2020-2021

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 Copper River Delta in full bloom with the Copper River and Childs Glacier in the distance. *Photo credit Teal Barmore.*

BIRDS
Burrowing into a Puffin Nest

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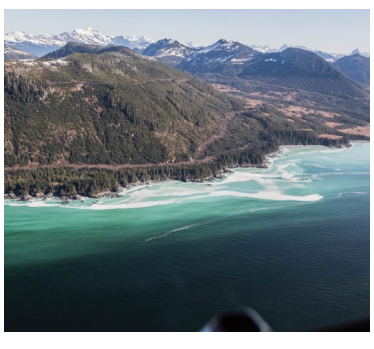

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OUR HOME

In her bestselling novel *Animal Dreams*, author Barbara Kingsolver wrote, "The very least you can do in your life is figure out what you hope for. And the most you can do is live inside that hope. Not admire it from a distance but live right in it, under its roof."

At the Prince William Sound Science Center, the founding belief three decades ago was that ecological health and community wellness are mutually reinforcing. We live under the roof of this hopeful idea every day. It's our home; one we share with an ever-growing community of partners, friends, and supporters.

The first physical roof under which we gathered to explore this hopeful idea was a leaky, tin roof on the northwest edge of Cordova's harbor. It offered an almost-warm place for us to begin exploring the question: What can we do to better understand this globally-relevant region, and share what we learn for the benefit of our community and the world?

Over the years, the Science Center and our partners expanded our explorations into earth's life support systems and have come to understand that healthy ecosystems and healthy economies unfold according to the same principles. Adaptation, resilience, balance, and regeneration are at the heart of success; rapid change, over-extraction, and lack of connections lead to failures. It is no accident that the world's richest waters of the northern Gulf of Alaska, which are connected to the wild forests and rivers of the region, have generated some of the world's richest fisheries. The healthier the environment, the healthier the economy. It is also no surprise that as the oceans rapidly warm, we experience cascading impacts in our communities.

KATRINA HOFFMAN
President & CEO
Prince William Sound Science Center

We count as significant not just formal research and education, but the wisdom of our region's elders and the desires of people who care deeply about this place, echoing a consistent wish: that we can generate a true understanding of our home and the changes afoot and work through them to ensure a resilient region for current and future generations.

Now, as we embark upon building our first new home in three decades – a 5-acre waterfront campus dedicated to economic, environmental, and community resilience – we invite you to join us under our roof of hopeful ideas. Gaining knowledge that prepares us for a changing world is at the heart of our mission. It's work we can't do without you. We're experiencing major changes right now. There's a pandemic; our state budget is in distress; warming oceans threaten the foundations of our region's economy. Amidst these and other as-yet unforeseen changes, resilience will be what carries us into a successful future that still supports ways of life that our community values. This resilience is strengthened with an engaged citizenry and supporters just like you.

If our mission resonates with you, we invite you to become a supporter of our efforts, so the resilience envisioned by our founders, staff, partners, and community members holds up our region's hopes for the future. ■

ANSWER KEY

Animal Home Match-up game on Page 19

Brown Bear	Den
Beaver	Lodge
Eagle	Aerie
Puffin	Burrow
Red Squirrel	Drey
Alevin	Redd
Sea Lion	Haulout
Bat	Roost
Hermit Crab	Shell

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

Dusky Canada Goose on the Copper River Delta. *Photo credit Evan Ward*

ACROSS THE MILES

MANAGING A MIGRATORY SPECIES

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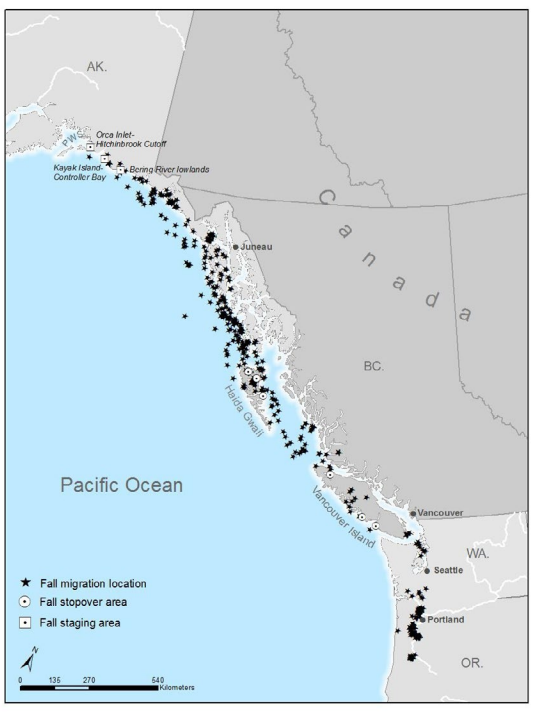
In the autumn months, the sky fills with an assortment of silhouettes, calls, and wing beats from thousands of birds—the indication of fall migration. Many birds migrate for the winter, traveling thousands of miles across country and state lines. For these birds there are no borders; the landscape is theirs to navigate without a need for a passport or special permissions.

Monitoring a migratory species is a bit more complicated. Not only are there borders between countries and states, but also landowners, agencies, rules, and regulations. One migratory species of interest on the Copper River Delta is the Dusky Canada Goose or "duskys". These large, white-cheeked geese breed almost exclusively on the Copper River Delta. By early November, they travel over 1,400 miles to western Oregon and/or southwest Washington where they will spend the winter.

A rapid decline in the population occurred in the 1970s. This decline spurred monitoring efforts to address concerns about the population size and habitats important to duskys. These concerns occur across the flyway and addressing them requires the involvement of multiple state and federal agencies in Canada, Alaska, Oregon, and Washington.



Fall migration route of Dusky Canada Geese, using satellite tags from the breeding area on the Copper River Delta to the wintering areas in the Pacific Northwest.
Pacific Flyway Management Plan 2015

On the breeding grounds in Alaska, the U.S. Forest Service, U.S. Fish & Wildlife Service, and Alaska Department of Fish and Game work cooperatively to track population numbers, address concerns with predators, and improve nesting success. Projects on the Copper River Delta include the installation and monitoring of artificial nest islands and increase of nesting habitat through tree removal. On the wintering grounds, refuge (U.S. Fish & Wildlife Service) and state agencies in Washington and Oregon regulate hunting, track population numbers, and address concerns with habitat degradation.

Management of migratory species requires collaboration from agencies across the flyway. Through shared conservation the dusky population is increasing, promising a brighter future for this species. ■

A Tufted Puffin on Middleton Island returning to their burrow.
Photo credit PWSSC

The entrance to a Tufted Puffin burrow at Middleton Island.
Photo credit PWSSC.

BURROWING INTO A PUFFIN NEST

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With a thick red bill and golden head plumes, the Tufted Puffin is one of the more iconic seabirds of the North Pacific Ocean. Its big bill is not just for catching fish, but also for building a nest burrow. Using their feet and bill, puffins dig their nest site as much as five feet past the entrance! They are nest-site faithful, returning to the same burrow every year to lay and incubate their eggs, and raise their chick over a period of about three months.

In 2018, we began capturing Tufted Puffins while in their burrows at Middleton Island in the Gulf of Alaska as part of a project funded by the North Pacific Research Board. Our objective is to determine where puffins reside during the non-breeding season. We rely on geolocator technology to help us determine where the puffins spend their time during winter. Geolocators are a small instrument affixed to a leg band that measures light levels that are then transformed into geographic locations.

While it may sound easy to capture a bird in its burrow, it can be challenging! One piece of equipment that helped locate puffins was our burrowscope, an infrared micro-camera, which sits at the end of a flexible hose and connects wirelessly to a tablet. Using the burrowscope we observed "remotely" whether or not the burrow was occupied. If an adult puffin was present, we carefully removed and outfitted the bird with a geolocator tag. Puffins wear these tags for a year until they return to their burrow the following summer to breed. At that point, our task is to recapture the birds and remove the geolocators for data analysis. In 2019, thanks to the camera, we recovered over 50% of our geolocators that were deployed in 2018. In 2020, we will return to the breeding colony and recapture puffins tagged in 2019, as well as any 2018 tags that were not retrieved. ■

UNRAVELING THE MYSTERY OF ALEUTIAN TERNS

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Aleutian Tern nest on the Copper River Delta. *Photo credit Melissa Gabrielson.*

Aleutian Tern adult on Copper River Delta. *Photo credit Evan Ward.*

Did you know that Aleutian Terns nest on the Copper River Delta? They were first documented in the 1970s when populations were some of the highest in the state—over 2,000 birds! However, the population in Alaska appears to be diminishing.

Declines in the Alaska population prompted questions about migration and winter habitats. Aleutian Terns are difficult to study because they do not always nest in the same place each year, they use a variety of habitats, there is a lot of movement between colonies, and information is missing about their natural history.

One unknown was where Aleutian Terns went in the winter. A small number of specimens indicated that they may be going to East Asia. In 2010, a geolocator study indicated that Aleutian Terns were indeed flying all the way to Indonesia and the Philippines for the winter! Wintering in southeast Asia introduces a variety of environmental stressors, such as coastal development and pollution, that may affect the Aleutian Tern population.

In 2018, a collaborative study between the Tongass National Forest, Chugach National Forest, U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, University of Alaska, Oregon State University, and others was initiated to address additional information gaps on the nesting population, migration routes, and winter locations.

On the Copper River Delta, aerial and ground surveys were conducted by the U.S. Forest Service, Cordova Ranger District to provide insight on Aleutian Tern numbers and habitat use on the breeding grounds. Multiple colonies still exist on the Delta, though the total number of birds is lower than historic accounts. This could be due to habitat changes, shifts in food sources, or environmental stressors on wintering grounds.

Over the years, we have learned some intriguing things about Aleutian Terns, but there are still many questions to be answered. As research continues further mysteries about this species will be unraveled. ■

WHAT HAPPENED TO THE HUMPBACK WHALES OF PRINCE WILLIAM SOUND?

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The 2014-2016 North Pacific marine heatwave (aka "The Blob") affected marine species from plankton to whales. Our surveys found that the number of humpback whales visiting the Sound dropped dramatically during The Blob and have yet to recover.

The decline in whales corresponded to a drop in the biomass of Prince William Sound herring, the primary food of humpbacks in the Sound. We also saw fewer calves and "skinny" whales, which also points to a nutritional issue.

Did the whales move somewhere else to find food? Or possibly die from starvation?

A tough question to answer with limited effort and a lot of water to cover.

To track down the missing whales we teamed up with Happywhale (happywhale.com).

Happywhale tracks whales around the world based on the unique patterns on their flukes. We learned that about 20% of the whales we identified in the Sound also visit Kodiak and about 6% show up in Southeast Alaska, one even made it to Russia.

Unfortunately, a lot of these observations happened before The Blob, so we do not know what happened to all of the whales, but we are still looking.

There is hope that they will turn up on the breeding grounds in Hawaii or Mexico and someone will snap a photo letting us know that the whales are still alive and have moved to greener pastures. ■

A humpback whale and seabirds congregate for a forage fish meal. *Photo credit John Moran, NOAA.*

Humpback whales in Prince William Sound showing a robust whale with large blubber layer (top) and malnourished whale showing (arrows from left to right) a sharp, less rounded spine, right scapula visible under skin, and appearance of rough skin from parasites and lesions (bottom).
Photos credit John Moran, NOAA.

SCIENTISTS INTEGRATE STUDIES OF

PREDATORS AND PREY

IN PRINCE WILLIAM SOUND

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Imagine the difficult life of a small fish in a big sea. Every animal larger than you wants to eat you, and while you're avoiding predators you must find food yourself! Being a top-level predator isn't much easier, always in search of the next meal as it hides beneath the water's surface. Add warming and variable ocean conditions to the mix and the complications increase.

The Gulf Watch Alaska program includes three projects that have integrated their fall surveys each year to explore the relationships between predators (seabirds and marine mammals) and prey (small fish scientists call forage fish). Forage fish are important secondary consumers because they convert stored energy from primary consumers, such as plankton, into energy that can be transported up the food chain. Without these calorie-rich forage fish, this energy would be entirely unavailable to species higher on the food chain, like Pigeon Guillemots and humpback whales. The program's combined fall study in Prince William Sound is termed the Integrated Predator-Prey Survey. Each of these projects has detected changes in the condition, number, and distribution of all the species they study during and following the Pacific marine heatwave (also called "The Blob") that began in 2014.

Before the marine heatwave occurred, forage fish, seabirds, and humpback whales tended to concentrate in specific areas of Prince William Sound in the fall. Since then, forage fish have become difficult to find by predators and scientists. Seabird distributions have changed, and humpback whale populations have dramatically diminished in the Sound. The three articles that follow provide a perspective on the state of forage fish, seabirds, and humpback whales in Prince William Sound since the marine heatwave event.

For more information about these and other projects of the Gulf Watch Alaska program visit our website gulfwatchalaska.org. Gulf Watch Alaska is the long-term monitoring program of the *Exxon Valdez* Oil Spill Trustee Council. ■

ARE WARMER WATERS DRIVING SHEARWATERS INTO PWS?

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Short-tailed and Sooty Shearwaters are common seabird species in Alaska during the summer months. Unlike many of the other birds that migrate to Alaska to breed in the summer months, shearwaters take advantage of the long daylight to overwinter, i.e. shearwaters breed deep in the southern hemisphere during the austral summer and overwinter in northern latitudes during the northern summer. Feeding mainly on euphausiids (krill) but also squid and small fish, these birds can feed on the surface or dive to catch their prey.

Researchers at the Prince William Sound Science Center conducting Gulf Watch Alaska fall and winter avian surveys (September-March) typically only see shearwaters in September near the entrances to the Gulf of Alaska when the birds are journeying south to breed. However, in September 2019 researchers observed increased densities of shearwaters deep inside the Sound. Then in November, researchers recorded a group of ~250 shearwaters in PWS. In over 10 years of surveys, only ~20 shearwaters total had ever been observed during the late fall and winter months.

Last summer there was a die-off event of Short-tailed Shearwaters in the Bering Sea. The observed shift in distribution in PWS this past fall may indicate that shearwaters were responding to poor conditions in the Bering Sea or Gulf of Alaska. Continued long-term monitoring of marine birds will enable scientists to identify changes in bird density and distribution that are valuable to understanding what is going on in the marine ecosystem. ■

Sooty Shearwater and reflection. *Photo credit Mark Rauzon, U.S. Fish & Wildlife Service.*

FORAGE FISH IN THE NORTHERN GULF OF ALASKA: ON THE ROAD TO RECOVERY AT LAST?

Squid, adult walleye pollock, herring, eulachon, northern smoothtongue, capelin, juvenile walleye pollock, krill, and shrimp are forage species that are caught by a modified-herring trawl in Prince William Sound during the Fall Integrated Predator-Prey Survey.
Photo credit Mayumi Arimitsu, USGS.

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After several years of diminished availability and quality of forage fish in the Gulf of Alaska, there are signs of improvement for capelin and sand lance populations in the region.

Data collected in 2019 by the U.S. Geological Survey (USGS) and numerous partners as part of the Gulf Watch Alaska long-term monitoring program revealed that older, more nutritious individuals from these key forage populations were less abundant during the 2014-2016 North Pacific marine heatwave (aka "The Blob").

For example, in Prince William Sound, capelin spawning at Port Etches (on the west side of Hinchinbrook Island) were younger and smaller than before, and sand lance near Naked Island (north of Knight Island) experienced extremely low growth so their total energy content was 89% lower than usual. During the prolonged warm spell, capelin virtually disappeared in seabird diets and surveys, and the sand lance population was dominated by only young individuals. By 2019, sand lance and capelin age, size, and total energy indicated improved health of these populations compared to 2016.

Caitlin Marsteller (USGS) and April Surgent (USGS) throw the cod end of the modified herring trawl overboard on the *USGS R/V Alaskan Gyre* during the Fall Integrated Predator-Prey survey in Prince William Sound.
Photo credit Anne Schaeffer, Prince William Sound Science Center.

In turn, improved foraging conditions were coincident with higher breeding success in seabirds, and an uptick in Prince William Sound humpback whale numbers during the fall. Monitoring changes in forage fish populations is critical to explaining the underpinnings of predator ecology in changing marine ecosystems. ■

Skeletal remains of a fin whale. *Photo credit Anne Schaefer.*

SHIFTING SANDS AND THE WHALE THAT DISAPPEARED

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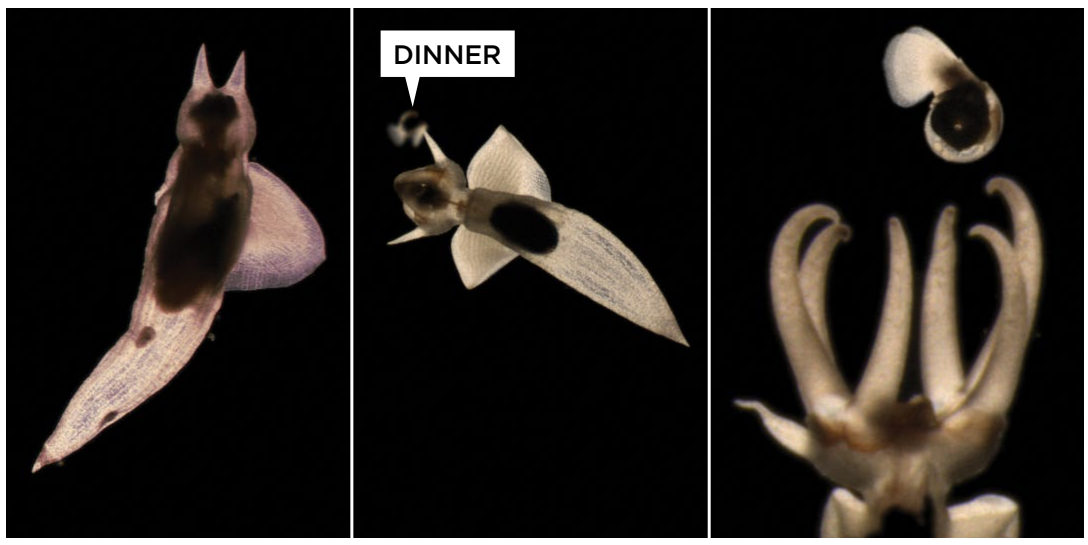
The Copper River Delta is home to the longest chain of barrier islands and sand spits in the Gulf of Alaska. This barrier chain owes its origins to the longshore transport of huge sediment outputs from the Copper River and the many local glaciers. Located at the far west end of the Delta is Egg Island. Unprotected from the Gulf of Alaska's dominant southeasterly waves, Egg Island's outer beach is constantly both eroding and growing (accreting).

Every few years a dead whale washes ashore at Egg Island, including a humpback whale this past 2019 spring. Back in 2009, a fin whale washed up mid-way on Egg Island next to a freshwater slough. We give informal names to these sloughs to more easily identify them during nest searches for Semipalmated Plovers. Not surprisingly, we named the slough, "Whale Slough." While an impressive landmark, it quickly began to disappear and by 2018, we were hard-pressed to find the whale's remains. Over the 10 years, the outer beach had accreted for hundreds of feet, so that now a shallow trench and sandbar lies between the whale and the Gulf of Alaska. These days, beach rye and driftwood, along with well-camouflaged nests of Semipalmated Plovers are more easily found in the area than the skeleton of this giant whale that once washed ashore. ■

FROM SEA ANGEL TO SEA DEVIL:

CLIONE LIMACINA CAUGHT ON CAMERA



LEFT: A sea angel (*Clione limacina*; 2 cm long) captured by Dr. Rob Campbell's zooplankton camera.

MIDDLE: A plump sea butterfly (*Limacina helicina*) swims dangerously close to the hungry sea angel.

RIGHT: The sea angel extends its six hunting arms to capture the sea butterfly prey.

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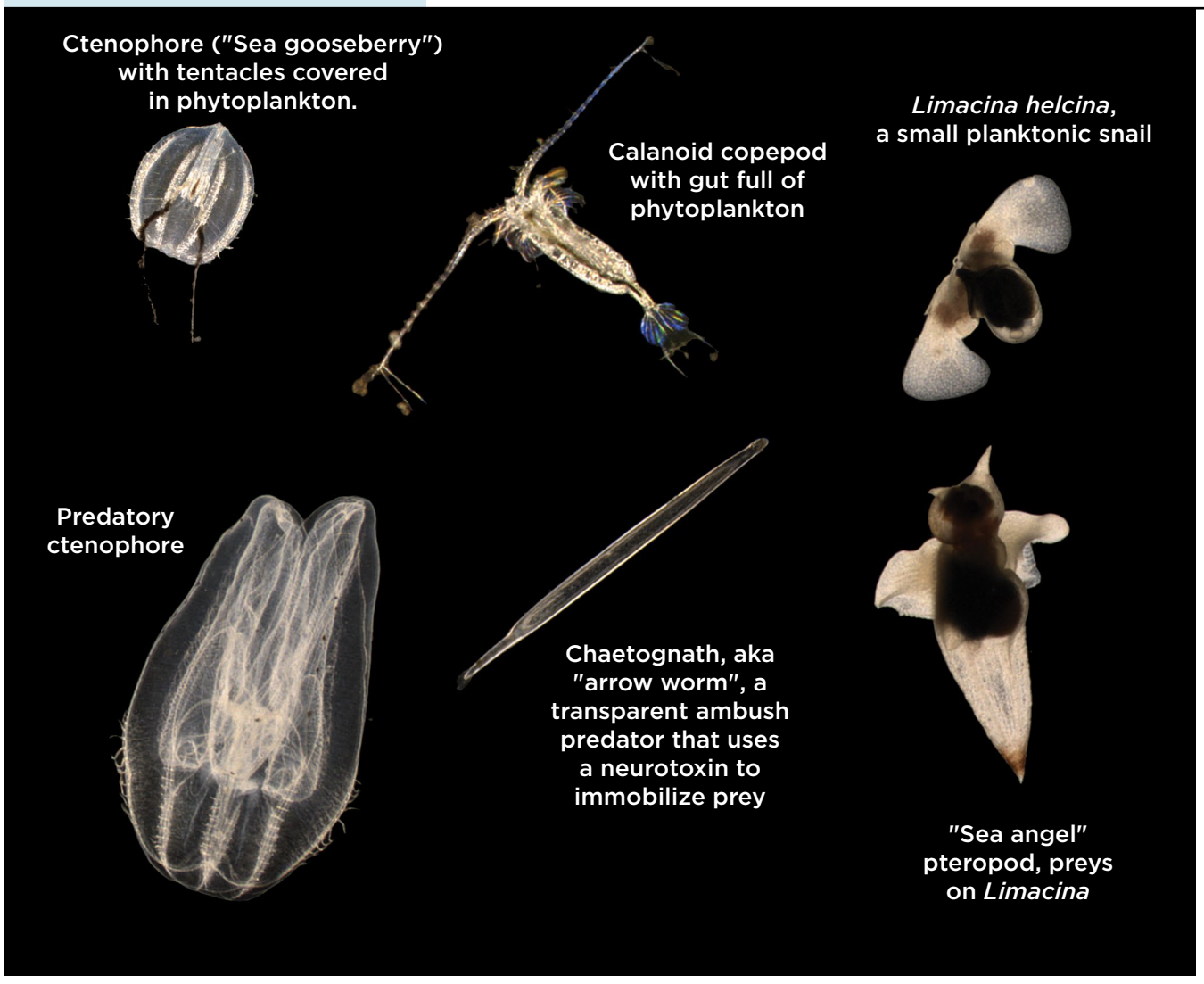
Sea angels *(Clione limacina)* are small (2-7 cm) charismatic zooplankton found in Prince William Sound. These invertebrates belong to a special order (Gymnosomata) of snails and slugs adapted to life in the open ocean. Instead of a muscular foot that leaves a slimy trail like slugs on land, the sea angel's foot is modified into two wing-like appendages that give these gastropods their innocent name. But these graceful angels turn into tentacled nightmares to their prey. When dinner floats by, this planktonic sea slug exposes six hunting arms from its head. Within 0.005–0.007 seconds, dinner is captured.

The species name for *C. limacina* is derived from the sole species of prey they rely on for growth and reproduction: *Limacina helicina* or sea butterflies. Sea butterflies are pelagic snails closely related to their sea angel predators. Unlike the soft bodies of sea angels, sea butterflies have a thin calcium carbonate shell like common snails.

Thanks to advances in camera technology, Dr. Rob Campbell collected these images using the PWS autonomous moored profiler (PAMPr). Attached to PAMPr, a camera with the ability to take microscopic images of live zooplankton collects data to examine species composition and abundance of the PWS zooplankton community and, every now and then, exciting sequences like this. ■



A selection of images of plankton captured by the plankton camera. Individual images not to scale.

COMPUTERS 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 deployed on an autonomous robotic profiler that is deployed every year in central Prince William Sound from spring to autumn. Over 1,500 twice-daily profiles from 60 meters to the surface have been done so far, collecting over 2 million images of individual plankters. Using Deep Learning techniques similar to those used by Google to automatically identify images on the internet, 43 different kinds of plankton have been identified, to an accuracy of about 90%. The images, along with other data collected by the profiler, are giving oceanographers an in-depth picture of how the plankton ecosystem of Prince William Sound works. ■

A photo of sugar kelp. The plant is about one meter in length. These kelps occur at the low-tide and upper subtidal levels and are attached to small rocks and pebbles in wave-protected beaches.

SUGAR KELP GENETICS

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A key concept guiding the development of Alaska's marine biological resources is protecting the ecology and genetics of wild populations. Seaweeds—an abundant, but underused resource have caught the attention of a growing number of commercial kelp farmers. Worldwide, seaweed harvests support a six billion dollar industry centered in Asia. Tremendous potential exists for the development of kelp mariculture in Alaska.

Unfortunately, not enough is known about either the ecology or genetics of the kelps in Alaska, which include sugar kelp, winged kelp, and bull kelp. How large are kelp populations? Where should brood stock plants be collected for grow-out in kelp farms? Will kelp farming affect wild populations?

A recent study of the genetics of sugar kelp, funded by the North Pacific Research Board, focused on estimating the geographic size of kelp populations. Three kinds of DNA markers were used to survey genetic variability among populations of sugar kelp around the Gulf of Alaska. The results revealed the presence of six closely related genetic lines. A limited number of samples in Prince William Sound detected two of these lineages, one collected at the Cordova breakwater and the other at Whittier.

Kelp in Alaska show a chaotic population structure with strong genetic differences between populations. This indicates there is limited movement between populations. With a better understanding of kelp ecology and genetics, kelp farming can be compatible with protection of the store of genetic variability in wild populations. ■

Annie Raymond, looking for kelp in the waters around Juneau.

RESEARCH ON KELP ECOLOGY TO SUPPORT

KELP FARMERS

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Graduate student Annie Raymond has been working with Dr. Stekoll (UA Southeast) on the phenologies of sugar kelp and winged kelp to provide much needed background information for mariculture. The project's goals are to better understand kelp reproduction in the wild and to test seeding methods to give more flexibility to kelp farmers.

Winged kelp occurs on most rocky intertidal beaches, but sugar kelp is found only on wave-protected beaches. Unlike most kelp species, sugar kelp never attaches to bedrock, but is found in sandy habitats attached to small pebbles, or to nothing at all.

Annie has found that young sugar and winged kelps appear in the early spring and can become fertile very quickly. However, the length of time plants remain fertile and the abundance of plants can vary greatly between sites and years.

In some areas kelp plants are annuals, but in other areas they are perennials. Even though winged kelp is an annual, its populations are more predictable from year to year along much of Alaska's coastline. For kelps in general, the release of spores is highly variable. Sometimes mature plants appear to be fertile, but do not release any viable spores.

Insights into the basic kelp reproductive biology and ecology from this study will be essential to kelp farmers and hatchery operators in their efforts to develop a kelp industry in Alaska that is economically viable and ecologically sustainable in the long run. ■

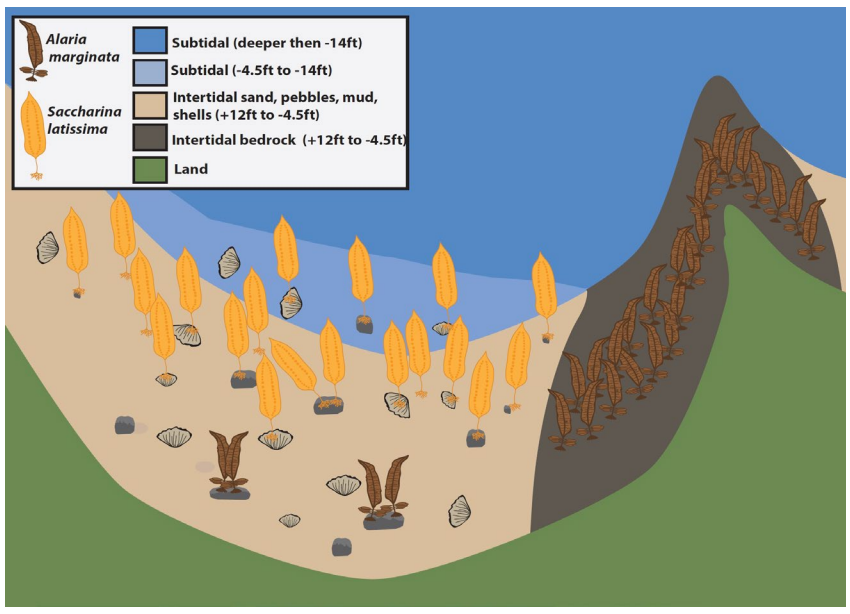

Fig. 2. Schematic of substrate types for sugar and winged kelps. *Schematic: Annie Raymond.*

KEEPING AQUATIC INVASIVES AT BAY IN THE CHUGACH NATIONAL FOREST

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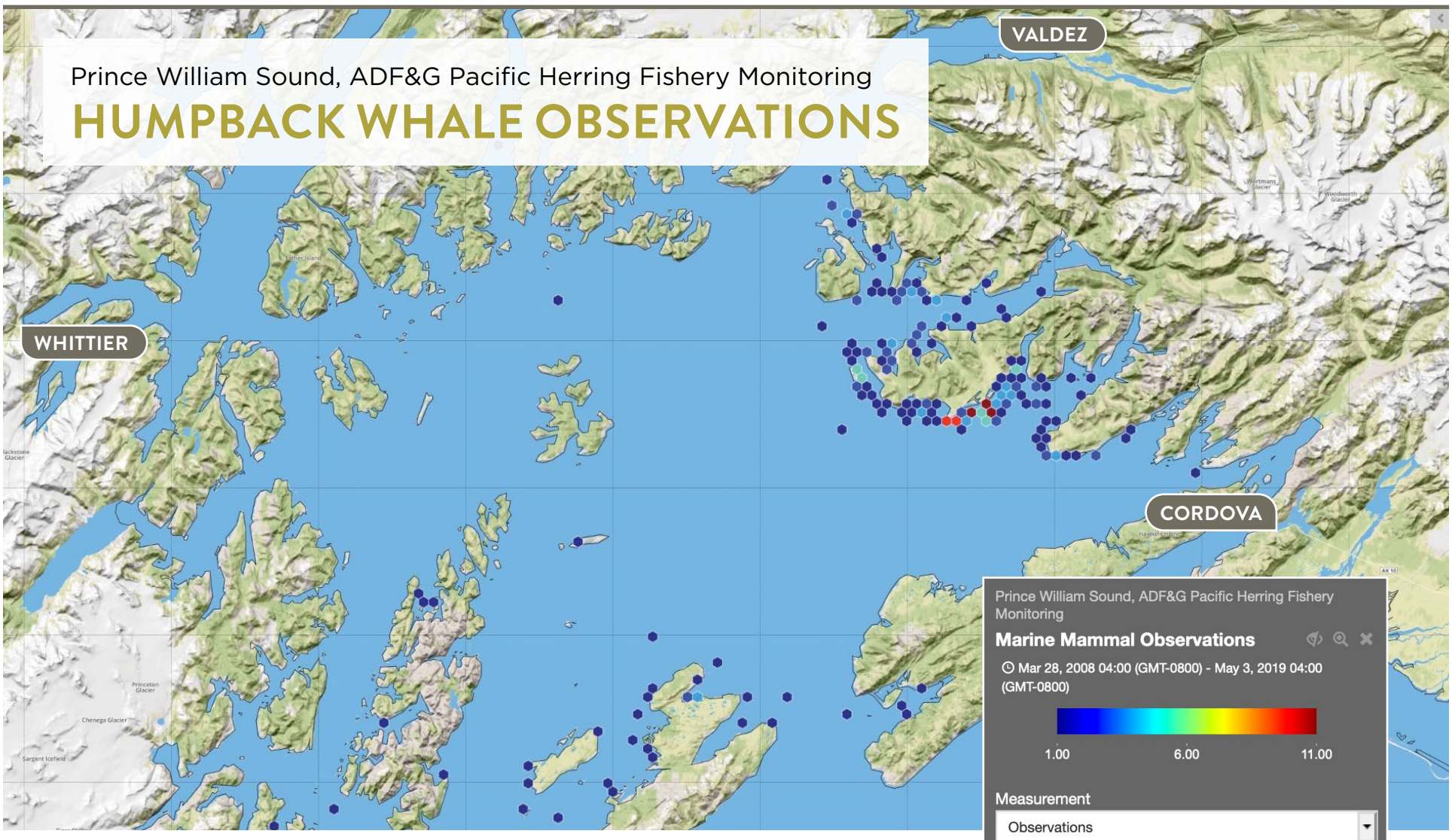
Elodea canadensis (aka Elodea) is the first aquatic invasive plant known to occur in Alaska. It was introduced into Eyak Lake near Cordova sometime before 1982, and has since established itself in multiple waterbodies across the Copper River Delta via boats, floatplanes, and natural flooding events. Elodea is known to occur in several waterbodies across the state from Fairbanks to the Kenai Peninsula. In many of these areas, Elodea is being actively treated or has been successfully eradicated.

The U.S. Forest Service, in partnership with the Copper River Watershed Project and researchers from Loyola and Notre Dame Universities, have been studying the on-site effects of Elodea and its impact on aquatic food webs of the Copper River Delta. The Forest Service is examining the feasibility of eradicating this aquatic invader from the Delta; results are anticipated in 2022.

Meanwhile, the Forest Service and other statewide entities are eager to stop further spread of this species into uninfested waterbodies. On the Chugach National Forest, Elodea appears to be contained to the Copper River Delta, however, the possibility of spread beyond the Delta exists.

To further minimize the spread of Elodea, the Chugach National Forest is employing a three-pronged approach of monitoring, rapid response, and outreach. The Forest Service is working with the University of Alaska Anchorage to develop a monitoring protocol to detect the presence of Elodea. Concurrently, the Forest Service is developing a waterbody vulnerability matrix that looks at criteria associated with increased Elodea infestations such as floatplane sites or waterbodies near road systems. This tool will identify high-priority waterbodies that should be monitored more frequently for Elodea. The Forest Service will also begin an Environmental Assessment for the Early Detection and Rapid Response to treat waterbodies outside the Delta, should Elodea be detected. Finally, education to minimize Elodea spread through unclean equipment will be ongoing. ■

James Ianni (Biological Science Technician, US Forest Service) with an Elodea-covered 1 m^2 quadrat — a simple scientific tool made of PVC pipe to measure percent cover of native and invasive aquatic plants underwater and collect water depth. *Photo credit Lauren Bien.*



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 the general public, mariners, resource managers, researchers, and other interested parties.

Anyone with an internet connection can search the portal for current and historical information from the greater Alaska region and immediately display this information on a map or graph. The information can also be downloaded as a data file. The AOOS ODE provides a way for users to find information they need to help make a variety of decisions.

Humpback Whale Observations

The ODE is used as a source of information on humpback whale observations in the example below. This screen shot of the ODE map displays counts of humpback whales observed as part of the Prince William Sound, Alaska Department of Fish & Game Pacific Herring Fishery Monitoring Program. These aerial surveys are conducted annually between late March and mid-May to observe the majority of spring Pacific herring spawning events. This screenshot displays all humpback whale sightings that occurred over the ten year period of surveys between 2008 and 2018. This information is one of thousands of data layers available for display and/or download. Go to https://portal.aoos.org/?ls=271fe275-77f9-6594-273e-9975c9df9c8f#map to view this information. ■

ALASKA HARMFUL ALGAL BLOOM NETWORK:

Coordinating a statewide approach to HAB awareness, research, monitoring, and response in Alaska.

PARTNER HIGHLIGHT: Southeast Alaska Tribal Ocean Research (SEATOR)

The Sitka Tribe of Alaska (STA), founder of SEATOR, has a vested interest in protecting traditional natural resources as well as the health of the local community. SEATOR was formed in September 2013 to unify 16 Southeast Alaska tribes in monitoring harmful algal bloom (HAB) events that pose a human health risk to subsistence harvesters.

Each tribal partner collects weekly algal and water samples at key community harvest times, making observations about the abundance of specific algae, salinity, and sea and air temperatures, that are housed in a central database. Tribal partners also collect bi-weekly shellfish samples to be tested for biotoxins, or more frequent samples whenever specific algae are present. These samples are processed and analyzed within a 48-hour period at the Sitka Tribe of Alaska Environmental Research Laboratory for toxin analysis. Results are emailed out to all SEATOR partners, local and state health officials, resource managers, and university staff. If detected toxin levels are above the regulatory limit of 80µg/100g or a SEATOR partner site is observing HAB species in their algae sample, a shellfish harvest advisory is issued by SEATOR and the local tribe for the affected community.

SEATOR's HAB program is serving as a model for other potential tribal and community-based monitoring throughout the state, including Prince William Sound. ■

Kari Lanphier, Environmental Lab Manager, Sitka Tribe of Alaska.

Deployment of a yellow autonomous underwater glider with *R/V Sikuliaq* in the background. *Photo credit NPRB/Brendan Smith.*

R/V Nanuq approaching the silty Copper River discharge plume.

Photo credit Seth Danielson.

LONG TERM ECOSYSTEM RESEARCH IN THE GULF OF ALASKA

The Northern Gulf of Alaska region including Prince William Sound is known for its biological productivity and diversity. From the lowest levels of the food chain (plankton) to its iconic salmon, halibut, crabs, seabirds, and marine mammals, this region supports many commercial, sport fish, and subsistence fisheries. Scientists at the University of Alaska and their many partners recently joined the National Science Foundation's Long Term Ecological Research (LTER) network that was created to test and develop ecological theories across a spectrum of ecosystems.

The US LTER network consists of 28 sites with a rich history of ecological inquiry, collaboration across a wide range of research topics, and engagement with students, educators, and community members. It brings together diverse groups of researchers with multi-decadal data collection and ecosystem experiments extending beyond the typical 2-4 year research grant. These sites allow each new generation of scientists to apply new tools and explore new questions in systems where the historical context is well understood, shared, and thoroughly documented.

Multidisciplinary research at well-established locations has been an important component of marine studies in Alaska. Many of these observations have been made offshore of Resurrection Bay, the fjord that connects Seward, Alaska, to the North Pacific Ocean. The Seward Line observations stretch 150 nautical miles from the inner continental shelf into miles-deep oceanic waters well past the shelf break. These observations have been critical in defining the ocean conditions that characterize the Northern Gulf of Alaska habitats and their associated biological communities.

Research data are collected year-round from instruments attached to stationary buoys, such as the Gulf Ecosystem Observatory, that measure a wide variety of parameters including water temperature, salinity, nutrients, currents, and ocean acidification, as well as underwater sounds including marine mammals and ship noise. Data are also collected from oceanographic cruises on the *R/V Sikuliaq* (261 ft. length) and *R/V Nanuq* (40 ft. length), two modern and state-of-the-art scientific research vessels operated out of the University of Alaska Fairbanks Seward Marine Center in Resurrection Bay. The newest addition to data collection methods for this project will include underwater autonomous gliders that can be launched from research vessels and then operate robotically, moving through the water for months at a time collecting important scientific data in places that lack shipboard observations.

Studies in the Northern Gulf of Alaska by the LTER project are currently focused on the growth of microscopic marine algae called phytoplankton. Like terrestrial plants, phytoplankton contain the green pigment chlorophyll and require sunlight and nutrients in order to live and grow. Phytoplankton form the base of the food chain in the ocean. Most are beneficial sources of food to animal plankton (zooplankton) and fishes, but some can generate toxins such as those that lead to paralytic shellfish poisoning. The growth of phytoplankton depends on a complex interaction of ecosystem factors such as temperature, water column stratification, light and nutrient availability. Knowing how this happens is vitally important to understanding how the ecosystem works.

Growth incubation experiments of phytoplankton from the Copper River plume water are showing how balances of fresh water, light, and nutrient availability impact phytoplankton growth. Water quality measurements and zooplankton collected using nets show how differing plankton communities thrive in fresh, brackish, and salty shelf waters that extend along the salinity gradient that extends from the Copper River outflow to the open ocean. Satellite-tracked drifters transmit hourly reports of GPS position and sea surface temperature and show how wind and tides modify the local currents.

Now you know what some of those buoys that you see on the ocean and some of the science vessels moving through the Sound and the Gulf of Alaska are doing. It's all in the name of science!

These ongoing observations are supported by Alaska Ocean Observing System, the M.J. Murdock Charitable Trust, the North Pacific Research Board, the *Exxon Valdez* Oil Spill Trustee Council, and the National Science Foundation. ■

OCEAN ACIDIFICATION UPDATE

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 waters have already become more acidic due to natural factors, an increase in ocean acidification could have major impacts.

HOW DO WE MONITOR OCEAN ACIDIFICATION?

When people think of acidity, they often think of the pH scale, but tracking ocean acidification requires more than that. A suite of variables needs to be collected simultaneously, and a long time series is needed to tease out trends from natural variability. Strategies for monitoring ocean acidification in Alaska's coastal and ocean ecosystems include ship-based monitoring, open ocean buoys, instruments attached to docks or moorings, shore-based systems in labs or hatcheries, and community-based water sampling.

NEW RESEARCH REPORT

The Alaska Ocean Acidification Network published an update to its annual State of the Science report in November 2019. The report provides new findings on the response of herring, razor clams, and pteropods to higher acidity water, as well as updates on Gulf of Alaska and Arctic modeling projects and nearshore monitoring in central and Southeast Alaska. The report can be found on the Alaska Ocean Acidification Network website at aoos.org/alaska-ocean-acidification-network/.

DID YOU KNOW?

SPECIES RESPONSE

Sixteen Alaska species have been studied so far in the lab to gauge their response to higher acidity water. The vast majority showed some form of negative impact to calcification, growth, reproduction, or survival when the acidity of the water was elevated. A notably resilient species was walleye pollock. Natural conditions are hard to imitate in the lab, so while these studies give us clues to how things may happen in the future, there are still many variables such as the influence on food chains or the role of adaptation or migration.

SEASONAL CONDITIONS

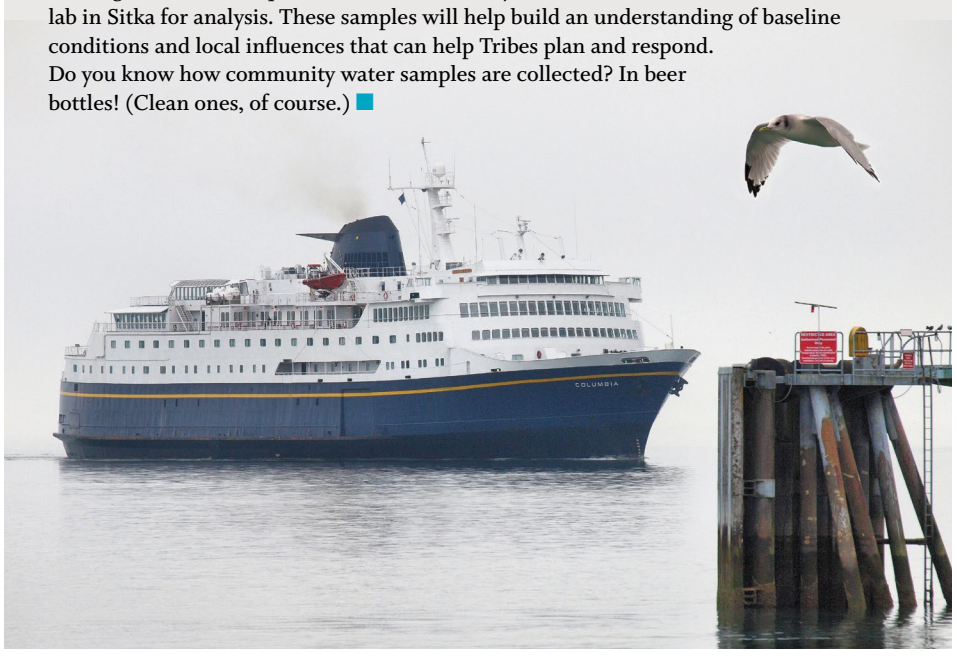
Ocean acidity and other chemical parameters that play a role in ocean acidification fluctuate on a seasonal basis. Fall and winter tend to be the most acidic or corrosive times of year when phytoplankton are no longer removing as much CO_2 from the water column (through photosynthesis) and stormy weather churns up bottom water (which tends to be more corrosive). Then in the spring/summer, levels reverse. These natural seasonal cycles can be easily tracked in multi-year data series.

SCIENCE ON THE FERRY

Since 2018, the state ferry *M/V Columbia* has been collecting OA data every three minutes during its weekly run between Bellingham, Washington and Skagway, Alaska (1,854 miles round trip). Over 290,000 measurements have been made! The partnership between research entities and the Alaska Marine Highway System provides a unique window into nearshore water chemistry and seasonal trends, and is giving scientists the opportunity to identify local hotspots. An example hotspot is Lynn Canal which runs between Juneau and Skagway.

TRIBES ARE INVOLVED

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, Southeast Alaska, and the Arctic 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.
Do you know how community water samples are collected? In beer bottles! (Clean ones, of course.) ■



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Paxson
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Copperville
Copper Center
Kenny
Lake
Chitin
Wasilla
C h u g a c h
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Valdez
Anchorage
Unakwik Inlet
Tatitlek
Portage
Whittier
Eaglek Bay
Bligh Reef
Blackstone Bay
Prince
William
Sound
Simpson Bay
Cordova
Alaganik
Eshamy Bay
Knight Is.
Egg Is.
Hinchinbrook Is.
Copper River
Hinchinbrook
Entrance
Chenega
Montague Is.
Seward
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Middleton Is.
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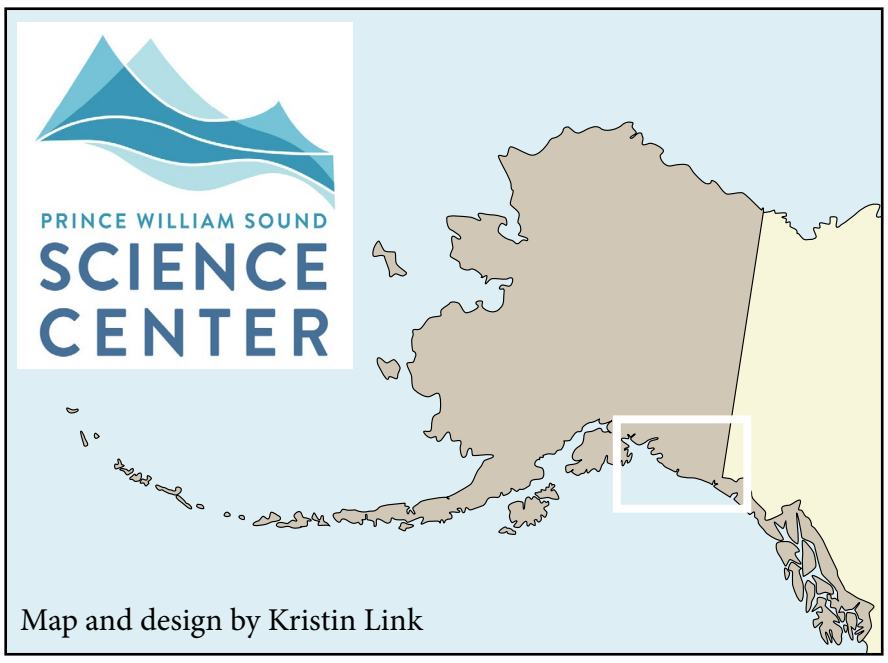
25
50
Miles
150°W
148°W
146°W

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

HERRING RESEARCH AND MONITORING

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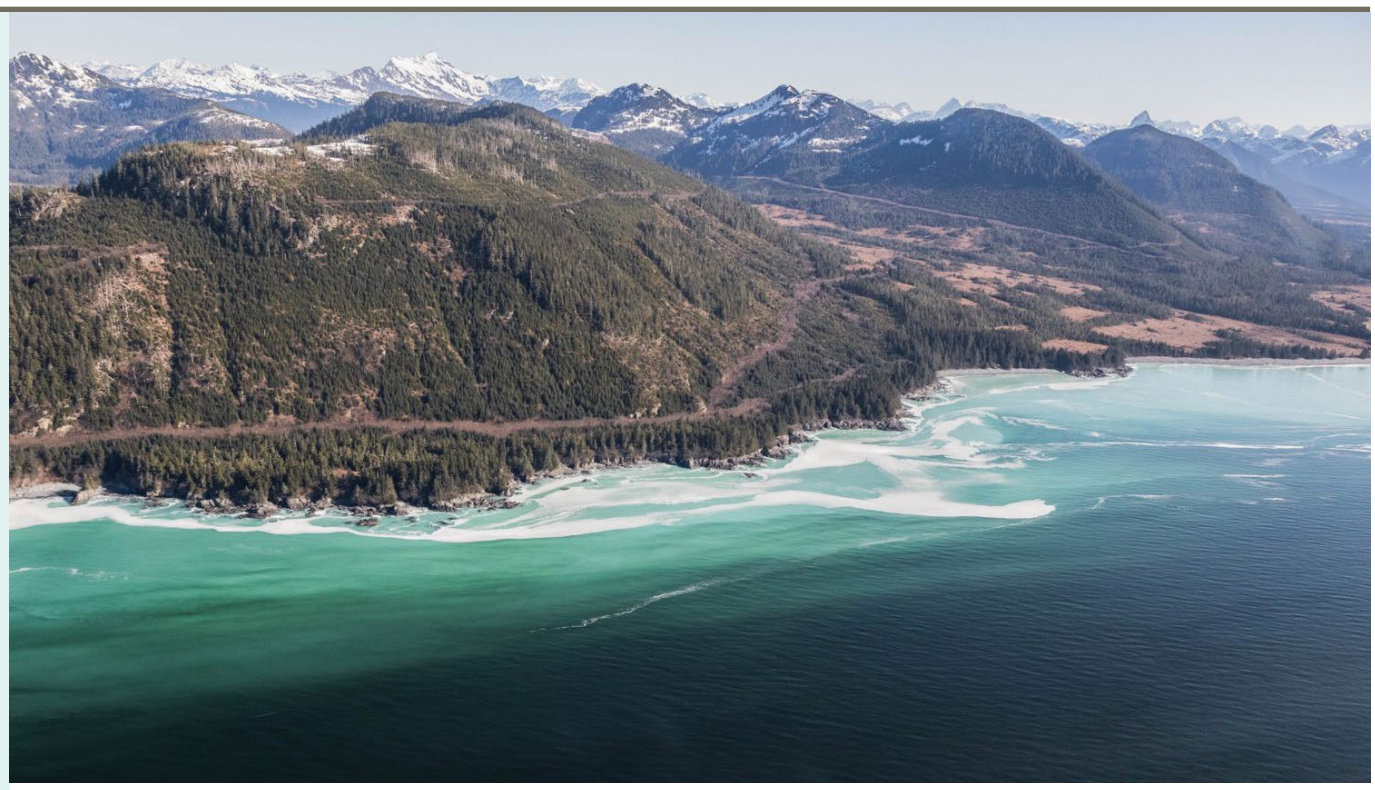
In the decades prior to 1990, there was a robust Pacific herring population in Prince William Sound (PWS) with a biomass of 130,000 tons. Not only are these forage fish a key link in the complex food web of PWS, but they once supported a lucrative early season commercial fishery that brought the communities 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 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 for the last six years.

The HRM 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 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. ■



HERRING POPULATION ESTIMATES

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Prince William Sound (PWS) Pacific herring population estimates are generated annually by the Herring Research and Monitoring (HRM) team with a Bayesian age-structure-assessment (BASA) model. The model inputs include aerial surveys of mile-days of spawn (total number of miles of spawn observed each spring), acoustic surveys of spawning biomass, age-sex-size, historical egg deposition, and disease prevalence data. The PWS surveys used by the model are conducted each spring. The survey area covers traditional spawning regions within Prince William Sound.

An output of the model is the annual median estimate of the biomass. In 2014, the BASA model estimated a declining trend in herring biomass. The observed mile-days of milt reached a record low level in 2018 (Fig. 1). The weight and length at age values have been low since 2015 meaning the population is composed of smaller than normal fish (Fig. 2). There are very few older fish being observed in the population as well. Disease researchers on the HRM team observed high levels of antibodies to the VHS virus in 2015. This suggests that an outbreak of the pathogen occurred between 2014 and 2015. The warm waters associated with "The Blob" are likely to have caused nutritional stress that may have contributed to the outbreak of the virus.

This year's BASA estimate of the 2019 biomass isn't available yet, but while still very low, the observed mile-days of milt in 2019 was nearly triple that of 2018. This appears to be driven by recruitment of new age-3 fish to the spawning population. Herring are categorized as a forage fish and are near the bottom of the food chain. Low abundance of herring may have negative impacts on predators that consume them including whales and salmon. ■

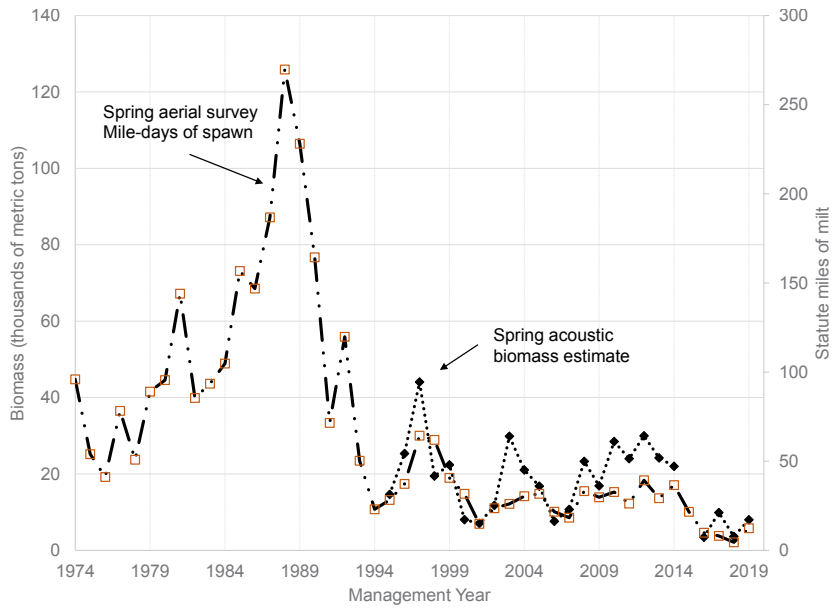

Fig. 1: Mile-days of milt in Prince William Sound based on aerial surveys and biomass estimates from acoustic surveys.

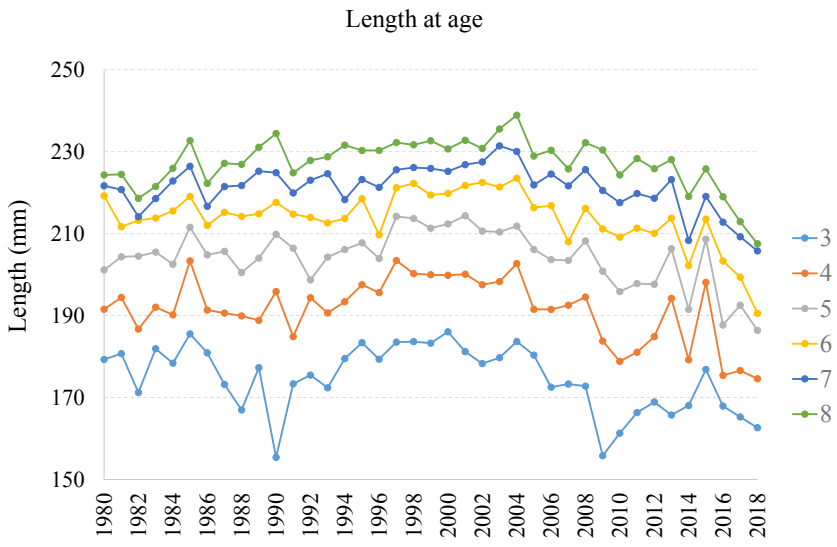

Fig. 2: Weight and length at age data collected by ADF&G.

VIRUS PERSISTS IN PACIFIC HERRING

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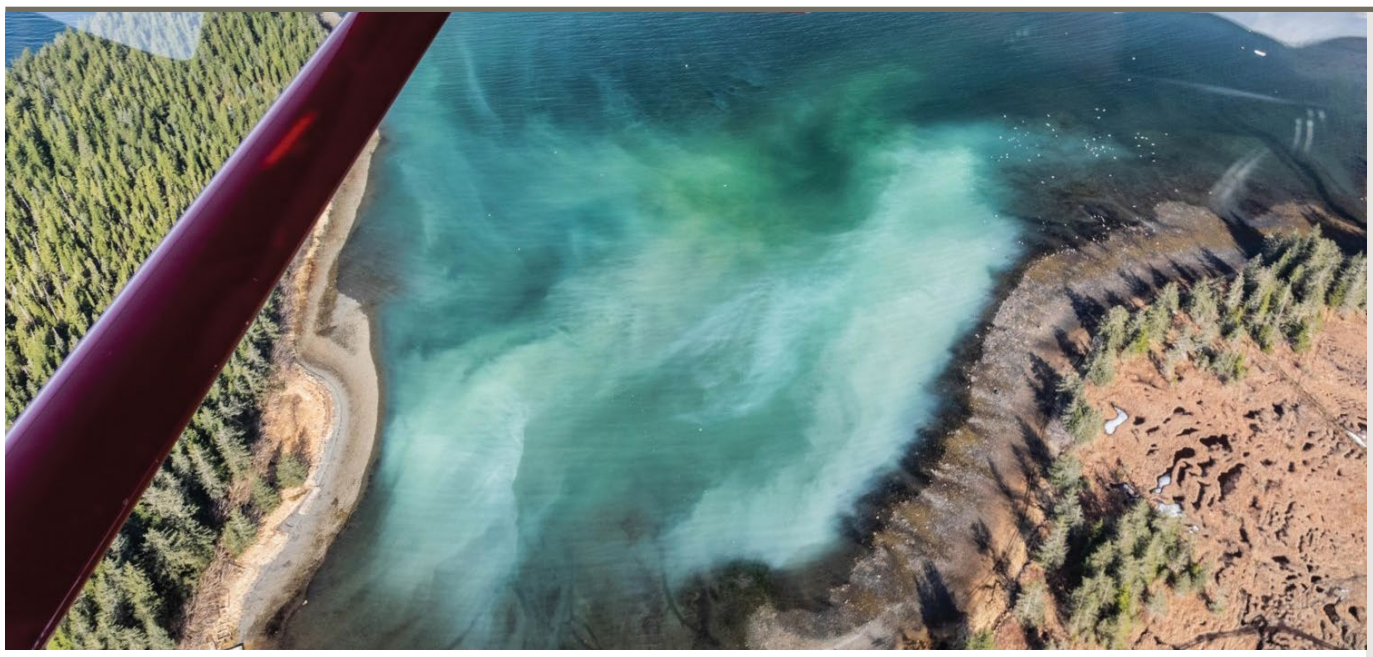
Infectious and parasitic diseases have profound impacts on animal populations, including humans. Unfortunately, population level impacts of disease are particularly difficult to understand in marine fishes, owing to challenges inherent to observing fish kills in the vast ocean. Mortality from a viral disease (viral hemorrhagic septicemia, or VHS) remains one of the leading hypotheses accounting for the decline and failed recovery of Pacific herring in Prince William Sound.

By studying the virus in the laboratory, scientists learned that herring are a super-susceptible host. However, if herring are fortunate enough to survive the disease, they develop antibodies and become immune to any future recurrences of the disease for the rest of their lives. Recent work has shown that these immune individuals continue to shed the virus for months, or years after fully recovering from the disease. Scientists have demonstrated that this shed waterborne virus can initiate new disease outbreaks when new groups of susceptible herring swim through the virus-laden water. These results demonstrate that Pacific herring are involved in the long-term persistence of VHS virus throughout Prince William Sound and the eastern North Pacific Ocean. ■



Aerial observation of herring spawning (white plume) by the Alaska Department of Fish & Game. *Photo credit ADF&G.*

HERRING IN THEIR HOME ENVIRONMENT:

WHAT MATTERS?

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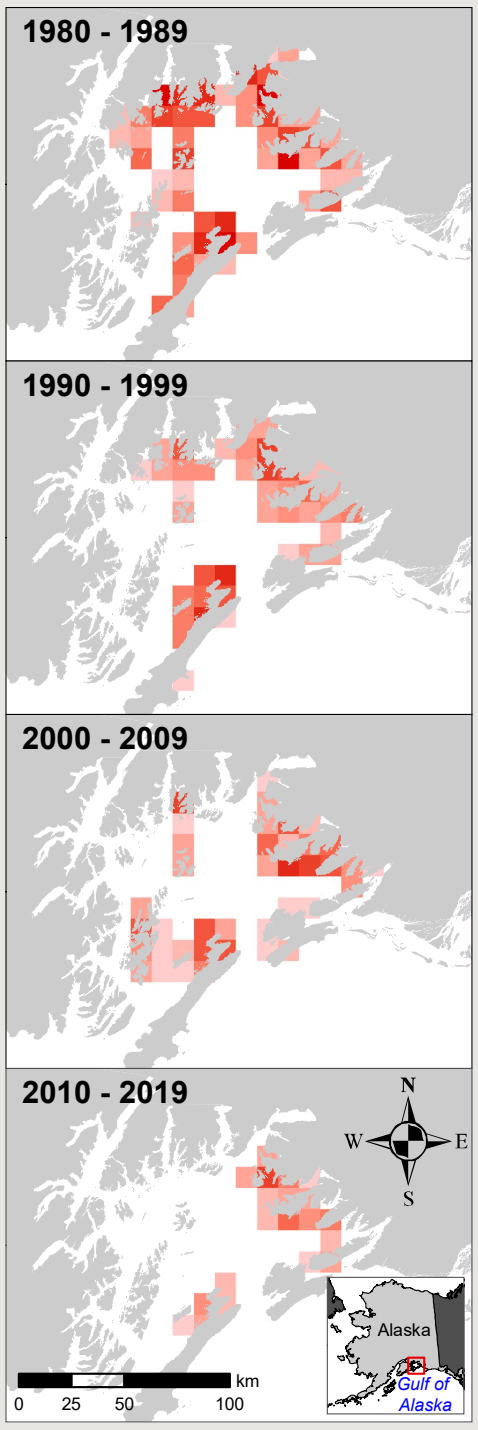
Herring are affected by their environment. This is a certainty for anyone interested in herring, from fishermen to researchers. However, the devil is in the details. Which factors affect herring? How? Where? When? These specific questions have puzzled fisheries scientists, particularly those studying herring, for over a century. Researchers are expected to keep tackling these questions, but their answers are nearly always fallible.

Why? The relationship between oceanography, prey, predators, and competitors with herring is more complex than experiments and models are designed to detect. For example, typical scientific methods require environmental relationships to stay the same over time; humpback whale consumption (per whale) of herring should cause the same percent decrease in herring survival next year as it did this year. Naturally, conditions beyond changes in whale numbers alter this relationship, such as whale behavior or how much their reliance on other prey changes.

To account for these issues, more sophisticated models have been developed to better detect and begin to explain the nature of these relationships. Such a model has been applied to Prince William Sound herring. Specifically, this new model looks at how regional factors such as climate indices, and local factors such as humpback whale numbers impact herring mortality. Results have shown these factors to correlate with changes in herring mortality, but the effects of many of these factors have changed over time. Both regional and local environmental factors are implied to be important for herring mortality and help to shed light on the past and present population dynamics of herring. ■



BIG CHANGES IN WHERE HERRING SPAWN IN PRINCE WILLIAM SOUND

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The location and timing of spawning plays a critical role in the survival of Pacific herring during their first year of life. The first time they spawn, herring are thought to select spawning areas somewhat randomly through dispersal or by following older fish, and then return to that spawning area in successive years. Although individual herring spawn only once per year, the whole population collectively releases batches of eggs over many weeks and sites. Staggered spawning by the population in space and time increases the chances that newly hatched herring will encounter one or more patches of plentiful food. This has the effect of hedging against uncertainty of when and where environmental conditions will be optimal during each life stage, and increases population resilience to fluctuations in the marine environment that impact first year survival.

In Prince William Sound, where aerial surveys monitor herring spawning every spring (*Top left photo*), herring no longer use the primary spawning areas that were used in the 1980s when the population reached its peak abundance (*See figure above*). Starting in the 1990s, spawning distributions have contracted towards the Southeast Sound over the past 30 years, an area where larvae experience higher mortality rates and are less likely to be transported to more productive nursery habitat in other areas of the Sound. This spatial shift may have reduced reproductive success and contributed to the population's lack of recovery. ■

FROM OIL SLICK TO CHRONICALLY SICK?

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The *Exxon Valdez* oil spill occurred March 24, 1989, when herring were preparing to spawn in Prince William Sound. The herring population experienced an unanticipated, abrupt decline three years later due in part to a mortality from infectious and parasitic diseases. Linking the oil spill to subsequent population collapse remains controversial. A major insight from years of studying the spill is that embryonic herring are profoundly sensitive to crude oil; exposure to vanishingly low levels of oil over a brief time early in a herring's lifecycle can have long-lasting health effects, and oil exposure can disturb immune function.

Could crude oil exposure during early life have compromised immune system development, thereby increasing the risk of major disease outbreak in later life? To address this question, over the past few years we have sought to simulate the events surrounding the 1993 herring collapse using 1) experimental exposures to environmentally relevant levels of Alaska North Slope crude oil, 2) fish from the Prince William Sound population and others, and 3) the same pathogens that caused the disease outbreak. Embryonic and larval herring were exposed to low levels of oil, left to recover and grow-up in clean seawater, then exposed to pathogens. Through this research, we are examining links between the *Exxon Valdez* oil spill from 1989 to the 1993 collapse of the fishery. ■

The remains from the *Exxon Valdez* Oil Spill after the second treatment by oil spill workers in Alaska taken July 1, 1989. *Photo credit: Alaska Resources Library and Information Services*

A technician prepares to measure streamflow below Bering Lake. Five years of streamflow data are typically needed to request an instream flow reservation that protects a minimum adequate water flow for Pacific salmon migration. *Photo credit U.S.F.S.*

MINIMUM FLOWS AND MEGAFLOODS AT BERING RIVER

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Who owns the water in Alaska's rivers? The state owns the water and grants water rights for withdrawal and use. State law also allows water to be reserved "instream" to protect fish; however, an instream flow reservation must be requested based on streamflow data. The U.S. Forest Service is measuring streamflow at Bering River (57 miles east of Cordova) with the intent to file instream flow reservation applications that request adequate flows to protect salmon migration through 25 miles of river.

Data collection is nearly complete, but it hasn't been an easy task. Field work is complicated by *jökulhaups* from Berg Lake (located on the NW margin of Bering Glacier).

If you speak Icelandic, you know a *jökulhaup* is a megaflood released from a glacier-dammed lake. Berg Lake, formed by the Steller Glacier, can release a *jökulhaup* that would fill 1 million Olympic-sized swimming pools in a single day! Historically, these events were rare; only four *jökulhaup* released from Berg Lake during the entire twentieth century. Unexpectedly, the Forest Service has observed seven *jökulhaup* during the last five years.

The U.S. Geological Survey has determined that glacier thinning is responsible for the increasing frequency of these megafloods. Steller Glacier has lost 400 vertical feet of ice since 1948. ■

SALMON XING: INSTALLATION OF FISH-FRIENDLY CULVERTS WILL RESTORE EASY ACCESS TO THEIR HOME

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As you drive along the Copper River Highway (aka "out-the-road" in Cordova-speak), salmon swim under your car. In addition to numerous bridges, you also pass over the tops of 50 culverts on each trip. Even though the streams flowing through these culverts appear shallow and small, they have outsized importance for salmon and trout.

Ideally, culverts allow water, sediment, and fish to pass from one side of the road to the other. Unfortunately, many older culverts are too small to allow the natural flow of water, damaging habitat quality and restricting the migration of fish. The ability to travel up and downstream freely is particularly important for juvenile coho salmon, which spend over a year in freshwater before heading to sea. Some of the northernmost cutthroat trout in the world also rely on culverts when they migrate under the Copper River Highway to access their spawning grounds.

A collaborative partnership between Copper River Watershed Project, U.S. Fish & Wildlife Service, Alaska Department of Transportation, Alaska Department of Fish & Game, U.S. Forest Service, and National Marine Fisheries Service was recently awarded $8.1 million dollars from the *Exxon Valdez* Oil Spill Trustee Council to install 11 fish-friendly culverts and remove two unneeded relic culverts over the next four years.

By replacing undersized culverts with "fish-friendly" designs, this project will improve 22 miles of spawning and rearing habitat, helping sustain valuable fisheries in the face of environmental stressors such as drought and warming water temperatures. The larger fish-friendly culverts also minimize the risk of road washouts, contributing to highway safety and reducing maintenance costs long-term. By improving habitat for salmon and protecting access "out-the-road," this project is a real win-win for all! ■

An example of a fish-friendly culvert installed under the Copper River Highway. Eleven similar culverts will be installed over the next four years due to a collaborative effort between the Copper River Watershed Project and five state and federal agencies. Inset photo: a juvenile coho salmon. Coho salmon rear year-round in streams across the Copper River Delta and will benefit from this project.

The Lower Delta sonar camp, 2019. A sonar is mounted on the frame to the left; the floats in the water are a small weir that directs fish away from the bank and in front of the sonar beam. The sonar electronics and control computers are housed in expedition-grade tents. *Photo credit PWSSC.*

EARLY SEASON SONARS HELP MANAGE THE COPPER RIVER SALMON FISHERY

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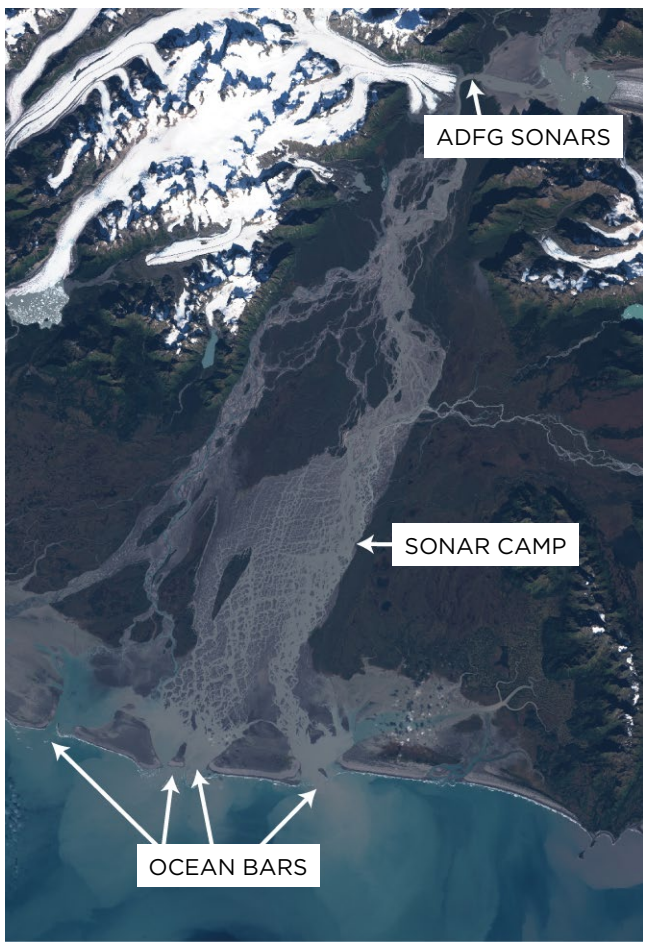
The Copper River salmon fishery is the first major salmon fishery to market each year. Copper River salmon are prized for their high fat content and command a price premium, particularly in the first few weeks of the season. The Copper River fishery is actively managed by Alaska Department of Fish and Game biologists, who are tasked with maintaining sufficient escapement (fish that enter the river to spawn, and become unavailable to the ocean-based fishery) when deciding on when and for how long to open the fishery. One of the primary measures state biologists use to estimate escapement are sonars installed at the first choke point in the Copper River, about 30 miles upriver from the bar crossings where the river meets the ocean. It may take up-migrating salmon several days to reach that point. The lag between when fish leave the ocean and when they are counted by the sonars can lead to overescapements and fewer fishing opportunities.

To provide better information to fisheries managers in the early season, the Copper River/PWS Marking Association has supported Science Center efforts since 2016 to deploy sonars at the lowest practical point in the Copper River Delta from May to early June. Sonars are deployed on both sides of the main channel, approximately 10 miles from the river entry point, producing a timelier estimate of fish movement into the river. Salmon are counted by technicians stationed at a backcountry camp set up on the bank of the river, and the data posted on the internet in near real-time for anyone to see. An increased likelihood for fishing opportunities is a big deal for the local economy—a modest fishing period where 25,000 fish are caught translates to more than half a million dollars in landed value. ■



The Copper River Delta, Sentinel-2 satellite image taken October 1, 2018.

SOCKEYE SALMON MIGRATION IN A CHANGING CLIMATE

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Salmon swim upriver for hundreds of miles to reproduce, relying on energy stored in their bodies after years of feeding in the ocean. A new study is focused on how changing ocean and river conditions might affect the likelihood that sockeye salmon complete this migration.

Tagged fish have a hole punched in their gill cover, and a long radio antenna extending from their mouth. All harvesters in 2020 are encouraged to report back if they are captured. *Photo credit Pete Rand.*

Researchers at the Prince William Sound Science Center (PWSSC) and University of Alaska Fairbanks (UAF) are teaming up to investigate migration dynamics in Copper River sockeye salmon. "We're interested broadly in what factors might impede them along their journey to the spawning grounds", says Dr. Pete Rand, the Principal Investigator from PWSSC. These factors include their body size and energy stores, disease, and the environmental characteristics of the river. "We have a two-pronged research approach: tracking individuals with radio tags to determine which ones successfully complete the migration, and sampling individuals at different points along their migration to gauge their condition and overall health," Dr. Kristen Gorman, the UAF Principal Investigator, recounts. One of the new technologies employed is the use of a microwave sensor to measure fat content on live fish; a small sensor is placed along the side of the fish and the sensor instantly records the percent of fat under their skin. This approach is much quicker and simpler than older, laboratory-based procedures that have been used in the past.

The research is intended to fill an important gap in our knowledge about fates of the fish while migrating up to the spawning grounds. "Getting answers to these basic questions in the Copper River, a huge, sprawling river system that runs thick with glacial silt, presents many challenges. Combining old and new, emerging technologies, and establishing strong research partnerships throughout the watershed, is clearly helping us get answers" recounts Dr. Rand. ■

Please visit **PWSSC.ORG** for more information on this study.

IN ALASKA, FORESTS GROW SALMON

LUCA ADELFIO AND DAN DONNELLY
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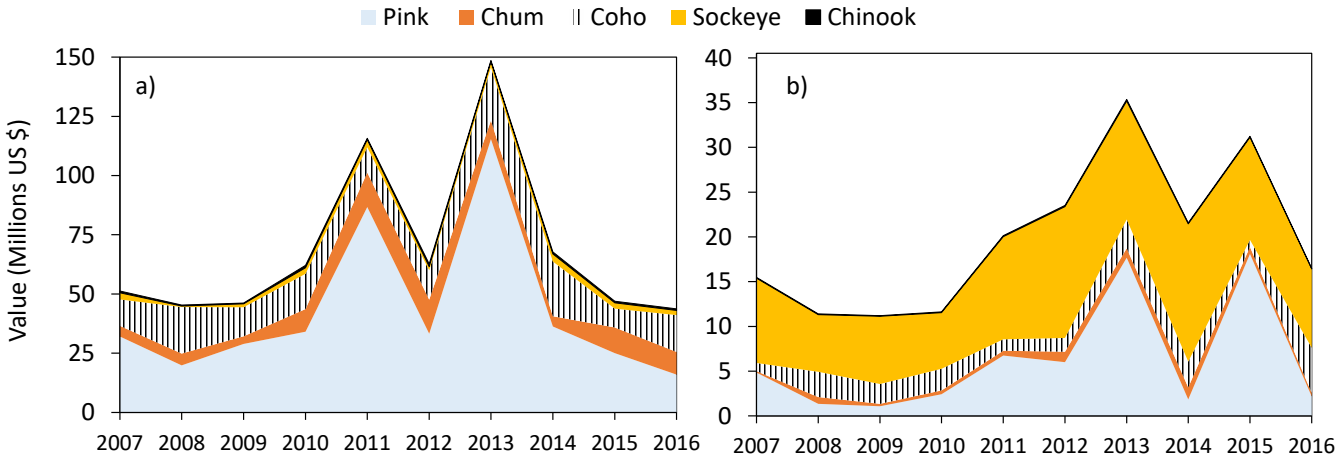
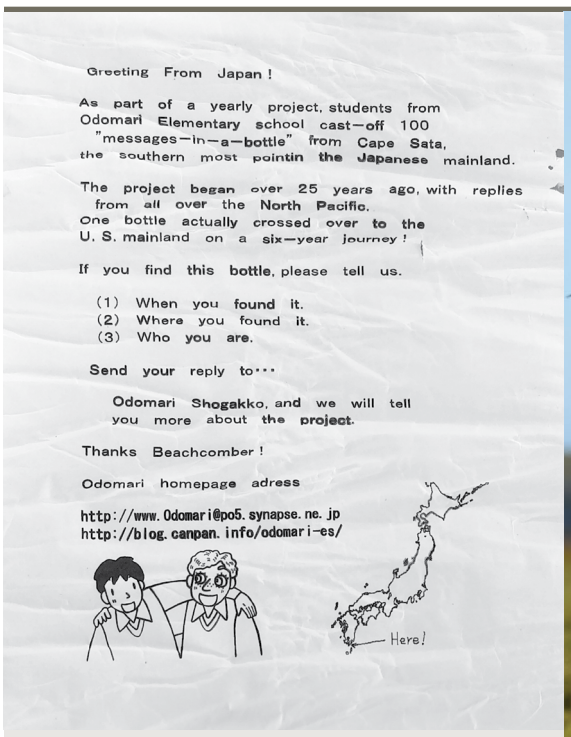
Pacific salmon fisheries are tremendously important to the economy, ecology, and culture in Alaska. In the southeastern and southcentral regions of the state, most salmon originate from cool, clean streams and lakes on the Tongass and Chugach National Forests. A recent peer-reviewed study underscores just how valuable these "forest fish" are to commercial fisheries. In this study, Adelaide Johnson and her co-investigators determined around 48 million forest fish are harvested by commercial fishermen each year, accounting for 25% of the statewide total Pacific salmon catch. These fish contribute an average of $88 million dollars in dockside value each season (see figure). In Southeast Alaska, pink salmon contribute most of the value—an average of $42 million annually. In the Prince William Sound region, sockeye salmon are the most valuable forest fish, contributing an average of $10.5 million annually. ■



This figure, produced by Johnson and her co-investigators, shows the estimated dockside value of five species of Pacific salmon from A) Tongass National Forest and B) Chugach National Forest harvested in commercial fisheries between 2007 and 2016. *Reprinted with author permission from: Johnson, A.C., J.R. Bellmore, S. Haught, and R. Medel. 2019. Quantifying the monetary value of Alaska national forests to commercial Pacific Salmon fisheries. North American Journal of Fisheries Management 39:1119-1131.*



English version of the message detailing the project and location of send-off. *Photo credit PWSSC.*

RECEIVED: 11 YEARS LATER!

MARY ANNE BISHOP
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Visiting a gull colony during the nesting season has its challenges—mainly, avoiding angry gulls aiming to defecate on you while collecting one of their eggs! But in May 2019, the gull colony offered up a surprise—and it was not a golden egg. Instead, it was a relatively large bottle with "beer" embossed on it, and what looked like a PVC pipe inside. "I think it has a message!" I told my colleague. A few days later, and with a bit of difficulty, the message was extracted without breaking the bottle.

The message-bearing beer bottle found on the beach of Egg Island. *Photo credit PWSSC.*

It was a message from Cape Sata Japan—the southernmost point on the Japanese mainland. The bottle was one of 100 released on 27 July 2008 by students from an elementary school in Japan. Over the past 11 years this bottle floated at least 4,500 miles via the Kuroshio current and the North Pacific Gyre and fortuitously landed on Egg Island, undoubtedly during a winter storm.

The message included information in English and Japanese (complete with a return, post-age-stamped envelope). I was encouraged to write to the bottle releasers and let them know when and where I found it. Unfortunately, the website listed in the message no longer existed, and my online search efforts revealed that the elementary school had closed in the intervening 11 years.

I showed the message to a fellow Cordovan who had lived in Japan. He photographed it, emailed a friend, and voilà (ジャーン in Japanese)! His friend wrote, "It was almost a miracle to find out my friend in Izumi used to teach at that school."

And as it turned out, this same person was the teacher of the student who had sent the bottle on its journey. Despite oceans currents and vast distances, we are all connected to each other in this small world. ■

Every year visitors flock to the Copper River Delta to witness the spectacle of migration. *Photo credit Evan Ward.*

CELEBRATING 30 YEARS OF THE COPPER RIVER DELTA SHOREBIRD FESTIVAL

ERIN COOPER
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Every May, one of the most spectacular natural phenomena on the planet occurs on the Copper River Delta. Millions of shorebirds congregate on the Delta mudflats in their last effort to fatten up before heading north. To celebrate this annual spring event and the Copper River Delta, the Shorebird Festival was born. The very first event was held in Cordova in 1990 to induct the Copper River Delta into the Western Hemisphere Shorebird Network as a Hemispheric site, the top ranking in the network. The Shorebird Festival was the first wildlife festival in the State of Alaska and has been the inspiration for festivals from Alaska to Chile.

Over the years, this festival has grown from presentations and field trips to include art, pie socials, birding instruction, and speakers from throughout the world. May 2020 marks the 30th anniversary of the festival. Sandy Frost, one of the original architects of the festival, notes that this event "has become more than what the original organizers had envisioned or hoped for" and "is a cornerstone of Cordova events" with activities that celebrate shorebirds, wetlands, art, and community. In order to keep our communities safe during the COVID-19 outbreak, the Copper River Delta Shorebird Festival planning committee decided that the Shorebird Festival would not go on as planned May 7-10.

TThe birds, however, migrated north and still filled Hartney Bay, Alaganik Slough, and the surrounding Chugach National Forest, feeding and resting as they headed to their breeding grounds. We enjoyed, celebrated, and shared the migration from our own respective perches in Cordova and elsewhere by connecting virtually through a variety of online outlets. Tune in to the Copper River Delta Shorebird Festival website to learn about the 2020 virtual festival and stay connected at coppershorebird.com. ■

NATIONAL OCEAN SCIENCES BOWL: INSPIRING CORDOVA'S YOUTH

MAYA RUSSIN
Cordova High School
Class of 2021

The Backstreet Buoys at the 2020 competition in Seward. *Photo by Lauren Bien.*

My passion for ocean sciences began three years ago, during my freshman year of high school. I decided to participate in the National Ocean Sciences Bowl (NOSB), and showed up to the first meeting—knowing nothing about the ocean.

NOSB is a national competition where teams of high school students write a research paper, give an oral presentation to a panel of judges, and gather to compete in a quiz bowl that tests each team's ocean knowledge. The 2019/2020 project topic was coastal resilience, and Cordova's team focused on the *Exxon Valdez* oil spill.

Through research and lessons taught by our coach, Lauren Bien, my love for the ocean has grown. During the Alaska regional competition in Seward every February, I'm overwhelmed by the number of students, coaches, judges, and scientists who are passionate about ocean science.

Being with them has made me realize how much I need to be around that energy all the time. I attribute my love for the ocean and science to NOSB, and joining despite the fact that I was the youngest team member and didn't know the simplest ocean concepts. February marked my third competition and I feel bittersweet about my upcoming final year on the team. ■

Visitors report finding solitude is an important value in the Wilderness Study Area. *Photo credit Tim Lydon.*

DATA CAN HELP FIND THE ANSWER.

Hunters and others value solitude in the Wilderness Study Area. *Photo credit Tim Lydon.*

TIM LYDON
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The Chugach National Forest has updated protocols for tracking trends in visitor encounters within the Wilderness Study Area (WSA) of western Prince William Sound. These methods align with U.S. Forest Service national protocols and create exciting new opportunities for citizen science.

Tracking trends in visitor encounters enables the Chugach National Forest to estimate degrees of solitude a visitor may find across the WSA and can inform allocation of outfitter/guide use, among other management decisions. While solitude is a difficult quality to monitor, it is a key WSA feature the Forest Service is charged with maintaining. It's also an important indicator of the wilderness values of western Prince William Sound, which remain listed as an *Exxon Valdez* oil spill injured resource.

The updated protocols use the Survey123 app, which can be loaded onto a phone or tablet. It also establishes a five-year rotation at specific sites in the WSA, which comprises nearly 2 million acres of the western Sound. Observers catalog numbers of boats, planes, and other parties encountered within specified distances and data automatically sync into an Access database to track trends.

The new protocol is streamlined and repeatable and allows for methodology consistency in Forest Service efforts to monitor visitor use. The Chugach National Forest looks forward to working with citizen scientists to gather the data. ■

STEWARDSHIP FOUNDATION BUILDS AGENCY CAPACITY IN THE SOUND

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The Prince William Sound Stewardship Foundation is a non-profit organization formed in 2017 to help maintain the Sound's "wilderness character," especially within the Nellie Juan-College Fjord Wilderness Study Area. The organization engages volunteers, fundraises, develops partnerships to increase the capacity of government agencies, and works to keep the Sound "healthy, clean and wild, for all to enjoy."

On May 18, 2020, the Foundation will co-host the 2nd annual Prince William Sound Natural History Symposium, along with the Chugach National Forest and PWS Regional Citizens' Advisory Council. The all-day event will be held online and open to the public. Eighteen expert speakers will present information on climate change, heritage, wildlife, botany, ocean changes, and more.

Citizen science is also on the 2020 agenda. It will be incorporated into the group's marine debris clean-up work, which uses a multi-year rotational approach focused on islands in the central Sound. The group will also contribute citizen science in support of Chugach National Forest management goals of the Wilderness Study Area.

Other 2020 Foundation work will include recreation site restoration in Blackstone Bay, USFS cabin and trail maintenance at Shrode Lake, and invasive species control in Whittier and Harriman Fjord.

If you can't make the presentations on May 18, recordings will be made available online after the event. To become involved, visit the Foundation's website (pwsound.org) or join its Prince William Sound Forum on Facebook @pwsstewardshipfoundation ■

Volunteers with the PWS Stewardship Foundation conducting citizen science on the Chugach National Forest. *Photo by Rich DiJulia/Aleph Johnston-Bloom.*

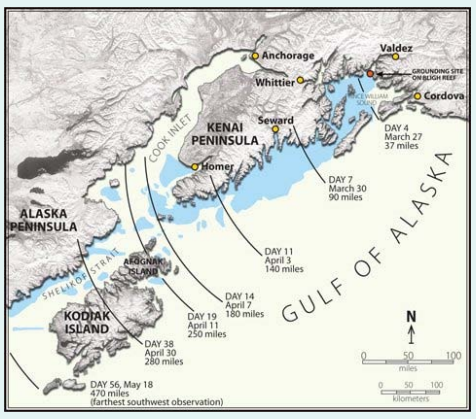
EXXON VALDEZ
A TIMELINE

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 sub-Arctic 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

In a spill, a vessel might set up boom (floating barrier for oil) to protect sensitive coastline. Or it might tow boom to gather spilled oil while another vessel skims the oil off the water, as in the photo. *Photo credit Cathy Hart Photography.*

UNIQUE SPILL RESPONSE SYSTEM
HELPS PROTECT OUR BEAUTIFUL ENVIRONMENT

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

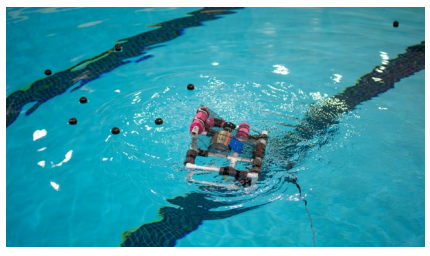
After the 1989 *Exxon Valdez* oil spill, Alaskans learned a valuable lesson: local fishermen must be included in the cleanup. Spill response planners learned that those who earn their livelihoods in a marine environment know their region's waters, coastlines, and tides better than anyone.

Today, these fishing crews are on contract and paid by Alyeska Pipeline Service Company's Ship Escort/Response Vessel System (SERVS). SERVS manages spill prevention and response for the Valdez Marine Terminal and the tankers that carry crude oil through Prince William Sound. These contracts ensure that vessels can quickly be on scene to contain, control, and clean up an oil spill before it spreads.

Crews are trained every year in deploying and operating spill response equipment. In on-water exercises, they practice the communications and chain of command used during a spill response.

Having local fishing crews trained and on contract before a spill is unique to this region. It makes sure that the people most impacted by a spill, those who live and work nearby, can be proactive in protecting our marine environment. ■

ADVANCING THE ROV CHALLENGE IN 2020



Remotely Operated Vehicle (ROV) "oil skimmer" which uses magnets to pick up ping pong balls painted with magnetic paint. This skimmer was built to simulate a real-life drum oil skimmer. *Photo by Nicole Webster.*

The MaTsunamis from Mat-Su Career and Technical High School use their ROV control box and video screen to move their ROV through a submerged hula hoop in the pool behind them. *Photo by Nicole Webster.*

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For the past 23 years, high school students from around Alaska have competed in the Tsunami Bowl, a regional competition of the National Ocean Sciences Bowl. This year, PWSSC educators led the nineth annual Remotely Operated Vehicle (ROV) challenge. Many multi-year competitors have completed the ROV challenge before; their ROVs have inspected berth infrastructure, navigated underwater obstacles, attached anchor chains, and responded to small "oil spills" in the local pool. For these teams, PWSSC created a new, advanced version of the challenge.

In part one, competitors attached underwater cameras to their ROVs and had to drive, navigate through hula hoops, and attach an anchor chain using only the video screen as a guide—simulating the real-world ROV experience. Points were deducted if teams tried to view the pool and their ROV from above. Afterwards, students moved to the deep end for part 2. They first responded to a small "oil spill" by attaching a pool noodle to their ROVs to round up drifting ping pong balls (the "oil").

Teams then set their ROVs aside and began using "oil skimmers" to respond to a larger oil spill. These skimmers, built by PWSSC educator Nicole Webster, are ROVs that use a magnetic metal drum to simulate a drum oil skimmer; when operated correctly, they pick up magnetic ping pong balls and deposit them in the back of the rig. Judging by the exclamations of many, this year's teams enjoyed the challenge of the inaugural Advanced ROV Challenge. PWSSC is excited to continue developing the challenge and inspiring future scientists and engineers! ■

The word "home" can mean different things to different people. It can be the structure in which you live. It can be the town or state in which you reside. The following activities explore a few different ideas of home: from making your own mini shelter, to an at-home craft, to different types of animal homes.

TO REDUCE THE USE OF SINGLE-USE PLASTIC BAGS, YOU CAN CREATE YOUR OWN REUSABLE BAGS WITH ITEMS FROM AROUND YOUR HOME!

T-SHIRT TOTE

SUPPLIES:

- Old T-shirts
- Scissors
- Needle + thread, sewing machine, or fusible bonding web

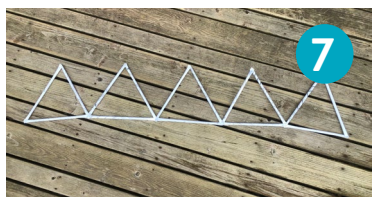
HOW TO:

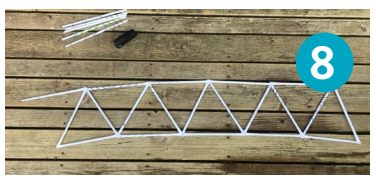
1. Cut off the sleeves and collar of the shirt.
2. Turn the shirt inside out and sew the bottom closed with a needle or machine. If sewing is not your thing, you can use fusible bonding web (found at craft and fabric stores), or use the fringe technique.
3. For the fringe technique, cut the bottom hem of the t-shirt in ¾" intervals, about 3" long. Knot the fringe together from front to back. For added security, tie the side-by-side pieces together as well.

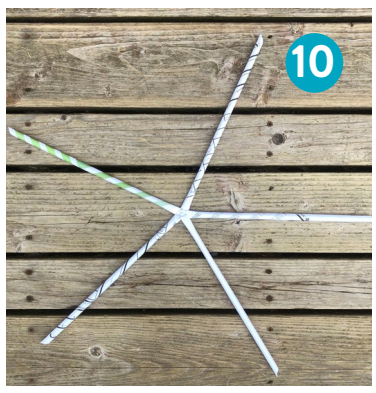
TIPS

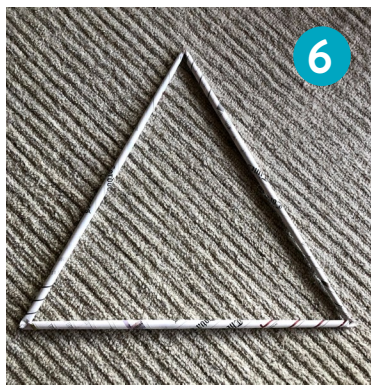
Make sure you wash your t-shirt tote often! Smaller shirts are great for produce and personal items. Larger shirts hold general groceries and gear for after-school activities and overnights!

GEODESIC DOME









Kids 12 and younger may need assistance
TIME: 90 minutes

SUPPLIES:

- 100 sheets of newspaper
- Dowel or pencil
- Clear tape
- Stapler
- Optional: duct tape and sheet

A. CONSTRUCT THE LOGS

1. Stack four sheets of newspaper.
2. Using the dowel (or pencil), roll on the diagonal to create a log. (Don't roll newspaper too tightly around the dowel.)
3. Remove the dowel and tape the papers in place.
4. Repeat until you have 25 logs.
5. Trim the ends of each log blunt, making sure all 25 are the same length.

CREATE THE BASE

6. Make five triangles with three logs each by stapling the ends together.
7. Arrange the five triangles in a line, with the bottom corners touching. Staple in place.
8. Staple five logs from tip to tip along the tops of the triangles.

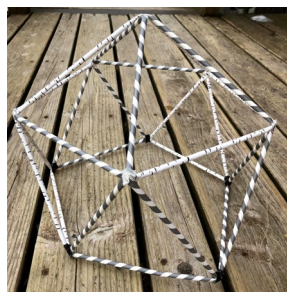
ASSEMBLE THE DOME

(This step requires two people)

9. Lift up base onto its side, round into a circle, and staple the ends together.
10. Staple remaining five logs together in a sunburst pattern.
11. Staple the free ends of the sunburst to the junctions around the top edge of the base.
12. If necessary, secture all junctions with extra staples and duct tape.

TIPS

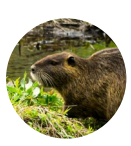
- Create a secret hideaway by draping the dome with a sheet.
- No room for a big dome or don't have enough newspapers? Make a mini dome with scrap paper or paper straws!



ANIMAL HOME MATCH-UP

Animals construct or find shelter in a variety of places. Can you match up the animal to its own unique home? *Answers on Page 2.*


BROWN BEAR


BEAVER

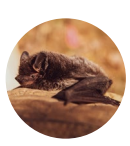

EAGLE


PUFFIN


RED SQUIRREL


ALEVIN


SEA LION


BAT


HERMIT CRAB

HAULOUT | BURROW | LODGE | REDD | DEN | SHELL | ROOST | AERIE | DREY

OUR NEW HOME

GOOD FACILITIES ARE IMPORTANT TO GOOD WORK.

After nearly 30 years, we've outgrown our current facilities. We're building a new campus on five acres of land at Shelter Cove in Cordova. The new center will enable us to expand our resilience impacts through world-class research and education facilities. The new buildings will feature running seawater, allowing our staff to pursue new research to support best practices in mariculture and aquaculture. New exhibits, a touch tank, and dormitory facilities will entice visitors and students from near and far. Our new laboratories will attract partners from around Alaska, the nation, and the world.

In our new center we'll generate knowledge important to environmental issues affecting the long-term health of the fish, birds, mammals, and people that support the economy of the region. This work will happen through carefully planned collaborations. We will share our hard-earned knowledge with many people, including scientists, managers, and local and regional community leaders.

Our vision is built on a record of past accomplishments and bolstered by our strong foundation of local knowledge as the only place-based community benefit institute on Prince William Sound. It is steered by the crucial need to more fully understand ecosystem change in the face of a shifting global climate and increasing human threats. Achieving these goals will position the center among the elite in the field of modern marine research, and assure that decisions about mitigating future ecological change will be made within a framework of the best information possible.

You can help advance the resilience of our region by supporting the Prince William Sound Science Center. Here's to creating a future we can all be proud of. Join us today.

DONATE NOW

VISIT
PWSSC.ORG/SUPPORT/NEW-BUILDING

T 907-424-5800
300 Breakwater Ave., PO Box 705 Cordova, AK 99574

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SCIENCE
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Prince William Sound Regional Citizens' Advisory Council

Copper River Watershed Project

USFS Cordova Ranger District