CRSP actually helped me become a steward. The program helped me realize that I could actually have a life and career centered around conservation." (Angie Kelly, 2010)

"I would definitely say that it has made me appreciate our rivers and view how important every stream that feeds into the Copper River is. Now as a road worker I understand the importance of having the proper procedures to not pollute the streams." (Dillon McCarthy, 2011 & 2013)

"[The CRSP] influenced me to go into the sciences, be outdoorsy, love nature, and have a desire to do what I can to protect it." (Sarah Hoepfner, 2011)

"Some things that have continued to form since that trip: a deep care for the environment (I actually adopted a zero waste life recently!), an interest in fisheries management, a care for outdoor education (president of my university's outdoor club!) . . . " (Shannon Lindow, 2009)

The words of the participants demonstrate why education partners invest resources into developing these place-based, hands-on learning adventures. Beyond the smiles, fun memories, and creative reflections and projects that result from these trips, a strong stewardship ethic, inspiration for future career paths, and desire to sustain the incredible natural world around us are the long-term outcomes that make these programs an integral part of sustaining healthy ecosystems for generations to come.



Artwork by Lindsey Gordon, 2018 CRSP Steward. Oil on canvas..

MOVEMENT

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While the Copper River Stewardship Program is an annual event, each year has a unique and exciting theme. This year's adventure was set in the theme of "Movement," a fitting refrain for the dynamic landscape of the Copper River watershed.

Not only did we physically move throughout the watershed using vans, rafts, canoes, ferries, a sailboat, and our own two-feet, we also studied the movement of elements that we encountered along the way: Copper ore at the Kennecott Mines, glacial silt from the Kennecott Glacier all the way to the mudflats of the Copper River Delta, and plants propagating through movement of wind and water.

In Prince William Sound we sampled zooplankton, little animals behind the largest daily-migration on the planet, and studied the movement of ocean currents. As we revegetated floating nest islands for Dusky Canada Geese on the Copper River Delta, we learned about the long journey they make to breed here. We could fill this entire publication with everything we discussed—the movement of people, animals, resources, and so much more. The 2018 stewards explain it best through their final projects and as one student summarized: "Movement. It is everywhere, steady or irregular, fast or slow, big or small. Everything moves, especially in Alaska."

POEMS BY JOSEPHINE BEAUCAMP, 2018 CRSP STEWARD

WATER

I grant life,
And allow death,
I am either not wanted,
Or suddenly needed,
I go around in cycles,
Ever-going and non-stopping,
In different forms,
I stay the same,
You can find me everywhere you go,
For 70% of you is me,
Hidden around the world or obviously placed,
You see me every day,
In several ways,
I am forever and always there,
For I am Water.

SEEDS

In the wind I blow,
My final destination I do not know,
Having no idea where I'll go,
Through the air I glide,
Oh, way up high,
Around the big blue sky,
Looking around for a place to land,
It doesn't have to be anything grand,
Just some ground where I can stand,
And probably expand,
Hopefully to a place full of fun,
Where I can soak up the sun,
Until my time is done.

ROCKS

No matter what happens I always remain,
It takes time but I don't go away,
Whether I am a boulder or a sand grain,
I will forever stay,
If I fall apart,
If I change,
I always get a restart,
Even if it's strange,
I will always be around,
I can neither die nor live,
For I am your ground,
And fertile dirt I give,
It takes time,
Heat and pressure too,
Until I get to my prime,
Until I get made anew.

The Copper River Stewardship Program is presented annually by the Copper River Watershed Project, Prince William Sound Science Center, WISE, BLM, U.S. Forest Service, and National Park Service.

WHOSE LAND IS IT ANYWAY?

DAVE ZASTROW AND ERIN COLE
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The Copper River Delta and Prince William Sound are wild and remote landscapes. Living in or traveling through these regions provides a true wilderness experience. Roads are few, and flying or boating is common.

When traveling the islands of the Sound or wetlands of the Delta, it may be a surprise to know there is a mosaic of property ownership and allowable access. Land is owned or managed by federal, state, Native Corporation, and private entities, who tend to expect the general public to know the land they are on and its permissible uses. Few physical markers exist to indicate ownership or boundaries.

Much of this wild land is owned by the public and managed by the U.S. Forest Service. Chugach National Forest is 5.3 million acres, 2.9 million of which is Cordova Ranger District. Ground conditions and vegetation make navigation through this landscape difficult. To assist travelers, the Forest Service manages a variety of roads, trails, and boat launches providing public access to public lands.

The Forest Service has strong partnerships with land owners and resource managers throughout the Copper River Delta and Prince William Sound. To continue enjoying the benefits of public land access, add property ownership to your trip planning and respect the boundaries of private property.

Visit the Cordova Ranger District office in Cordova or call 907-424-7661.

Aerial photo of the Copper River Delta. *Credit: Milo Burcham*

EXXON VALDEZ A TIMELINE

MARCH 23, 1989:

On March 23, 1989, the oil tanker *Exxon Valdez* left the Valdez Marine Terminal at 9:12 p.m., bound for California with a full load — approximately 53 million gallons — of North Slope crude oil.

The tanker Captain, Joe Hazelwood, was granted permission to change course to avoid icebergs from nearby Columbia Glacier. He gave orders to the Third Mate to maneuver the tanker to the new course and then retired to his quarters. For reasons that remain unclear, the tanker was never returned to its proper course.

MARCH 24, 1989:

Just after midnight on March 24, the *Exxon Valdez* oil tanker grounded on Bligh Reef, spilling at least 11 million gallons of crude oil into Prince William Sound, the largest oil spill in U.S. waters.

The initial response to the spill was slow, uncoordinated, and ineffective. Seas and winds were calm for three days, but almost no response equipment was available.

MARCH 27, 1989:

On March 27, a storm blew in with winds up to 70 mph, spreading the oil spill to the southwest along at least 1,400 miles of shoreline (see figure, above).

More information on the immediate and long-term impacts of the spill, as well as links to other oil spill resources can be obtained from the legacy organizations established after the spill.

- The *Exxon Valdez* Oil Spill Trustee Council oversees the 1991 $900 million civil settlement for restoration of injured resources and services. The restoration plan includes habitat protection, research and monitoring, and direct restoration.
  evostc.state.ak.us
- The Oil Spill Recovery Institute was established by Congress in 1990 to focus on improved technologies and ecological research related to oil pollution in the marine environment of Arctic and Subarctic regions.
  pws-osri.org
- The Prince William Sound Regional Citizens' Advisory Council is an independent nonprofit organization whose mission is to promote environmentally safe operation of Alyeska Pipeline's Valdez Marine Terminal and associated oil tankers.
  pwsrcac.org

30 YEARS LATER

EVOS LESSONS STILL POIGNANT

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In the weeks and months following the 1989 Exxon Valdez oil spill, an unlikely alliance of visionaries and mavericks—government, industry, and citizens alike—came together to transform oil spill preparedness. Two weeks after the spill occurred the Alaska Department of Environmental Conservation told Alyeska Pipeline Service Company (Alyeska) to create a response system with sufficient equipment, vessels, manpower, and support to handle a 10 million gallon spill or risk being shut down. After long days of intense analysis and reluctant compromise, Alyeska presented an Interim Plan which included many of the elements later incorporated into state law and regulations, which are still the standard today. The system was designed to restore public confidence in the safety of oil tanker operations without crippling the industry responsible for bringing Alaska oil to market. "Nobody got everything they wanted, but in the end we all got something we could live with," said Michael Williams, BP representative.

A report from Prince William Sound Regional Citizens' Advisory Council and Nuka Research and Planning Group reconstructs the story of those fervent months and their outcomes. The story is 30 years old, but the lessons are poignant today. Every individual interviewed for this report was adamant that if the system created after the 1989 spill were to be weakened or removed, Alaskans would face the risk of another major oil disaster in the Sound. Read the full report at www.bit.ly/ExxonValdezLegislation

A participating team ponders their ROV design. *Credit: PWSSC*

AQUATIC ROBOTICS

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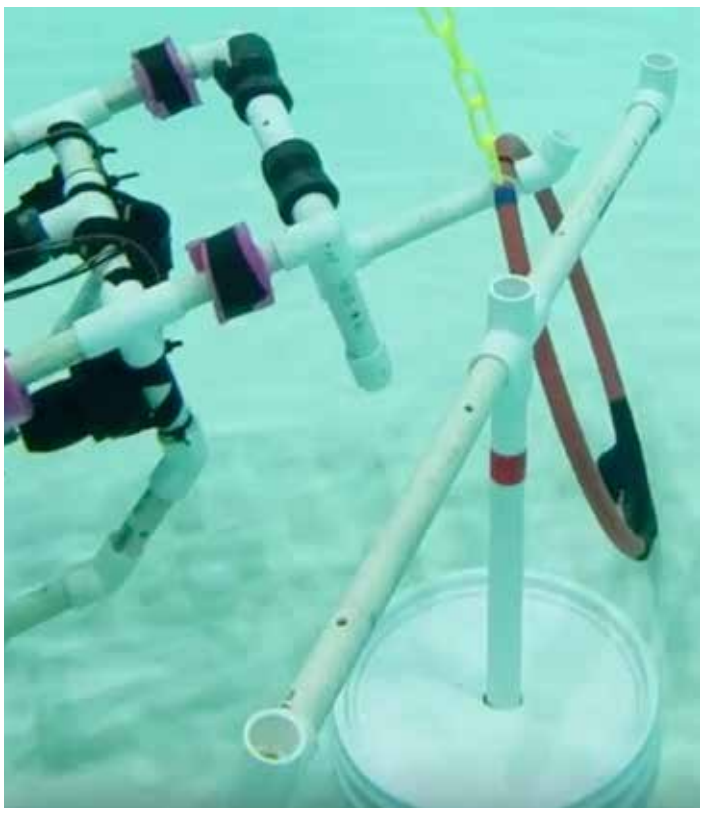
If you walk into Seward High School in late February, you may notice the hallways are more crowded than usual. That's because for the past 22 years, Seward has been the host site of the Tsunami Bowl, Alaska's regional competition of the National Ocean Sciences Bowl. For the previous eight years, PWSSC has hosted a Remotely Operate Vehicle (ROV) challenge for participating teams at the competition.

Before giving students the task of engineering their very own ROV capable of completing various underwater challenges, participants are briefed on what ROVs are, how they are used, and in this challenge scenario—vital importance in oil-spill prevention efforts. Equipped with a kit of PVC piping, motors, a battery, control box, and some electrical tape, teams have one hour to design and build a functional ROV capable of completing five challenges. Competitors are tasked with attaching an anchor chain to a submerged structure, cleaning up a mock oil spill, navigating through an underwater hula hoop, and more.

During the build process at this year's event, a returning Mat-Su senior and former ROV competitor commented, "The design process is always new and exciting, and our design this year will be different from previous years." Once the ROVs enter the water, teams have an opportunity to test their designs and make last minute adjustments, with buoyancy being a critical modification to ensure their ROVs can complete the tasks without sinking or floating to the surface. The ingenuity, comradery, and perseverance demonstrated throughout the competition by each team was by far the most exciting part!



An ROV takes on a tricky underwater challenge.
Credit: Shannon Easterly

Many thanks to the supporters of the ROV Challenge, including Prince William Sound Regional Citizens' Advisory Council, Oil Spill Recovery Institute, Alyeska Pipeline, and Alaska Tsunami Bowl.

SLIME

STANDS THE TEST OF TIME

KITCHEN CHEMISTRY IS A GREAT WAY TO EXPERIMENT WITH EASILY AVAILABLE SUPPLIES.

Trends come and go, but slime has stuck around for decades. Today you can find endless DIY recipes online. Here is one of our favorites, with a couple of options for variety. Try them out, and then experiment with your own ideas.

▶ TIPS:

- Younger children will need help from an adult.
- Store slime in an air tight container.
- Slime-making equipment can be washed with soap and warm water.

WORD SEARCH

- ALASKA
- BIRD
- COPPER
- DELTA
- EGGS
- FISH
- LEARN
- OCEAN
- OIL
- PLANTS
- ROCK
- SLIME

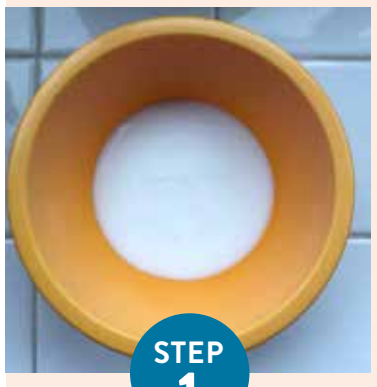
B	I	R	D	H	P	C	U	G	G	P	R
N	L	C	I	Y	L	P	C	G	M	A	G
P	E	S	V	Q	A	L	A	S	K	A	X
V	L	E	A	R	N	F	F	O	T	R	E
V	D	A	K	J	T	L	Q	C	G	K	O
R	E	N	Z	D	S	B	E	G	G	S	T
C	L	E	K	M	O	I	L	J	M	U	Y
Q	T	D	N	S	F	I	S	H	O	L	I
W	A	A	M	L	D	G	R	O	C	K	R
L	B	D	R	I	C	O	P	P	E	R	M
Z	L	W	O	M	B	U	U	B	A	V	B
P	B	G	P	E	U	H	O	J	N	Y	U

▶ REGULAR OR GLITTER SLIME

(See footnote on how to turn this into fluffy slime)

- 3 oz (6 TBSP) washable glue or glitter glue
- ¼ tsp baking soda
- 2 TBSP water
- 1 tsp saline solution*
- Baby oil
- Food coloring (optional)

▶ INSTRUCTIONS



STEP 1

Add glue to bowl.

STEP 2

If using food coloring, add a few drops and mix until combined.

STEP 3

Add baking soda and mix.

STEP 4

Add water and mix.†

STEP 5

Add saline solution. First, mix with a spoon or wooden craft stick. As the slime starts to form, use your hands to knead the mixture. It will be really sticky at first; it takes a few minutes for everything to combine. If the slime is still sticky after two or three minutes of kneading, add a few drops of baby oil to your hands and work into the slime. Repeat if necessary.

** Make sure your saline solution contains boric acid and sodium borate—without these ingredients, the slime will not form.*

† If you want to make fluffy slime, simply mix in 1-1½ c. of foamy shaving cream to your bowl after step four. You might need to add extra food coloring to make a darker color. Fluffy slime will lose its fluff after a day, but it's still fun for play!

THE NEXT GENERATION
A CHANGING WORLD

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We're the region's nonprofit with boots on the ground,
boats in the water, and students in the field 12 months per year.
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to join us in supporting the resilience of one of the world's last great places.

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