NEWSWAVE

NEWS FROM THE U.S. DEPARTMENT OF THE INTERIOR: OCEAN, GREAT LAKES, AND COASTS

Special Feature*— Restoring Native Fish to the Great Lakes, see page 12** ***Winter 2021

BOEM: First Wave Energy Research Project

Advancing Marine Hydrokinetic Technology

By John Romero (BOEM)

On February 16, the Bureau of Ocean Energy Management (BOEM) announced they have issued a lease for the first wave energy research project in Federal waters off the U.S. west coast.

"This is the first time a lease has been issued to support the testing of wave energy equipment in Federal waters off the U.S. west coast," said BOEM Director Amanda Lefton. "Ocean waves contain a tremendous amount of energy, and this opportunity offers exciting potential to demonstrate the viability of wave energy technology and expand the nation's renewable energy portfolio."

The Federal marine hydrokinetic energy (MHK) research lease was offered to Oregon State University (OSU) for the PacWave South project.

See related story, page 29

Read the press release: *https://www.boem.gov/boem-issues-lease-first-wave-energy-research-project-federal-waters*

A conceptual illustration shows how marine hydrokinetic technology harnesses energy from ocean waves, tides and currents, and converts it into electricity to power our homes, buildings and cities. The wave energy converters that will be tested at PacWave South are floating or underwater devices that are moored to the seafloor and capture energy from the moving waves. Image credit: BOEM

Newly Constructed Resting Houses Share Cultural Traditions

By DOI's Office of Insular Affairs

The Kosrae Island Resource Management Authority has completed the construction of several traditional resting houses using Kosraean traditional knowledge and resources in the Mahkontowe Conservation Area (MCA). These projects are part of a larger effort to protect cultural and natural resources and to develop eco-heritage tourism. The local resting houses will have a dual purpose of supporting tourists as well as local Kosraen agriforesters.

Kosrae's Utwe Resting House.

The project was funded through the Compact of Free Association in Kosrae State in the Federated States of Micronesia. The resting houses are named for and located within the 4 municipalities of Kosrae; Utwe, Malem, Lelu, and Tafunsak that each have areas located within the MCA. This unique use of Compact funds helps Kosrae preserve cultural traditions while also promoting the protection of natural resources for tourism and economic development.

See Kosrae page 5

Tracking Elusive Male Sea Turtles with Satellites

By Kristen Hart and Andrew Crowder (USGS)

Dr. Kristen Hart with a recently satellite tagged male loggerhead sea turtle in Biscayne National Park. Photo credit: Jackie Guzy, USGS

Through satellite telemetry, researchers have discovered patterns of migratory behavior of long-lived imperiled marine reptiles.

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In This Edition

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The Atlantic Coast Joint Venture (ACJV) partnership is working to address threats to shorebirds and migratory species. Five years ago, the ACJV focused on three flagships species –Black Rail (*Laterallus jamaicensis)*, Saltmarsh Sparrow (*Ammodramus caudacalus*), and Black Duck (*Anas rubripes*), developing Conservation Plans for each. The Black Duck Conservation Plan is expected by fall of 2021.

Read about 2020 accomplishments: *https://acjv.org/the-year-in-review-looking-back-on-2020/?fbclid=IwAR1vZiuX2XC4QLQRwCe6OQVvYP0Rz2Pv119dCuL2es3xrQVU2S213x8_VS4*

Learn more: www.acjv.org, or *www.atlanticflywayshorebirds.org*

The American Black Duck was once the most abundant dabbling duck in eastern North America. Black duck populations began declining steadily in the 1950s and reached an all-time low by the 1980s, having lost more than half of their historical population. Photo credit: Fyn Kynd Photography, Creative Commons

NEWSWAVE is a quarterly newsletter from the Department of the Interior featuring ocean, Great Lakes, and coastal activities across the Bureaus.

Visit us online: *https://www.doi.gov/ocean/newswave*

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Assessing Salt Marsh Vulnerability Nationwide

Landsat-Based Maps Combined with Other Assessments Provide Metrics and Tools to Inform Coastal Management Strategies

By Neil Ganju, Brady Couvillion, and Zafer Defne (USGS)

Salt marshes are valuable coastal wetland ecosystems that provide habitat, carbon storage and protection for coastal communities. Yet, these systems are under stress due to chronic forces such as sea-level rise and episodic forces such as coastal storms. In addition, changes in land use and human infrastructure can impact their stability.

If sediment supply is limited, salt marshes cannot keep up with sea-level rise at the rates observed in recent decades and predicted through the 21st century. Extreme changes in salinity, which may occur during coastal storms, can reduce vegetative cover. Additionally, constant wave action and shoreline erosion cause marshes to retreat. Under optimal conditions, marshes may retreat landward,

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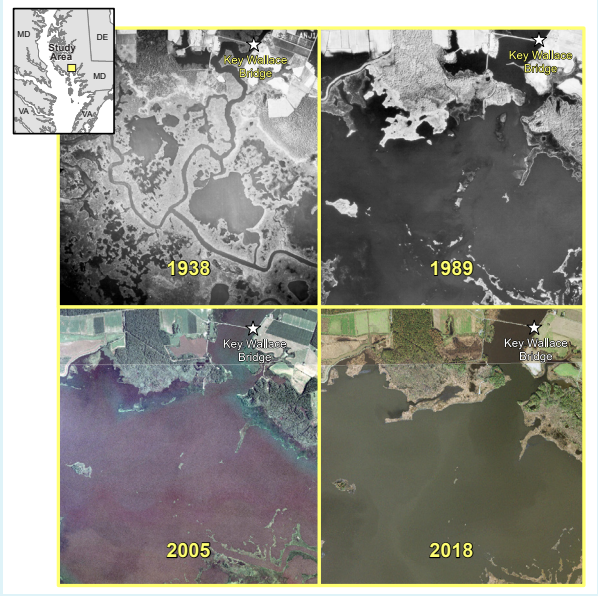
Blackwater National Wildlife Refuge (NWR) is one of more than 560 refuges in the National Wildlife Refuge System administered by the U.S. Fish and Wildlife Service (USFWS). The refuge system represents the most comprehensive wildlife resource management program in the world. Learn more: *https://www.fws.gov/refuge/Blackwater/*. Sunset over Blackwater River photographed from the wildlife drive at Blackwater NWR. Photo credit: Ray Paterra, USFWS

What is the UVVR and Why is it Important?

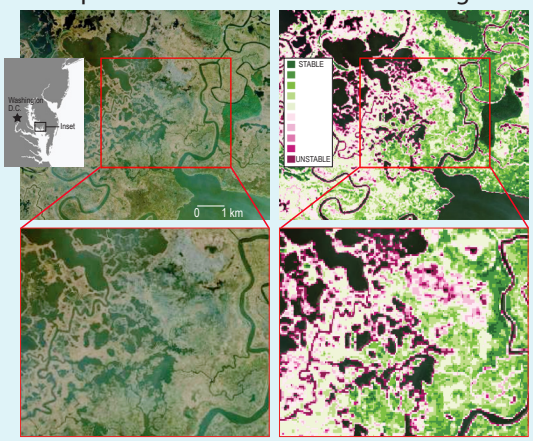
Although elevation is considered the standard metric for evaluating resilience to future sea-level rise, elevation and other point- or transect-based field measurements do not provide complete spatial coverage over the marsh plain, or account for other salt marsh features such as tidal channels and ponds within the marsh.

The United States Geological Survey (USGS) has shown that marsh resilience can also be evaluated using a metric called the UnVegetated-Vegetated marsh Ratio (UVVR). The UVVR is defined as the ratio of unvegetated area to vegetated area across an entire marsh system. Therefore, it covers marsh plain, channels, ponds, and intertidal flats. The most detailed UVVR assessments use aerial imagery at high resolution (1 meter (m) x 1 m pixels) and classify the pixels as either vegetated or unvegetated. The pixels are then added up over marsh "units" (akin to watersheds) to compute the UVVR metric for each individual marsh unit. With satellite imagery, the high-resolution assessments are used to calibrate the spectral data from the optical sensors on the satellite to give an estimate of the UVVR over the satellite pixel (30 m x 30 m in the case of Landsat).



More than 5,000 acres of wetlands have been lost within the Blackwater NWR, Maryland since the late 1930s. The loss of coastal wetland over time is captured in this progression of satellite images spanning 1938 to 2018. Light colors indicate vegetated areas, and dark colors indicate open water. Image credits: USFWS and USGS

Recent studies by the USGS and other researchers have shown that the UVVR is an excellent indicator of marsh stability. In fact, it is strongly correlated with elevation, and low marshes tend to have higher UVVRs, while high marshes have lower UVVRs. Apart from its value as a stability metric, the UVVR is an important metric for quantifying the ecosystem services that marshes provide. Habitat quality, carbon storage, and coastal protection are all related to the vegetative cover, and therefore the complete spatial picture provided by the UVVR is essential.



Aerial photograph and corresponding Landsat UVVR data for the area surrounding Blackwater NWR, inset showing the detailed pixel-based wetland status. Image credits: USGS

Coastal Wetlands: The State and Future of a Precious Resource

Coastal wetlands and salt marshes occur across a narrow range of elevation, water level, and salinity conditions, relying on their own growth and sediment input to maintain or increase their extent. Their growth is balanced against waves and sea-level rise that physically erode them. The vegetation in these productive wetlands naturally buffer the destructive forces of coastal storms by slowing down the flow of water and dissipating waves.

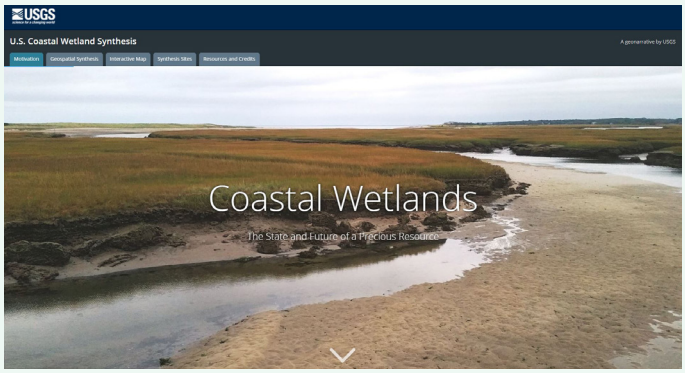
Overall, coastal wetland landscapes stabilize shorelines, provide habitat, and deliver vital ecosystem services as well as cultural and recreational opportunities. Coastal wetlands need to persist in order to maintain these diverse services. They also need room in the landscape to move both vertically and laterally to counteract the effects of sea-level rise and storms. Their growth and ability to move and expand are controlled by complex interactions between water level, sediment supply, and salinity, and other influences. Estimating the present and future ecosystem services of marshes requires a better understanding of their areal extents and what processes help them maintain those extents.

For decades, Federal agencies have been collecting data to monitor coastal wetlands.

- USFWS established a National Wetlands Inventory (NWI) to provide information on the types and distribution of wetlands,
- U.S. Department of Agriculture has collected imagery during the agricultural growing seasons in the continental United States under the National Agriculture Imagery Program.
- USGS has collected data on tidal water levels and topographic elevation and is conducting work to assess the physical condition of coastal wetlands and how they may change in response to storms, sea-level rise, and human activity.

On-the-ground field surveys in salt marshes have provided crucial data on how elevation and vegetation respond to the physical environment. As advances are made in remote sensing technology, data are becoming available in greater quantities and at higher frequencies and resolutions.

Explore online: *https://wim.usgs.gov/geonarrative/uscoastalwetlandsynthesis/*



A new geonarrative describes how the USGS is assessing the physical condition of coastal wetlands and how they may change in response to storms, sea-level rise, and human activity. Image credit: USGS

Marshes continued from page 3

but in developed and urbanized areas this path is blocked by human infrastructure such as levees, seawalls, roads, and neighborhoods, and the overall extent of salt marsh habitat is significantly reduced.

In order to track changes and trends in the extent and health of these coastal wetlands, land and resource managers within the U.S. Department of the Interior (DOI), State agencies, and nongovernmental organizations (NGOs) need metrics that provide a robust picture of both their stability and vulnerability. Understanding the dynamics and threats to marsh areas can inform strategies for prioritizing areas for restoration and associated investments in human infrastructure.

The USGS started intensively mapping salt marsh vulnerability after Hurricane Sandy made landfall near the salt marshes of Edwin B. Forsythe NWR in New Jersey in 2012. One of the components of that vulnerability analysis was a new metric: the UVVR.

Soon after, the USGS, through a Natural Resources Preservation Program project with the National Parks Service (NPS), mapped the UVVR across four U.S. National Parks along the northeast Atlantic seaboard: Cape Cod National Seashore, Fire Island National Seashore, Gateway National Recreation Area, and Assateague Island National Seashore. The product of that study was a detailed mapping of UVVR across over 5,000 individual marsh parcels that will assist the NPS in identifying the most unstable marshes in order to prioritize restoration activities.

"Coastal national parks are experiencing extensive loss and degradation of salt marshes. These will be exacerbated by increases in sea-level rise and wave-induced erosion," said Cathy Johnson, a coastal ecologist and NPS Northeast Ocean and Coastal Resource Program Coordinator. "The NPS is committed to climate change adaptation strategies that promote ecosystem resilience, including marsh restoration where appropriate, but resources to implement such activities are limited. Broad-scale UVVR mapping will help us to assess long-term viability of marsh units and prioritize salt marsh restoration areas to maximize long-term ecosystem benefits."

Additionally, the USFWS intends to use the UVVR in combination with other metrics to identify opportunities

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for potentially restoring high-quality habitat along the Atlantic seaboard for the saltmarsh sparrow, an at-risk species that uses high elevation marshes for nesting.

"If we want to reverse saltmarsh sparrow declines, we must work only in those marshes that are most likely to respond well to management action. The UVVR tool helps guide these decisions so that land managers can avoid those marshes with little chance of becoming high-quality habitat and focus instead on those with a strong opportunity for conservation return," said Aimee Weldon, the USFWS Atlantic Coast Joint Venture Coordinator.

A Comprehensive Assessment Tool

Until recently, all UVVR assessments had been determined for an individual estuary or at state scales for stakeholders interested in using the UVVR to establish baseline metrics, identify the most vulnerable marshes, and inform management strategies. These repeatable assessments demonstrated that UVVR could be used comprehensively for the entire Nation, using aerial photography. However, those prior studies were labor-intensive and relied on multiple aerial surveys through the National Agricultural Imagery Program. Each individual study required detailed merging of elevation and imagery data, as well as interpretation of multiple imagery classes. The solution to this bottleneck is using Landsat satellite imagery to estimate the UVVR across the whole Nation at a 30-m resolution. This enables DOI and State managers to get broad assessments of the most vulnerable marshes without requiring site-specific studies. It also provides baseline data that will prove valuable as newer satellites come online and provide higher resolution products.

USGS scientists developed a methodology to use Landsat 8 imagery, for the 2014-2018 period, where they derived the UVVR at a 30-m resolution for the coastal wetlands of the contiguous United States. Moving forward, the USGS aims to maintain regular delivery of updated UVVR assessments using aerial imagery, Landsat, and newer satellites to support marsh restoration efforts by NPS, USFWS, and coastal State agencies. The new data products complement detailed mapping by the USFWS' NWI program by enabling comparison of vulnerability between different wetland types differentiated by the NWI. The national map of UVVR can also be combined with the Coastal National Elevation Database (CoNED) to generate national estimates of marsh lifespan, under varying sea-level rise scenarios. These metrics give managers robust decision-making tools to guide investment in restoration that ultimately protects our Nation's coastal communities and ecosystems.

Learn more: *https://www.sciencebase.gov/catalog/item/5f28109582cef313ed9cd787*

Access the data in the USGS Coastal Change Hazards portal: *https://marine.usgs.gov/coastalchangehazardsportal/*

Kosrae continued from page 1

In July 2020, the Kosrae State Government also received the Underrepresented Communities grant from the NPS, which supports efforts to nominate Kosrae's Mahkontowe Conservation Area to the U.S. National Register of Historic Places. Authorized by the National Historic Preservation Act of 1966, the NPS' National Register of Historic Places is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect America's historic and archeological resources. There are several other locations in the U.S. territories and the freely associated states currently listed.

The MCA is a 15-square kilometer area which hosts a variety of significant cultural, archaeological, and natural aspects. It was proposed by the Kosrae State Historic Preservation Office of the Kosrae Island Resource Management Authority and enacted into Kosrae State Law 11-156 on June 7, 2018.

View of Mahkontowe, Kosrae's 'sleeping lady', which is part of the island's origin story and subject of rich oral history.

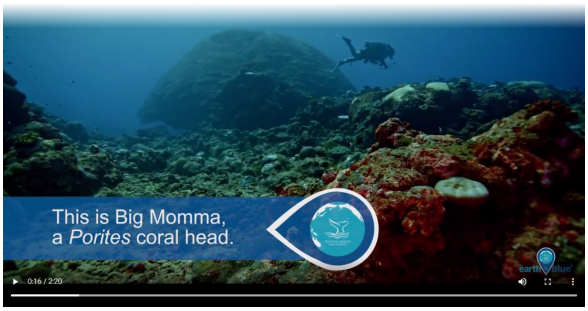
Kosrae's Lelu Resting House.

Learn more: *https://www.doi.gov/oia/press/trump-administration-applauds-eco-heritage-tourism-efforts-kosrae-micronesia?fbclid=IwAR0lHLMl5D_FVNLr7UbVQZvt5-uv393zeIj2PrYSYIjLl6lyoQbVK7J1OTo*

Mahkontowe Conservation Area: *https://kosraehpo.wordpress.com/mahkontowe-conservation-area/?fbclid=IwAR25QrRw0yi2lLu_36wvO4ZYc7BKqVkTTM39vleqNFfDut0epZjhG9wYqv8*

Massive, Record-Setting Coral Colonies on Tau Island, American Samoa—New Study to Understand and Protect

By Ian Moffitt, Eric Brown, and Bert Fuiava, NPS



Watch a video about these large coral heads: *https://sanctuaries.noaa.gov/earthisblue/wk146-protecting-big-momma.html* Image credit: NOAA

A collaborative team of the National Park of American Samoa (NPSA), the American Samoa Coral Reef Advisory Group (CRAG), American Samoa Department of Marine and Wildlife Resources (DMWR), and the NOAA National Marine Sanctuary of American Samoa (NMSAS), recently documented and measured one of the largest known corals in the world. The coral colony measured 22.4 m across, and 8 m tall, with a circumference of 69 m at the base and was discovered in the waters around the island of Ta'u, Manu'a, within the NPSA. This coral was measured in November 2019 as part of an effort to catalogue all large (≥2 m diameter) *Porites* colonies around Ta'u.

The coral is in the genus *Porites*; genetic analysis is still required to determine the exact species. To date, this is the biggest colony recorded in American Samoa and one of the largest colonies documented worldwide. It is currently unknown why such large corals exist around this particular island, but according to a new report, "possible explanations include mild wave or atmospheric climates and minimal anthropogenic impacts. Physiologically, these colonies may be resistant and/or resilient to disturbances. Large, intact corals can help build past (century-scale) climatic profiles, and better understand coral persistence, particularly as coral communities worldwide are declining at rapid rates."

The NPSA is currently seeking guidance from the villages on Ta'u Island to decide a name for this massive coral. Although other large species of *Porites* have been reported around the world, to our knowledge, none of these reported colonies have exceeded the size of the largest colonies measured on Ta'u. Documented growth rate measurements for *Porites* spp. in similar climates are estimated to be between 12.2 millimeters per year (mm/y) and 19 mm/y. Using these metrics, we estimate this large coral to be between 420 and 652 years old. Identifying areas where long-lived corals exist and thrive will be critical in evaluating changes in climate patterns and identifying resilience factors that may improve management of coral reef ecosystems in the South Pacific.

In addition to this particularly massive *Porites* coral, the team also documented the diameters of 84 individual *Porites* colonies measuring over 10 m, 393 *Porites* colonies between 6-10 m, and 498 colonies between 2-5 m. These corals were documented by snorkelers on towboards using a calibrated visual estimation approach. They were found on three sides of the island of Ta'u with most of the largest corals occurring on the western coast. It is thought that oceanographic conditions play a role in both the distribution and longevity of these corals. Due to the large number of these massive colonies, it is evident that specific conditions around the island of Ta'u are conducive to the growth of these resilient corals, and this would warrant some level of protection. An ongoing study aims to understand why there are so many of these massive corals in the waters around the Island of Ta'u. Initial results have been published in Nature Scientific Reports.

Read the report: "A new record for a massive *Porites* colony at Ta'u Island, American Samoa" in *Scientific Reports*: *https://www.nature.com/articles/s41598-020-77776-7*

The newly identified and measured *Porites* sp. colony (22.4 m across and 8 m tall) located in the NPSA. See SCUBA divers in the top left for scale. Photo credit: Alexa Elliott, Changing Seas/South Florida PBS

Insular Areas Establish New MPA Agreement

Between National Marine Sanctuaries in American Samoa and Palau

By Tanya Joshua, DOI

"Through our partnership with NOAA and with the sister sanctuary agreement between the National Marine Sanctuary of American Samoa and the Palau National Marine Sanctuary, we look forward to continuing to lead the way in ocean conservation – through joint ocean discovery, learning and effective MPA management," said Yimnang Golbuu, CEO of Palau International Coral Reef Center.

DOI's Office of Insular Affairs celebrated the signing of a Memorandum of Understanding (MOU) on marine protected areas, including the establishment of a 'Sister Sanctuary' arrangement between Puipuiga lautele o le Gataifale o Amerika Samoa, the NMSAS, and the Euotelel a Klingil a Debel Belau, the Palau National Marine Sanctuary.

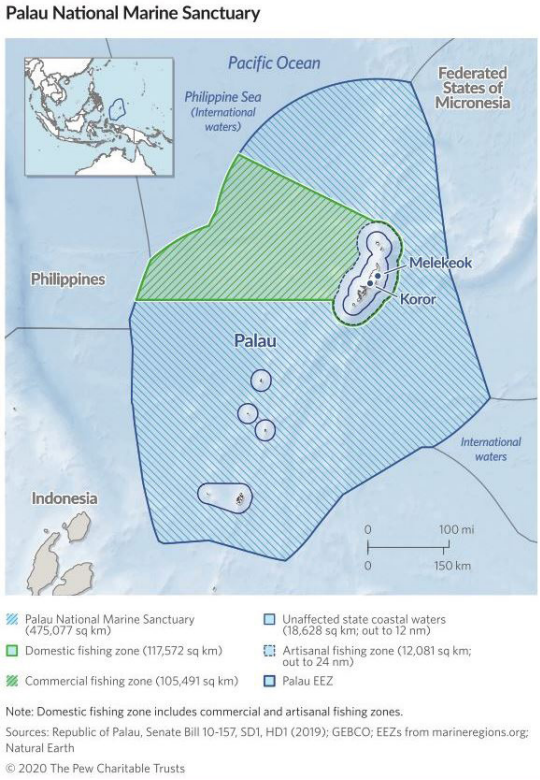
The recently signed agreement establishes a sister site partnership between the NMSAS administered by the National Oceanic and Atmospheric Administration (NOAA) and the Palau National Marine Sanctuary, which is administered through Palau's International Coral Reef Center.

The agreement expands opportunities for regional collaboration in marine protection by connecting the U.S. territory of American Samoa in Polynesia, in the South Pacific, to the Republic of Palau, a Pacific Island nation in Micronesia, in the northwest Pacific. This new partnership is expected to include collaboration with the national marine sanctuaries in the State of Hawai'i.

The NMSAS comprises six protected areas, covering 13,581 square miles of nearshore coral reef and offshore open ocean waters across the Samoan Archipelago and is now the largest national marine sanctuary in the National Marine Sanctuary System.

The Republic of Palau is one of three freely associated states in a special relationship with the United States under a Compact of Free Association. Palau is dedicated to marine conservation, upon which their vital ecotourism economy is based and was the first country in the world to announce a shark sanctuary in 2009. In 2015, Palau President Tommy Remengesau, Jr. further extended protections by signing a law that designated 80% of Palau's exclusive economic zone, approximately 193,000 square miles, to be a national marine sanctuary, which went into effect on January 1, 2020.

Palau is also part of the Micronesia Challenge wherein the leaders of the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, and the U.S. territories of Guam and the Northern Mariana Islands have committed to effectively conserve at least 30% of the near-shore marine resources and 20% of the terrestrial resources across Micronesia. Both American Samoa and Palau are members of the U.S. Coral Reef Task Force where all U.S.-affiliated Pacific Islands and stateside jurisdictions collaborate to protect coral reefs.



Map of the Palau's EEZ, National Marine Sanctuary and designated fishing zones. Image credit: Republic of Palau's Automated Land and Resource Information System (PALARIS)

Watch this short video to get a glimpse of the coral reef coverage in NMSAS. *https://americansamoa.noaa.gov/gallery/*

Learn more about the MOU and the Sister Sanctuaries:

- *https://www.doi.gov/oia/press/trump-administration-announces-agreement-between-national-marine-sanctuaries-american*
- *https://sanctuaries.noaa.gov/news/dec20/tale-of-two-sanctuaries.html*

NMSAS: *https://americansamoa.noaa.gov/*

Visit Palau International Coral Reef Center: *http://picrc.org/picrcpage/*

Learn more about the Micronesian Challenge: *http://micronesiachallenge.org/*

Study on Threatened Coral May Guide Reef Restoration

By Heather Dewar, Ilsa Kuffner, and Meaghan Faletti (USGS)

Nursery-grown elkhorn coral (*Acropora palmata*) transplanted into Dry Tortugas National Park survived and thrived, growing twice as fast as corals planted in other locations in the Florida Keys, according to a new USGS study published in *Endangered Species Research*.

USGS researchers are studying the growth and success of nursery-grown transplanted corals in the Florida Keys; research that might help this population of the threatened species rebound. Reefs there have experienced significant coral loss in recent decades from coral bleaching, disease and human-related disturbances. Elkhorn coral, listed as threatened under the Endangered Species Act, is of special concern because it is the only species that builds the reef-crest zone—the part of the reef that dissipates waves, protecting shorelines and creating habitat for other species—in the tropical Atlantic.

Tall, branching elkhorn corals once were abundant in parts of the Keys, but in 1982-83 the population crashed across the entire western Atlantic due to white band disease, which is caused by an unknown pathogen. Scientists don't fully understand why the species has not recovered since then, but population fragmentation, climate change, and other coral diseases have all played a role.

The new elkhorn coral colonies planted in the park, which lies about 62 miles west of Key West, may act to "genetically rescue" the one remaining genetic strain known to persist in Dry Tortugas National Park.

"Our study shows that bringing in nursery-grown elkhorn coral fragments can boost the odds that these colonies can cross-fertilize and eventually produce an abundance of coral larvae," said USGS research marine biologist Ilsa Kuffner, the lead author of the study. "Since the Florida Current flows from the Dry Tortugas toward the main Keys reef tract, elkhorn larvae from the Dry Tortugas could be carried by currents and re-seed other parts of the reef tract."

To determine if some elkhorn coral strains are more resilient than others, or whether some Keys sites are more hospitable, USGS coral scientists received permission from Biscayne National Park, Dry Tortugas National Park, and the Florida Keys National Marine Sanctuary—part of the NOAA Office of National Marine Sanctuaries—to conduct an experiment using nursery-grown fragments donated by the Coral Restoration Foundation.

Threatened elkhorn coral, shown at one of 30 USGS "calcification stations" in Dry Tortugas National Park, is the main species that creates the reef-crest zone where waves break, providing shoreline protection and habitat for marine life. This colony, raised from a fragment donated by the Coral Restoration Foundation, overgrew the "calcification station" where it was attached for an experiment. Photo credit: Ilsa Kuffner, USGS

"If we can introduce enough genetic diversity to places like the Dry Tortugas that provide excellent habitat for this species to thrive, the corals will reproduce and provide offspring that have a better chance of responding to stress, seeding future populations that are better adapted to the changing environment and making a stronger, more resilient population," said Kuffner.

USGS scientists transplant fragments of threatened elkhorn coral, *Acropora palmata*. Photo credit: Andréa G. Grottoli, Ohio State University

USGS scientists have worked with the NPS and NOAA to study this coral reef system since the 1960s and credit both for making the ongoing research possible.

"Our partnership with the USGS and their research directly informs our coral conservation efforts at Dry Tortugas and Biscayne National Parks," said Pedro Ramos, superintendent of Everglades and Dry Tortugas National Parks. "The results of this study will help to identify locations for replanting nursery-grown corals and assist in the restoration of a more genetically robust, reproductive population."

Read the press release: *https://www.usgs.gov/news/usgs-study-threatened-coral-can-guide-reef-restoration*

Learn more about USGS coral reef research: *https://www.usgs.gov/natural-hazards/coastal-marine-hazards-and-resources/science/coral-reefs*.

Learn more:

Biscayne National Park: *https://www.nps.gov/bisc/index.htm*

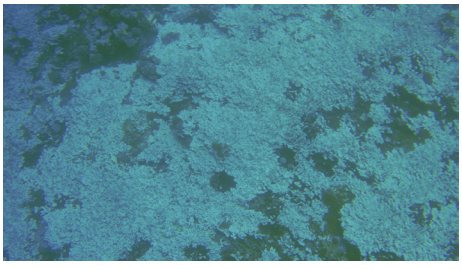
Dry Tortugas National Park: *https://www.nps.gov/drto/index.htm*

'Wave-Driven Cooling' Potential Relief for Shallow Water Corals in Warming Seas

By Curt Storlazzi and Ann Tihansky (USGS)

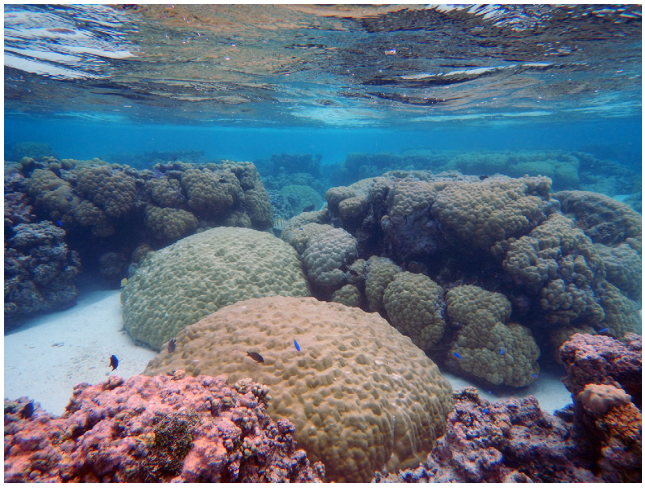
A new report shows that localized underwater wave-driven cooling in coral reef environments could be a critical mechanism for reducing coral bleaching severity and delaying bleaching conditions by buffering sea surface temperatures that are predicted by Intergovernmental Panel on Climate Change (IPCC) global emission scenarios.

As the ocean warms due to increasing global carbon dioxide emissions, the frequency and severity of large-scale coral bleaching events are increasing. These bleaching events are monitored and predicted using sea surface temperature (measured or projected) at the ocean surface. However, surface temperature does not always reflect what corals experience at depth below the surface. There is an increasing body of evidence from localized field studies that subsurface water movement driven by underwater waves in the water column ('internal waves') can flush the reefs with cooler, deeper water (wave-driven cooling), reducing their exposure to the observed high sea surface temperatures. Although these cooling effects have been documented at specific sites, coral researchers and climate modelers want to be able to identify how and where this flushing mechanism creates thermal refugia for corals around the world so it can be incorporated into management strategies and policies.



A large expanse of bleached coral (white areas) off Kwajalein Island, Republic of the Marshall Islands in 2014, after a large bleaching event occurred due to high water temperatures. Photo credit: Tom Reiss, USGS

Coral reef scientists at the USGS, NOAA, and academia working through the U.S. Coral Reef Task Force first documented the effects of this flushing and cooling via these internal waves as an important modulating force for understanding when future bleaching events would occur for coral reefs worldwide. In some areas, such internal wave-driven cooling can delay the onset of severe bleaching for corals at depth by up to decades, with the greatest thermal (cooling) benefits for corals in the Indian Ocean, North and South Pacific Oceans, and the Coral Triangle. In addition, the thermal benefits afforded by the wave-driven cooling vary by IPCC global emission scenarios. For scenarios where little emission controls are instituted (higher emissions) the greatest cooling effects are experienced earlier in the 21st century. For moderate/mediated emission scenarios, these benefits are extended to later in the 21st century. The study's results indicate that the influence of internal wave-driven cooling mechanisms could delay bleaching for distinct coral reef areas across the global ocean and thus providing thermal refugia.



Healthy corals in shallow areas on the island of Ofu within the NPSA in 2020. The different colors indicate these corals have healthy populations of symbiotic zooxanthellae living within their tissue. Photo credit: Curt Storlazzi, USGS

Better understanding of where and how wave-driven cooling occurs can help identify areas that provide natural havens for corals from thermal stress. This information can assist resource managers with decisions regarding locations and placement of marine protected areas (MPAs) and developing strategies for helping coral reefs survive and adapt in the face of climate change.

MPAs have been used as a management tool for protecting and preserving coral reefs around the globe. Primarily established to protect specific coral species of concern, coral ecosystem biodiversity, or socio-economic drivers, they have not been established to protect corals from increasing ocean temperatures. Temperature-induced coral bleaching is projected to increase in both magnitude and frequency. Through combined assessment of wave-driven cooling and sea surface temperatures, linked with future IPCC scenarios and timelines for thermal stress and bleaching response, managers have tools and guidance for identifying strategic areas where corals will be best protected against future thermal stressors. This can also be used in evaluating potential MPA locations and making planning decisions that protect and preserve coral reefs, related ecosystems, and the closely linked human economies that depend on them.

Read the report: *https://www.nature.com/articles/s41598-020-70372-9*

Learn more:

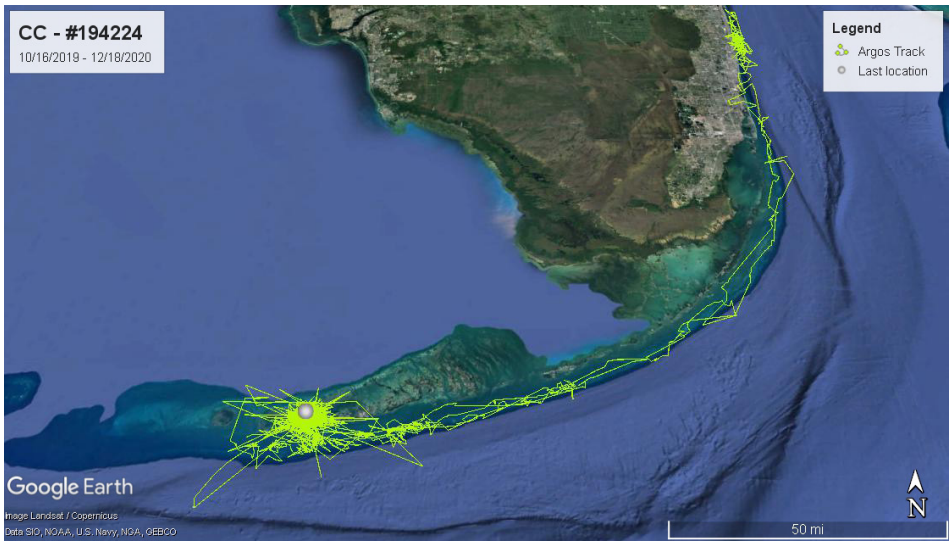
https://www.usgs.gov/centers/pcmsc/science/coral-reef-project

Turtles continued from page 1

Many sea turtle tracking and ecological studies have focused on females due to ease of access to individuals on the beach during a nesting event. In contrast, male sea turtles have been understudied and details of their behavioral ecology remain largely unknown. A better understanding of male movement patterns and space-use could help inform understanding of population dynamics, spatial ecology, and threats faced by male sea turtles.

USGS Scientist Dr. Kristen Hart and her team at the Wetland and Aquatic Research Center (WARC) in south Florida have focused research efforts over the last decade on capturing, tagging, and tracking male sea turtles to fill these knowledge gaps.

Satellite tagged male green sea turtle after release in the Dry Tortugas National Park. Photo credit: USGS



The Satellite tracking map (yellow lines show satellite locations over time) of a loggerhead sea turtle tagged in the Florida Keys National Marine Sanctuary. The male turtle traveled to the southeastern Florida coast for a probable breeding foray during March of 2020. Image credit: Google Earth

Between 2009 and 2019, the team outfitted 40 male sea turtles with satellite tracking devices, including 25 green turtles (*Chelonia mydas),* eight loggerheads (*Caretta caretta), six* Kemp's ridleys (*Lepidochelys kempii)*, and one hawksbill (*Eretmochelys imbricata).* The team captured turtles in the water at sites across the southeastern region of the United States including areas in the northern Gulf of Mexico, in several areas in south Florida within the Florida Keys National Marine Sanctuary, and within Buck Island Reef National Monument in the Caribbean at St. Croix, U.S. Virgin Islands.

Once published, the male turtle tracking dataset will be one of the largest male tracking studies ever documented worldwide. Preliminary analyses of the spatial tracking data has allowed Hart's team to decipher the timing of male breeding migrations and movement behaviors that could help inform sea turtle management and protection strategies.

Decontaminating Ships of Invasive Species

USGS Inventor Nationally Recognized with Patent

By James Mitchell (USGS)

Barnaby Watten, a retired USGS scientist, invented a new method to decontaminate a ship's outer hull from invasive aquatic species. As a result, the USGS has been awarded U.S. Patent no. 10,800,497.

Many aquatic species can cause harmful problems when they are transported from their natural habitat to non-native areas. This can happen when these organisms are taken in as ballast water or by attaching themselves to wet surfaces of a ship. Once they are in or on the ship, they can be unintentionally carried from one port to another, creating a pathway that introduces non-native organisms to local water systems. They also impact the native ecosystem, It can cause serious problems with local ecosystems and boats, equipment, and industrial and municipal infrastructure.

Watten addressed these issues by creating a unique process that uses treated water and an inflatable bladder in a lock structure. When a ship enters a lock, the bladder fills up with air to move the treated water upwards until it is in contact with the outer surface of the ship. Once the invasive species are immersed in the treated water, they are eliminated.

Barnaby Watten adding sodium hydroxide to a ballast water test chamber aboard the Motor Vessel (M/V) *American Spirit*. Photo credit: USGS

Learn more: *https://nas.er.usgs.gov/*

Sharing Texas Beaches with Shorebirds

By Amanda Lawrence (USFWS Knauss Fellow)

The Texas Gulf Coast is a popular recreational destination to millions of people annually. Along with beach-going and boating, bird watching is another way locals and visitors enjoy some iconic coastal public lands. The Great Texas Coastal Birding Trail is a popular driving trail that connects bird sanctuaries and nature preserves throughout the Gulf Coast area.

The USFWS-Coastal Program and American Bird Conservancy are working with local resource managers to conserve globally important shorebird habitat along the upper Texas Gulf Coast Land region. These areas also support diverse recreation including fishing and off-roading. The partnership is working to balance these many uses by protecting and monitoring nesting sites and raising awareness through public outreach. While these specific conservation efforts are focused on the Wilson's plover (*Charadrius wilsonia*), least tern (*Sternula antillarum*), and snowy plover (*Charadrius alexandrinus*); many other bird species also benefit.

The Texas Gulf Coast, home to the economic and industrial hub of the Houston-Galveston metropolitan area, also includes a richly diverse wilderness. The area provides critical habitat for hundreds of shorebird and waterfowl species, some rely on these beaches for nesting, including the snowy plover, while others use the beaches as an important rest stop on long-distance migratory journeys.

Texas takes its outdoor recreation seriously. Legislation like the Texas Open Beaches Act ensures that the public will have access to state-owned beaches. However, such access can come at a cost to the natural resources. Driving vehicles on dunes, crowds of people and unleashed dogs roaming through natural areas can destroy both the habitat and the wildlife that rely on these coastal areas for their food and shelter.

The USFWS and the American Bird Conservancy often work with local coastal managers to provide resources and information to help them best manage coastal areas. One effective strategy for reducing impacts on shorebirds is by raising public awareness about them. Sometimes, simple signage referred to as 'virtual fencing' can alert beachgoers about active nesting areas, encouraging them keep their distance and enjoy areas that do not intrude on wildlife.

A snowy plover chick rests within a tire track, showing the small bird's perspective on how vehicular activity and the tire tracks can affect these and other shorebirds. Photo credit: Justin LeClaire, Coastal Bend Bays and Estuaries Program, American Bird Conservancy

The USFWS and Gulf Coast Bird Observatory (GCBO) have teamed up to educate people about beach-nesting birds and positive actions people can take. Through these efforts, the public can learn how they can reduce their impact on beaches and associated habitats. Through public outreach and education, people learn to share the beach with these beach-dependent species.

Learn more about the USFWS Coastal Program accomplishments across the country: *https://www.fws.gov/coastal/pdfs/Annual-Accomplishment-Report-(508-compliant)-2020-06-29.pdf*

Gulf Coast Bird Observatory

Monitoring nesting habitats and bird populations is critical to understanding how birds use the beaches, as well as examining human impacts to these habitats.

More than 300 bird species rely on habitats along the Gulf at some point in their lives. However, these habitats are increasingly competing with coastal development and impacts from natural disasters. The GCBO fulfills its mission of protecting the birds and their habitats by using sound scientific research, land protection and enhancement, community engagement, and educational outreach.

The USFWS Coastal Program works with the GCBO to band shorebirds along the Texas coast. By improving our understanding of bird population distributions, migration patterns and other information, we have the science needed to support management decisions such as recovery objectives for bird species.

Learn more: *https://www.gcbo.org/*

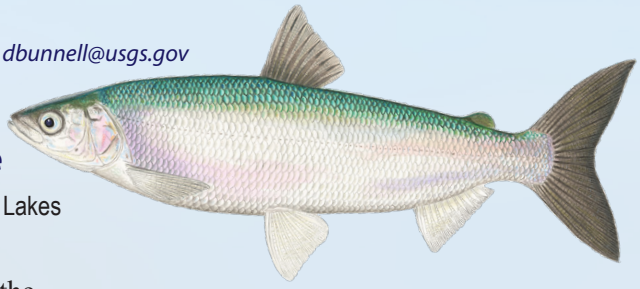
This special feature details collaborative efforts in restoring coregonine species (a sub-family within the Salmonidae family) across the Great Lakes Basin. These stories also highlight DOI's diverse role in providing science and operational support to many fishery managers and partners during a critical era in the ecological history of the Great Lakes for a fishery management priority.

For information contact: Kurt Schilling, email: Kurt_Schilling@fws.gov, Bo Bunnell, email: dbunnell@usgs.gov

Restoring Native Fish to the Great Lakes

DOI's Role in a Complex, Large-Scale, Societal Challenge

By Bo Bunnell (USGS), Kurt Schilling (USFWS), John Dettmers and Andrew Muir (Great Lakes Fishery Commission), and Josh Miller (USGS)



A Lake Superior Cisco (*Coregonus artedi*), one of the several extant coregonine species in the Great Lakes. Artist: Paul Vecsei, courtesy of the Great Lakes Fishery Commission (GFLC), used with permission.

The Great Lakes once teemed with a diversity of native fishes that present-day Great Lakes residents cannot experience. In particular, an assemblage of coregonine species populated complex and diverse habitats, from the deep waters to shallow coastal embayments and into the numerous tributaries across the Great Lakes Basin. This sometimes difficult-to-study group has been called "Darwin's finches of the Great Lakes," given that as many as 11 species were described in the Great Lakes in the early 1900s. In that era, coregonine diversity and abundance supported important fisheries throughout the Great Lakes region as well as being prey for top native predators, such as lake trout. Coregonines were foundational to the Great Lakes food web.

Similar to the fate of the passenger pigeon, once North America's most abundant bird which swarmed the skies over the Great Lakes, the coregonines that flourished under these waters also began to vanish. By the mid-20th century, genetic diversity declined within the various coregonine species, likely due to stress on local populations. Impediments to abundance and continuity of populations differed across the lakes but included overfishing, dams, urbanization, pollution, deterioration of coastal and riverine habitat, and negative interactions with invasive species such as sea lamprey (*Petromyzon marinus*), alewife (*Alosa pseudoharengus*), and rainbow smelt (*Osmerus mordax*). This loss of diversity led to less resilient populations and fisheries, making them less able to rebound from dramatic changes in the environment.

When fishery scientists consider the resiliency of a fishery, they sometimes compare the situation to a financial investment portfolio. A sensible investor selects a well-balanced, diverse portfolio—one that survives the ups and downs of financial markets. Likewise, an ecosystem that contains complex and diverse habitats often can support a diversity of populations within a species. As a result, when one population declines, for whatever reason, another population might thrive. In total, the human-induced stressors of the 20th century destroyed key habitat, reduced genetic and ecological diversity within coregonine species, and ultimately led to the extinction or extirpation (i.e., local extinction) of many species. What remains today is a prey fish community of relatively few native coregonines and, in some lakes, periods of domination by non-native prey species. Some of those non-native prey species have also begun to decline in abundance in recent decades, coincident with management efforts to reduce nutrient pollution and the stocking of salmonine predators. These cumulative ecosystem changes threaten the sustainability of the $7 billion sport, recreational, tribal, and commercial Great Lakes fisheries and a way of life for the 35 million people living around the Great Lakes.

Some impediments to coregonines have decreased over time. The

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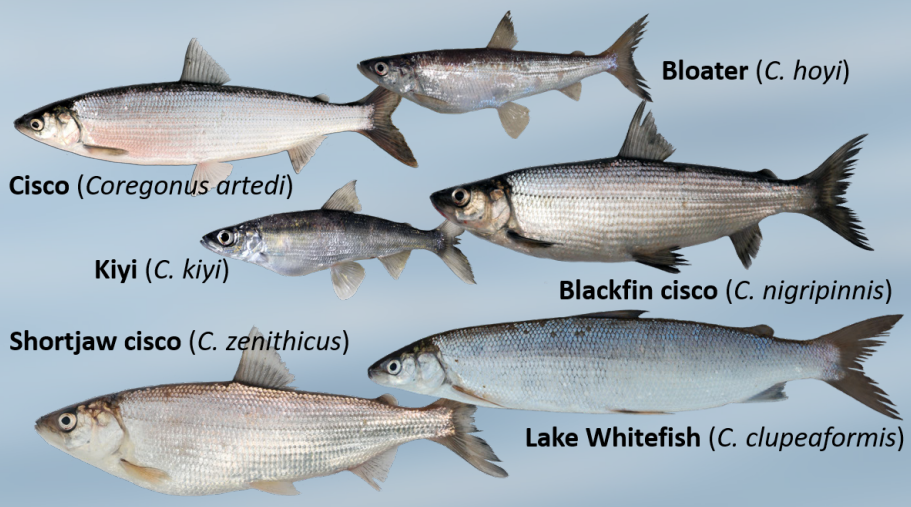

Example of some of the diversity of native coregonine species in the Laurentian Great Lakes. Photo credit: Andrew Muir, GFLC, public domain.

Cisco caught under the ice in a northern Michigan drown river mouth off Lake Michigan. Photo credit: Brad Briggs, public domain.

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bi-national 1954 Convention on Great Lakes Fisheries enabled cooperative fishery management and control of the invasive sea lamprey. The 1972 binational Great Lakes Water Quality Agreement successfully reduced excessive nutrient inflows into the Great Lakes. High nutrient inflows previously made many of these systems hospitable to non-native prey fishes following the collapse of the native coregonines. As a result, many fishery management agencies across the basin are now either actively restoring, or considering whether and how to restore, native coregonine prey fishes to foster a more diverse and resilient prey fish community that supports diverse fisheries in these changing lakes.

The four DOI Bureaus in the region, including the USGS, USFWS, NPS, and Bureau of Indian Affairs (BIA), recognized an emerging need for coregonine restoration science to support the priorities of the states, tribes, and province of Ontario that have fisheries management authority in the Great Lakes. In 2016, DOI bureaus began actively working with the GLFC, which implements the 1954 Convention on Great Lakes Fisheries to develop a science based Coregonine Restoration Framework (Framework) to enhance and restore coregonine populations across the basin. This Framework was adopted by Great Lakes fishery managers in 2018

See related story, page 15.

A DOI Steering Committee uses the Framework to enhance DOI collaboration and provide operational support, research, and monitoring required to advance restoration efforts. The Steering Committee includes representatives from the four DOI Bureaus, GLFC, and U.S. Department of State. Committee members bring their extensive individual and agency expertise and agency resources to this large-scale, complex societal challenge.

The strength in the unified DOI approach, acting in partnership with the Great Lakes fishery management agencies, lies in the robust

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USGS Receives New Authorizing Legislation for Great Lakes Fishery Research (GLFRA Act)

By Russell Strach and Josh Miller (USGS), and Marc Gaden (GLFC)

The Great Lakes support a $7.0 billion fishery and contain 20% of the world's available fresh water. In December 2019, the President signed into law the bipartisan Great Lakes Fishery Research Authorization Act (GLFRA Act), which was authored by Representatives Fred Upton (MI) and Mike Quigley (IL), and Senators Gary Peters (MI) and Rob Portman (OH). The Act authorizes the "Director of the [USGS] to conduct monitoring, assessment, science, and research, in support of the binational fisheries within the Great Lakes Basin." These activities make up the USGS Great Lakes Deepwater Science Program (Program) operated by the Great Lakes Science Center (GLSC) within the Midcontinent Region of the USGS.

The Program was previously preserved within DOI by a 1970 Presidential Executive Order transferring commercial fishery science responsibilities from DOI to NOAA-National Marine Fisheries Service, but leaving Great Lakes Federal deepwater fishery science responsibilities and five large oceanographic-size research vessels within DOI.

Science conducted under the Program is necessary to support multi-jurisdictional, bi-national fishery management decisions throughout the Great Lakes. The USGS carries out annual, lake-wide prey fish assessments and conducts research on invasive species control and restoration of native fishes and their habitats. The new law authorizes research on deepwater ecosystem sciences, biological and food-web components, fish movement and behavioral investigations, fish population structure, fish habitat investigations, invasive species science, use of existing and new technologies, and impacts on Great Lakes fishery resources.

To carry out the Program, the GLSC operates a fleet of recently modernized oceanographic research vessels, one on each of the five Great Lakes, capable of carrying out month-long fishery research assignments. In addition, the GLSC operates a fleet of smaller research vessels and two large, recently modernized aquatic research laboratories in Michigan. A third large aquatic research laboratory—the Tunison Laboratory of Aquatic Science in New York—is slated for a major modernization investment in the next few years and will serve as a hub for native fish restoration science throughout the lower Great Lakes Basin.

The GLFRA Act also authorizes Federal appropriations of up to $15.0 million (M) annually in fiscal years 2021 through 2025 to support the Program. The Act was funded in fiscal year 2021 at $13.0M, which is an approximately $4.4M increase since the 2019 law was passed.

The USGS Great Lakes fishery research vessel (R/V) fleet. Photo credits: USGS

R/V *Muskie, 2011*
- Aluminum hull
- Length: 70 ft
- Beam: 18 ft
- Draft: 5.5 ft
- Cruising speed: 12 kts

R/V *Arcticus, 2014*
- Steel hull
- Length: 77 ft
- Beam: 26 ft
- Draft: 8.9 ft
- Cruising speed: 9.5 kts

R/V *Kaho, 2011*
- Aluminum hull
- Length: 70 ft
- Beam: 18 ft.
- Draft: 5.5 ft
- Cruising speed: 12 kts

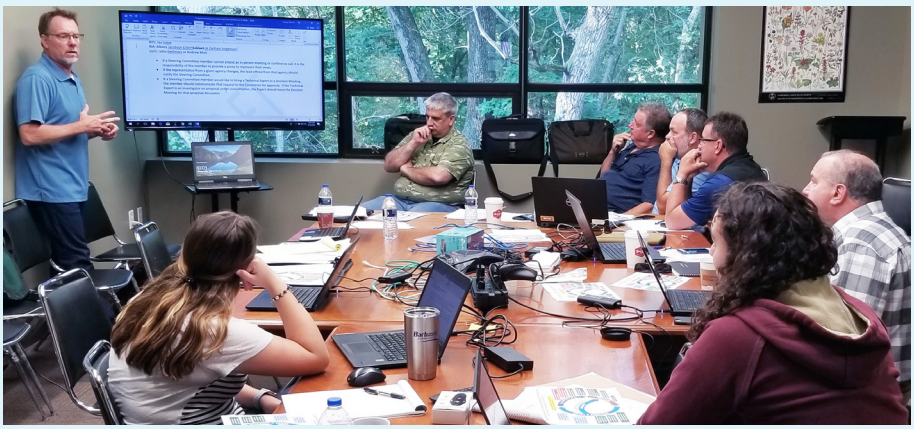
R/V *Kiyi, 1999*
- Steel hull
- Length: 107 ft
- Beam: 27 ft
- Draft: 10 ft
- Cruising speed: 10 kts

R/V *Sturgeon, 2004*
- Steel hull
- Length: 104 ft
- Beam: 25 ft
- Draft: 10 ft
- Cruising speed: 11 kts

DOI Coregonine Steering Committee

The DOI Coregonine Steering Committee has two primary charges. First, the members solicit and select collaborative project proposals submitted for funding under the Great Lakes Restoration Initiative (GLRI). These proposals are generally led by USFWS or USGS and often include partners from state agencies, tribes, or academic institutions. Since 2017, more than $4.8M of GLRI funds have been awarded by the committee, providing science support for restoration planning or fish hatchery enhancements requested by fishery managers to reintroduce coregonines into Lake Ontario (*See related stories, pages 17-18*).

Second, a longer-term goal is to assist the states, tribes, and Ontario in their development of science-based restoration plans. In anticipation, the DOI agencies are focusing their efforts on synthesizing existing fishery and environmental data that will generate maps, tables, graphs, and other displays of geographic information to assist in this complex, interagency planning challenge. (*See related story, page 16*).



The Coregonine Steering Committee met in October 2018 at the USGS Great Lakes Science Center station near Chesterton, Indiana, that is located within the Indiana Dunes National Park. Photo credit: Russell Strach, USGS.

Restoring continued from page 13

capabilities, tight network of relationships, deep experiential history in Great Lakes fishery science and management, and refined expertise that is spread across the basin's geography. The agencies are working hand-in-hand to understand the lessons of the past and joining forces, project-by-project, to strategically accomplish lake-specific priority objectives.

Looking forward, Great Lakes fishery managers and scientists recognize that coregonine restoration will occur over decades, given the complexity of the challenge and the size of these lake ecosystems. The role of DOI agencies in this effort is to provide the science and operational support to Great Lakes fishery management agencies so that the restoration effort is as effective as possible and consistent with principles of adaptive management and modern conservation biology. In the long term, by restoring this community of native coregonines across the basin, fishery managers hope to bring about more stable fish communities, an increase in fishery productivity and economic value, and more diverse fishing experiences for the region's 35 million residents.

Thank you to additional contributors: Russell Strach, Ralph Grundel, Kurt Newman, Cory Brant (USGS), and Andrea Miehls (GLFC).

The Great Lakes Coregonine Restoration Framework

By John Dettmers and Andrew Muir (Great Lakes Fishery Commission)

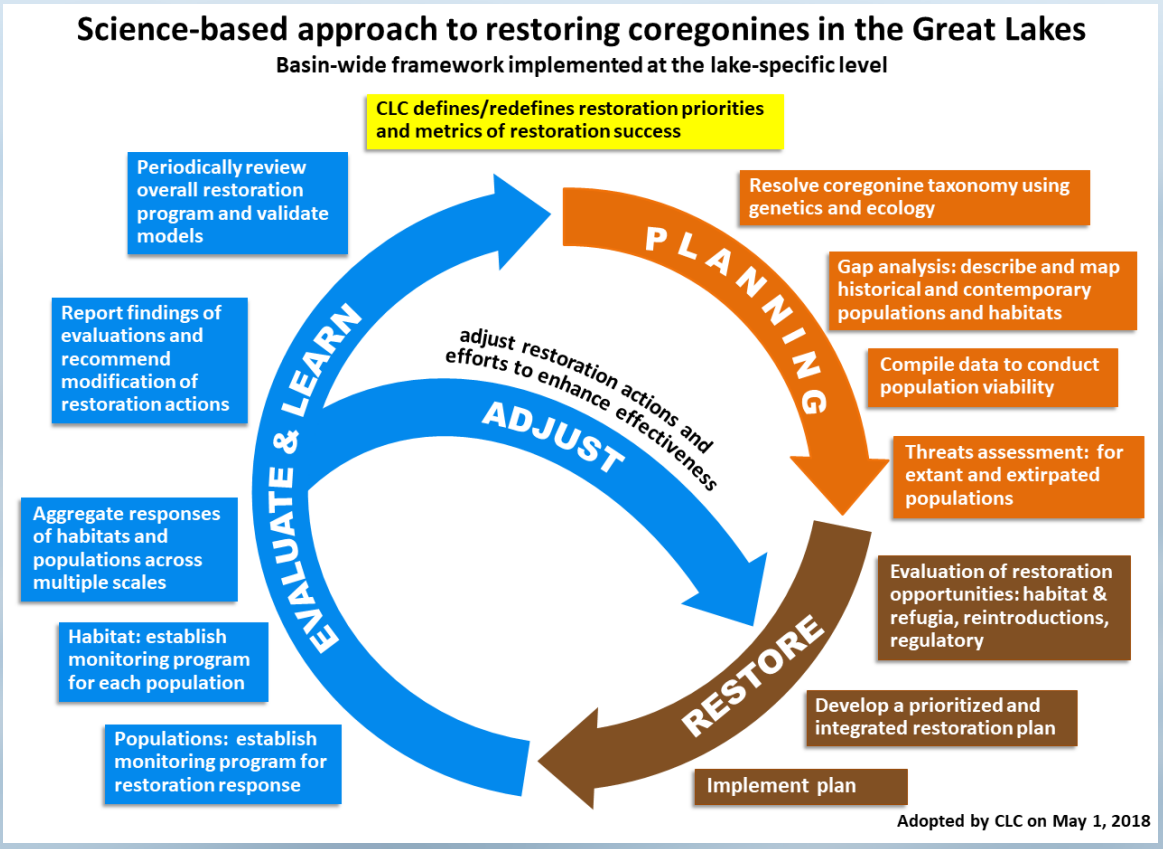
In May 2018, the Council of Lake Committees (CLC), made up of senior fishery managers from eight Great Lakes States, three U.S. Tribal organizations, and the Province of Ontario, gathered in Windsor, Ontario, to discuss a basin-wide strategy for restoring native coregonine fishes.

The CLC endorsed an adaptive, science-based Coregonine Restoration Framework that was developed by the USGS GLSC and USFWS in coordination with the Great Lakes Fishery Commission (GLFC). This Framework was designed to identify key uncertainties and establish a road map that could allow restoration to proceed as appropriate for each lake committee.

Fishery management in the Great Lakes proceeds cooperatively, with decisions made by consensus. Each of the Great Lakes is managed by a lake committee, comprising the relevant fishery management agencies. Fishery managers on some lakes (such as, Lakes Huron and Ontario) had already begun restoration efforts, whereas managers on other lakes faced challenges reaching consensus. Indeed, the lakes differ with respect to their Fish Community Objectives (such as, agreed upon management targets), and variables responsible for reductions in diversity, distribution, and abundance of coregonines. For example, Lake Superior's food web is largely intact (*See related story, page 23*), whereas Lake Ontario's food web is currently dominated by non-native prey fishes.

The framework provides consistent guidance at a basin-wide scale, and identifies several challenging science questions, such as resolving what constitutes a discrete coregonine unit (or population), the historical and present-day distribution of these units, and the impediments to each unit's success. Addressing the science questions is fundamental to successful coregonine restoration, but not an impediment to positive progress, with activities ongoing in many areas of the framework. Current activities within the framework focus on (1) identifying common methods to address the primary scientific tasks (orange boxes); (2) developing restoration plans for lakes Huron and Ontario (brown boxes); and (3) establishing evaluations for Lakes Huron and Ontario (blue boxes), where Cisco and Bloater restorations are respectively underway (*See related stories, page 17-18*).

Scientists within DOI are working closely with scientists from Great Lakes fishery management agencies, academia, and the GLFC to provide science support for the activities of the coregonine restoration framework.



The Great Lakes Coregonine Restoration Framework demonstrates the adaptive nature of the cooperative science-based approach. DOI scientists are contributing to the planning activities (orange boxes) by leading and participating in task teams, undertaking research projects, and, with the GLFC, coordinating basin-wide coregonine science. Progress in the planning phase of the framework will assist fishery managers to set or evaluate restoration priorities and achievable goals (brown boxes), inform restoration plans, and evaluate progress (blue boxes) toward the desired goals for each coregonine unit in each lake. Image credit: CLC

Looking to the Past to Inform the Present

By Cory Brant (USGS)

The Great Lakes are home to an estimated 140 native species of fishes, all of which are part of what make this massive expanse of fresh water one of the most unique and mysterious ecosystems on the planet. Affectionately called "lake herring," "ciscoes," "whitefish," "chubs," and many other names depending on the community you visit, small, silvery coregonines once occupied nearly every available habitat within Great Lakes. They provided food for top predators in the lake as well as for indigenous peoples of the region since time immemorial, fed multiple nations through the Industrial Revolution and The Great Depression, and were even sent to troops during World War II.

Great Lakes ciscoes are packed for freezing at the Northern Cold Storage and Warehouse Company in Duluth, Minnesota, in approximately the 1930s. Photo courtesy of the John Van Oosten Library, USGS. Photo credit: Photographer unknown

A primary task during the science planning phase of the Coregonine Restoration Framework (*See related story, page 15*) is to describe and map historical populations and habitats of coregonines in the Great Lakes (*See related story, page 25*). While a substantial amount of historic information regarding native Great Lakes coregonines exists, much of it remains inaccessible for research or mapping in its original format because it is not readable by computers. To address this, the team is building a historic coregonine database designed to accommodate data from a diverse range of sources and materials, including interviews, Traditional Ecological Knowledge, reports and documents, manuscripts and dissertations, historic maps, and photographs, all the way back to 1900. A multidisciplinary team of biologists, data scientists, GIS experts, managers, and historians across multiple DOI and partner agencies have been collecting, digitizing, and learning from over a century's worth of historical documents and other records.

It is essential to study and map historic coregonine habitat use for several reasons, including: (1) to accurately identify diversity and differences among populations, (2) to illustrate where critical habitat once existed and where losses have occurred, and (3) to target areas for habitat restoration or protection. The database will be an ever-growing repository, allowing present and future researchers to access historic information to inform coregonine restoration for decades to come.

A specimen of Deepwater Cisco (*Coregonus johannae)* at the University of Michigan Museum of Natural History collected by Walter Koelz on August 19, 1920, in Lake Michigan—a species that is now considered extinct. Photo credit: Cory Brant, USGS

Partnership Restores Cisco to a Lake Huron Bay

By Chris Olds and Scott Koproski (USFWS)

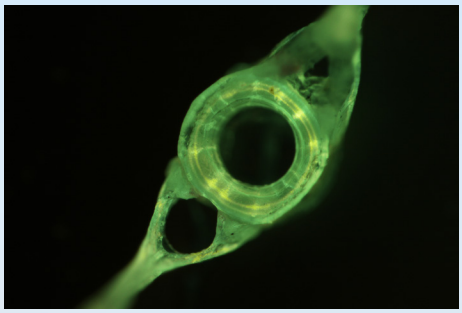
The USFWS has collaborated with state, tribal, federal, and provincial partners to plan, implement, and evaluate a Cisco rehabilitation program in Saginaw Bay, Michigan, in Lake Huron. Rehabilitating Cisco to Saginaw Bay will rehabilitate a native plankton-eating prey fish to help connect the offshore and nearshore food webs, provide an alternative source of prey for Walleye (*Sander vitreus)* that could reduce their pressure on Yellow Perch (*Perca flavescens*), and restore a fishery that once was abundant in southern Lake Huron. The year 2020 marked the third year of raising Cisco at the USFWS Jordan River National Fish Hatchery (JRNFH) in northwest Michigan. Accelerated infrastructure development and rearing systems have contributed to the program going from zero to over two million fish produced for reintroduction into Saginaw Bay.

During the planning phase of the Great Lakes Coregonine Restoration Framework (*See related story, page 15*), the Lake Huron Technical Committee (LHTC) established a Cisco Workgroup to develop a Cisco Stocking and Evaluation Plan (Plan) for Lake Huron. The Plan was approved by the Lake Huron Committee fishery managers in October 2018. It calls for the stocking of one million Cisco annually in Saginaw Bay and identifies surveys necessary to evaluate progress toward rehabilitation. Prior to release, all hatchery-released fish are fed a commonly used diet that deposits a mark in their vertebrae. This is done so that, following post stocking surveys, when the vertebrae are removed and placed under a fluorescent light, the vertebrae display a gold halo-like ring indicating the origin of the fish (hatchery-raised or wild recruitment).

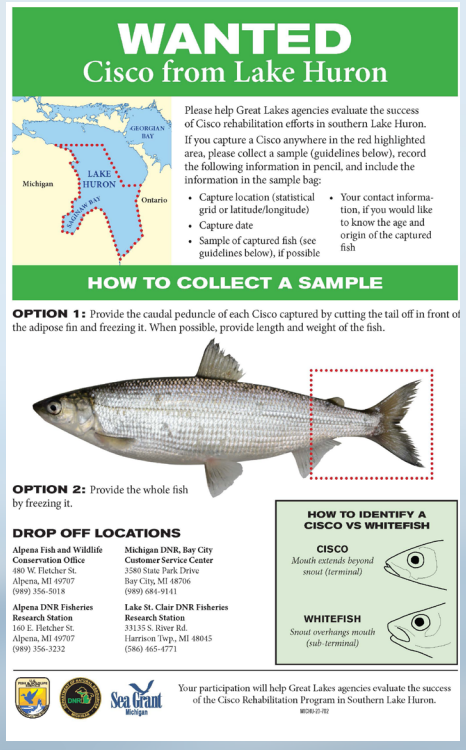
Netting adult Cisco in the Les Cheneaux Islands of northern Lake Huron to collect eggs for raising in the JRNFH. Photo credit: USFWS

The Cisco Workgroup comprises biologists spanning a variety of expertise including fish hatchery operation, genetics, data analysts, and fishery managers. When developing the Plan, the workgroup identified surveys necessary to assess the survival of hatchery-released Cisco and subsequent recruitment of those fish to the fishery in the lake to evaluate the stocking program. Part of the Plan is to have surveys designed to look for Cisco at all life stages. State, tribal, provincial, and federal agencies conduct surveys spring through fall using or modifying existing surveys to include Cisco or developing new surveys to specifically target Cisco at times when they may be concentrated. Many partners are contributing time and resources to make this rehabilitation effort a success.

Lake Huron anglers and sportfishing groups are also contributing to the success of the project. Working with partners like Michigan Sea Grant and an advisory committee to the Department of Natural Resources (DNR), project goals and objectives have been communicated broadly to all sportfishing groups to generate support. The Cisco Workgroup coordinated with Michigan State University Extension Program and Michigan Sea Grant to develop flyers to be posted at boat launches around Lake Huron. The flyers inform anglers how to identify, report, and/or turn in Cisco caught while fishing so that biologists can identify the fish origin, assess adult survival, identify recruitment success, and, ultimately, rehabilitation success.



A Cisco vertebrae with two gold rings indicating that it was a hatchery-raised fish released in the fall. Photo credit: USFWS



Flyer generated by the partners notifying local anglers of how they can participate in the Cisco restoration program.

Biologist and managers have been working together for over a decade on the best approach to rehabilitate Cisco in Lake Huron. Seeing the Cisco Restoration Plan come to fruition has been the high point in the career of many involved. The USFWS and all the partners recognize the important ecological role native Cisco can play in the Lake Huron fish community.

Restoring 'Bloater' to Lake Ontario

By Mike Millard (USFWS); Jim McKenna, Brian Lantry (USGS)

The disappearance of the native deepwater coregonines in Lake Ontario by the 1950s led one Canadian researcher in 1973 to describe the abyss of Lake Ontario as "strangely devoid of fish." Since then, invasive prey fish—Alewife and Rainbow Smelt—have seasonally occupied the deep waters of the lake, yet the niche arguably remains underutilized. With improved water quality and reduced invasive species populations, many believe the time is ripe for re-introducing native deepwater prey fish.

The Lake Ontario Fish Community Objectives adopted by fishery managers that comprise the Great Lakes Fishery Commission's Lake Ontario Committee (LOC) established a goal of restoring a self-sustaining, diverse assemblage of native prey species and emphasized deepwater coregonines. The 2014 LOC Lake Trout Management Strategy also emphasized the value of restored deepwater coregonines to the reproductive health of native lake trout. Of the four native deepwater coregonine forms that were extirpated from Lake Ontario, the two most appropriate candidates for reintroduction are Bloater and Kiyi.

In 2011, New York State Department of Environmental Conservation (NYSDEC) and Ontario Ministry of Natural Resources and Forestry (OMNRF) contacted USFWS and USGS for assistance in reintroducing Bloater. They needed a ready source of wild Bloater eggs and a facility in New York that could lend expertise and conduct experiments with raising captive Bloater. The international partnership bore fruit that year when a team of USFWS biologists and local fisherman captured wild Bloater in Lake Michigan during extreme winter conditions, fertilized their eggs, and successfully transferred them to the OMNRF White Lake Fish Culture Station in Ontario and to the USGS Tunison Laboratory of Aquatic Science (TLAS) in New York. These fish ultimately became the first Bloater reintroduced to Lake Ontario in 2012.

The commercial fishing trawler *Peter Paul* out of Two Rivers, Wisconsin, breaks ice to reach known Bloater spawning grounds in January 2014. Photo credit: USFWS Green Bay Fish and Wildlife Conservation Office

Over the next several years, these facilities undertook groundbreaking research to maximize Bloater survival, including determination of optimal hatchery fish densities and diets. Because of the difficulty in securing sufficient numbers of wild eggs in January and February in Lake Michigan, scientists at the University of Windsor and OMNRF spearheaded physiological research to develop Bloater broodstock lines (or captive populations) that could produce viable eggs while maintaining genetic diversity. This foundational science prompted additional research at TLAS and at the USFWS Northeast Fishery Center (NEFC) and Allegheny National Fish Hatchery in Pennsylvania.

This DOI partnership with OMNRF and NYSDEC strives to meet the LOC goal of stocking up to 500,000 Bloater into Lake Ontario each spring using fertilized eggs from wild Bloater collected in Lake Michigan and domestic broodstock. Though short of annual

See Bloater page 19

Watch underwater video of the 2014 Bloater release into Lake Ontario off the USGS R/V Kaho: https://www.youtube.com/watch?v=nkyzu8OHzfM

The 70-foot USGS R/V *Kaho*, Oswego, New York. Photo credit: USGS

What is Barotrauma?

'Bloaters' are a coregonine species that are sometimes referred to as a "deepwater cisco" because they reside in the deeper waters of the Great Lakes. When brought to the surface via fishing nets, the fish "bloats" because, due to the quick ascent, gases in its swim bladder expand from the decrease in pressure. This physiological impact from changing pressure is named 'barotrauma.'

Bloater caught in Lake Ontario off the USGS R/V *Kaho*. Photo credit: Brian Weidel, USGS

Bloater continued from page 18

production goals due to egg viability and availability, nearly one million Bloaters have been stocked into Lake Ontario since 2012. The OMNRF has released over 450,000 of various life stages off Main Duck Island in northeast Lake Ontario and off Cobourg Harbor on the north shore of the lake. On the south shore, the USFWS, USGS, and NYSDEC have collaborated to release approximately 487,000 off from Oswego, New York, using the USGS R/V *Kaho* and a landing craft serving NYSDEC.

The USGS, NYSDEC, and OMNRF have used annual fishery surveys to assess the success of these reintroduction efforts and have recovered nine surviving Bloaters to date, the first Bloaters caught in Lake Ontario in almost 40 years. Acoustic telemetry studies in Canadian waters are also providing information about post-release survival and behavior. Additional USGS studies with USFWS are revealing how barotrauma may affect survival of released fish (*See sidebar on this page*). Given the challenges of restoring a native prey fish to a lake as large as Lake Ontario, fishery managers have benefitted from the binational science support, including key contributions by DOI agencies.

The USFWS, USGS, and State and provincial agency personnel are working together to identify new ways in which each DOI agency can best contribute to meeting the fishery management goal of re-introducing up to 500,000 Bloaters each spring. Scientists at USFWS's NEFC are conducting research to maximize survival and fitness of eggs from the domestic broodstock line, including a recently funded proposal seeking to evaluate how different diets can improve egg quality and survival using USFWS facilities and USGS's TLAS. They are also ensuring the genetic diversity of stocked Bloater and the domestic broodstock are maintained at sufficiently high levels.

Domestic Bloater broodstock at OMNRF's White Lake Fish Culture Station, Ontario, Canada. Photo credit: USFWS

The USGS will conduct research at TLAS to produce Bloater that are as close to wild-produced fish as possible with regard to growth, ability to avoid predators, etc. In 2021, TLAS also hopes to begin experiments with Kiyi, the other candidate identified for re-introduction by the LOC (*See related story, page 20*). USFWS hatchery facilities will play a primary role in producing Bloater, adapting to ongoing scientific research conducted by DOI and academic scientists from Canada and the U.S.

Special thanks to contributors: Larry Miller, Lowell Whitney, and Ted Treska (USFWS); Bo Bunnell (USGS); and Michael Connerton (NYSDEC).

Paul Haver (center) leading the crew to spawn wild-caught Bloater on Lake Michigan. Photo credit: Roger Gordon, USFWS

The Impact of Barotrauma on Released Fish

By Owen Gorman (USGS)

When hatchery-raised Bloater are released into the offshore waters of Lake Ontario, they typically seek deep water quickly, descending up to 65 m in approximately five minutes. With this rapid descent, the change in barometric pressure could potentially impact their behavior, physical condition, and survival. The USGS and USFWS came together at the JRNFH in Michigan to study the impact of "compression barotrauma" on released Bloaters using a newly developed USGS device in November 2020. In a series of trials, scientists pressurized Bloater in a 50-gallon vessel, simulating their descent upon release in the wild. Preliminary results suggest that compression barotrauma may affect behavior, physical condition, and survival of fish. The findings may lead to changes in the way fishery managers release hatchery-raised Bloater in the wild. Further studies are planned.

The USGS Hyperbaric Apparatus for Fish used to assess barotrauma in Great Lakes fishes. Photo credit: Owen Gorman, USGS

Reintroducing Kiyi: Breaking Ice to Fill Knowledge Gaps

By Kris Dey (Little Traverse Bay Bands of Odawa Indians) and Jason Smith (Sault Ste. Marie Tribe of Chippewa Indians)

Among the Great Lakes, only Lake Superior retains the majority of the coregonine diversity that once characterized the Great Lakes (*See related story, page 23*). For example, Kiyi, which lives in the deepest waters of the lakes up to 230 m, remains abundant in Lake Superior after being extirpated in Lakes Huron, Michigan, and Ontario. Fishery managers on Lake Ontario have expressed interest in reintroducing Kiyi, but large knowledge gaps remain. These include basic life history such as spawning timing, behavior, and location, the degree of potential hybridization (i.e., reproduction between species), and the feasibility of raising Kiyi in hatcheries ultimately for release in the other lakes. For fishery managers to more seriously consider whether to reintroduce Kiyi, biologists must fill these knowledge gaps.

Beginning in 2016, The Nature Conservancy and the USGS sought to clarify when Kiyi spawn. By tracking gonad development spring through fall, they predicted that Kiyi spawned in early winter. To pinpoint Kiyi spawning, they hired a commercial fisher from Munising, Michigan, with a tug capable of breaking ice to collect fish; it is difficult to sample Lake Superior during the harsh winter months, which is why biologists know so little about Kiyi spawning. Repeated winter collections from 2017 to 2020 suggested Kiyi were spawning in late December through early-mid January.

The multi-organization research team employs a commercial fishing vessel to access the deep waters of Lake Superior mid-winter to acquire spawning Kiyi, January 2019. Photo credit: Courtesy of Patrick Hugener, Head in the Clouds Photography; public domain

Tribal biologists work aboard a commercial fishing vessel on Lake Superior in January 2021, to collect deepwater coregonines and spawn them to explore the feasibility of capturing Kiyi eggs to raise in Great Lakes region laboratories. Photo credit: Jason Smith, Sault Ste. Marie Tribe of Chippewa Indians, public domain

In January 2021, scientists from Sault Ste. Marie Tribe of Chippewa Indians (SSMT) and Little Traverse Bay Bands of Odawa Indians (LTBBOI) joined the commercial fisher out of Munising to collect and artificially spawn deepwater ciscoes. The fish they caught were identified and sorted into species, which will be confirmed by genetics analysis later. They experimented with cross-fertilizing between Kiyi and some of the other gravid (such as, egg-carrying) coregonine species to determine the viability of hybrid coregonines. The fertilized eggs were transported to the LTBBOI Fisheries Enhancement Facility in Pellston, Michigan, while the parent fish were saved for subsequent imaging and biological data collection at the SSMT laboratory.

The team predicts the egg incubation period will last up to 110 days. After the eggs develop eyes in about 50 to 60 days, each batch of fertilized eggs will be split into three groups for replication. Two groups will be sent to the USGS GLSC aquatic laboratories in Ann Arbor, Michigan, and Cortland, New York, while the third will remain at the LTBBOI Fisheries Enhancement Facility. They will be raised under similar conditions among the labs which will help the biologists assess the feasibility of rearing Kiyi in captivity and allow them to test the hypothesis that hybrid offspring are not viable when they backcross with other deepwater coregonine species in Lake Superior.

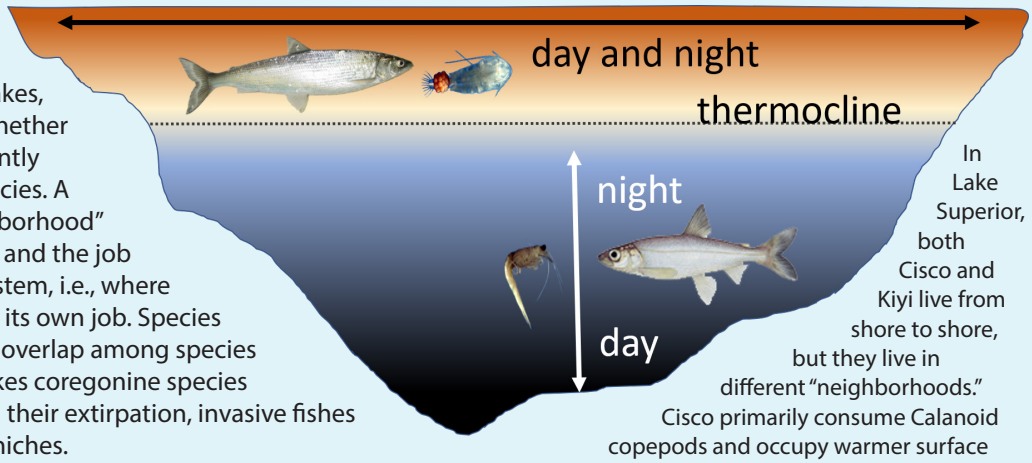
Filling these three crucial knowledge gaps regarding Kiyi life history, potential for hybridization, and feasibility of rearing Kiyi in hatcheries will inform future restoration planning in lakes where re-introduction of Kiyi is prioritized.

Special thanks to contributors: Matt Herbert (The Nature Conservancy), and Mark Vinson and Bo Bunnell (USGS).

What Fish Eat, and Where They Eat it, Could Guide Coregonine Reintroduction Efforts

By Mark Vinson (USGS)

As coregonine reintroduction efforts advance across the Great Lakes, fishery managers must evaluate whether candidate species' niches are currently vacant or occupied by invasive species. A species' niche describes the "neighborhood" where that species lives in the lake and the job that species performs in the ecosystem, i.e., where each species has its own place and its own job. Species diversity is maximized when niche overlap among species is minimized. Historically, Great Lakes coregonine species occupied unique niches. Following their extirpation, invasive fishes moved into some of those vacant niches.



In Lake Superior, both Cisco and Kiyi live from shore to shore, but they live in different "neighborhoods." Cisco primarily consume Calanoid copepods and occupy warmer surface waters above the thermocline, which is where the water temperature quickly transitions from warmer surface waters to the colder deep. Kiyi live on the bottom during the day and migrate upward to the thermocline at night feeding on Mysis, a small crustacean that exhibits the same daily migratory behavior. Credit: Mark Vinson, USGS

To address this issue, Caroline Rosinski and colleagues at the USGS used some novel approaches to describe habitats and diets of three native coregonine species—Bloater, Cisco, and Kiyi—and invasive Rainbow Smelt. They found niche overlap was minimized by these fishes by eating different prey or when eating similar prey doing so in different locations. Kiyi had the most unique niche of the species evaluated and appear to occupy a niche that is currently vacant in the other Great Lakes. This means Kiyi could be a good candidate for reintroduction into lakes they previously occupied.

Read the project paper: *https://doi.org/10.1002/tafs.10219*.

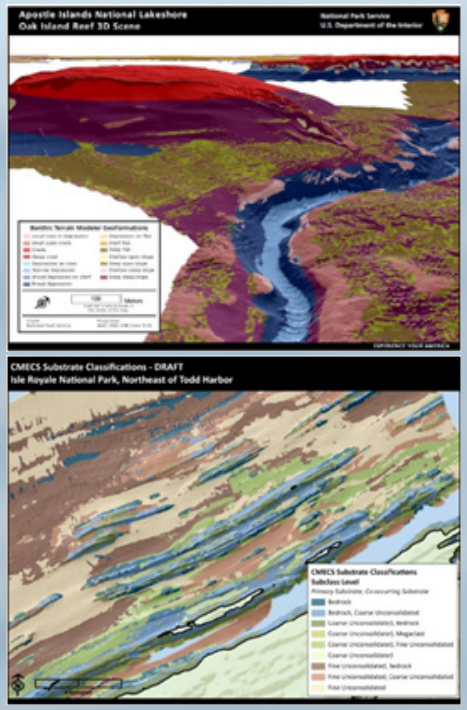
Mapping Lake-Floor Habitat in the National Parks and Lakeshores of the Great Lakes

By Jay Glase, Brenda Lafrancois, and Nathaniel Penrod (NPS)

Since 2010, the NPS, with support from the GLRI, has been mapping lake floor habitat in NPS Parks and Lakeshores of lakes Superior and Michigan. The project originated as a way to better understand submerged aquatic habitat at NPS units, but several agencies and organizations are now using the data and information for multiple purposes.

The NPS has collaborated with other Federal and academic partners to develop maps of lake bottom morphology and in some locations detailed substrate (i.e., bottom type) maps using NOAA's Coastal and Marine Ecological Classification Standard (CMECS). The NPS continues to work with NOAA and DOI partners to prioritize additional mapping locations in Lakes Superior and Michigan.

Results from these and earlier efforts will contribute to coregonine restoration efforts by providing lake geomorphology and substrate maps in locations in and near the Apostle Islands National Lakeshore and Isle Royale National Park in Lake Superior and Sleeping Bear Dunes National Lakeshore in northern Lake Michigan. Information from these geospatial datasets can be used to inform managers on habitat use by coregonines to aid with restoration efforts in the lower Great Lakes as well. (*See related story, page 26*).



Top, the lake floor geomorphology output from the Benthic Terrain Modeler at Oak Island Shoal, Apostle Islands, categorizes morphological features on the lake bottom. Bottom, a detailed substrate map shows CMECS classifications at the subclass level; Isle Royale National Park, Lake Superior. Image credits: NPS

Acoustic Sledding on Lake Superior to Assess Native Cisco

By Dan Yule (USGS), Jared Myers (USFWS), and Ian Harding (Red Cliff Band of Lake Superior Chippewa)

Fishery scientists and managers have been using hydroacoustic surveys to estimate abundance of Lake Superior Cisco, a native coregonine species, for two decades. This method involves transmission of sound waves from the ship towards the lake bottom and recording the returning fish detections (echoes) in the water column. Traditional fishing gear (e.g., mid-water trawl or gillnet) is also deployed so the scientists can better appreciate the biological characteristics of the fish they see with hydroacoustics.

Fishery managers are increasingly relying on hydroacoustic surveys to help regulate the Lake Superior Cisco harvest by commercial fishers. Nearly 2.2 million pounds are harvested annually, and that product reaches a wide range of markets. The flesh is processed into smoked fish and fillets while the roe is primarily sold to Scandinavian countries where it is marketed as Löjrom, a type of caviar. This industry has a rich cultural history and provides sustenance and employment opportunities to local communities across the Lake Superior basin. For example, Anishinaabe people, such as the Red Cliff Band of Lake Superior Chippewa, have long relied on the fishes of Lake Superior for subsistence and commerce. The Red Cliff Band recently opened a fish processing facility and the Cisco fishery has been a vital component to both the business and community.

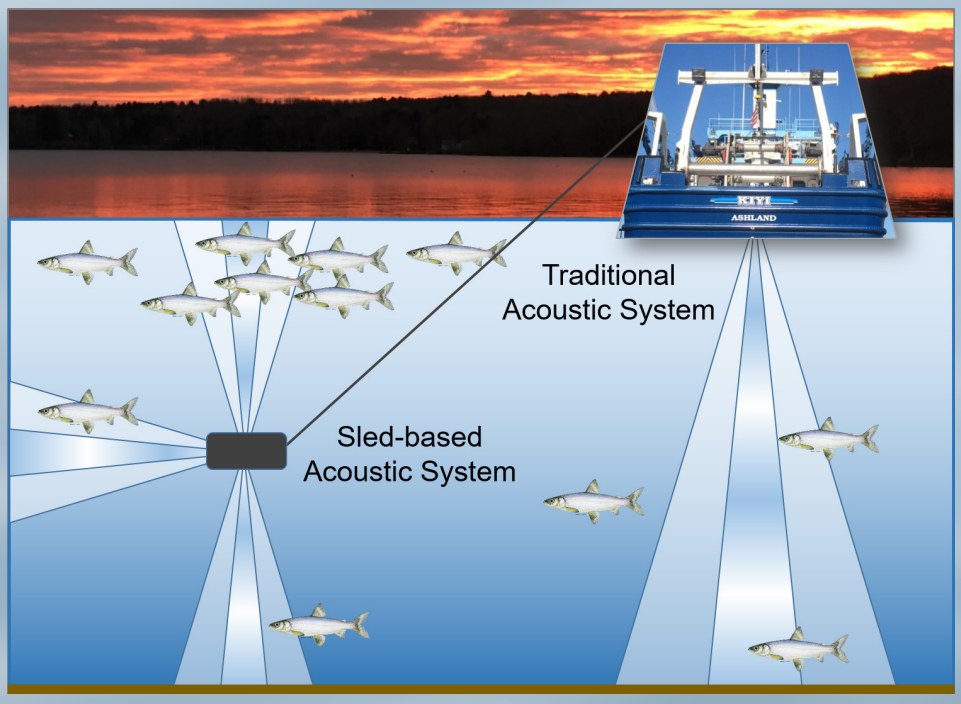
Cisco are difficult to sample because hydroacoustic surveys are best conducted during the fall when fish congregate in surface waters along the shoreline. Although this may be good for commercial fishers looking to capture Cisco with nets, the situation presents a challenge for scientists attempting to use acoustics to measure the abundance of fish at a given location. Traditional acoustic methods use sampling equipment attached to the research vessel and aimed downward toward the lakebed (see schematic below). This leads to low sample volumes near the surface and the potential for fish to swim away from the boat before they can be measured by the acoustic system.

The USGS, USFWS, and Red Cliff Band of Lake Superior Chippewa recently combined resources to assemble and test a new hydroacoustic system that relies on a sled towed behind and to the side of the vessel and deeper in the water column (see schematic below). The sled allowed the first ever mobile acoustic survey on Lake Superior that looked in multiple directions as opposed to just down. By using this new approach, a much larger volume of surface water was effectively sampled. In addition, the new approach could better detect fish that were displaced by the vessel that would be otherwise undetected by the traditional approach.

The USGS worked with the private sector on the design. The USFWS helped finance the submersible echosounder and funded a graduate student at the University of Minnesota-Duluth. The Red Cliff Band contributed funding for the fiber optic communication system that was critical for real time adjustments and data visualization during collections. All three agencies and the university participated in the field work.

Results from the new sled were compared to the traditional down-looking acoustic method along transects in western Lake Superior during the summer of 2018. While conditions during this summertime study were markedly different from the conditions that would be expected during a fall spawning Cisco survey, it did provide greater context to the limitations of traditional acoustic sampling. The two survey approaches provided significantly different estimates of fish density near the surface (approximately

See Acoustic page 23



Schematic showing standard hydroacoustic survey (right) and the new towed hydroacoustic sled (left). Image credit: Jared Myers, USFWS

Lake Superior as a Reference Point

By Owen Gorman (USGS)

Lake Superior represents the exemplar Great Lake: it retains a nearly intact native fish community and its ecosystem has not been "re-engineered" by invasive mussels as have the lower Great Lakes. As such, Lake Superior serves as somewhat of a reference point for rehabilitating fish communities in the lower Great Lakes.

Lake Superior shoreline, Pictured Rocks National Lakeshore. Photo credit: Josh Miller, public domain

However, Lake Superior is not pristine and has undergone dramatic changes over the past century. Rapidly expanding European settlement of the basin in the late 19th and early 20th centuries drastically altered the watershed. Clear-cutting of forests resulted in catastrophic soil erosion and sedimentation of wetlands and bays. Fish stocks were depleted and rapidly growing cities discharged large volumes of untreated wastes. By the early 1960s, a combination of overfishing and rapid expansion of invasive sea lamprey resulted in the near collapse of the fish community.

Around this time, a concerted bi-national effort was launched to control sea lamprey and restore decimated native lake trout stocks across the Great Lakes. Early efforts were focused on Lake Superior where remnant lake trout stocks remained. The strategy was successful, and by the close of the 20th century, lake trout stocks were restored, native fishes, including coregonines, dominated the fish community, and sea lamprey were under control. Meanwhile the forests regenerated, land management practices were instituted, the Clean Water Act was passed, and human population levels dropped. Lake Superior recovered much of its former integrity, though it continues to face challenges due to changing climate. The lake currently retains all six original coregonine species, including Cisco, Kiyi, Bloater, Shortjaw Cisco, Blackfin Cisco, and Shortnose Ciscoe.

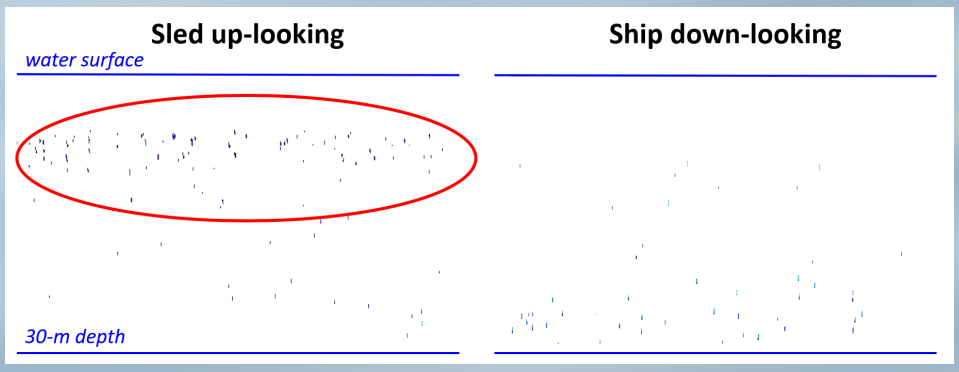
Due to its recovered state, Lake Superior has provided valuable information to guide coregonine restoration efforts across the other lakes, such as elucidating the ecology of Cisco during various life stages and the role lake trout and coregonines play in transferring energy throughout the ecosystem.

Acoustic continued from page 22

4–9 m below the lake surface) with the sled up-looking transducer providing 56 times higher densities compared to the traditional down-looking method. Densities also varied significantly in the middle of the water column (9–14 m layer) where densities were 6.2 times higher in the sled survey. Midwater trawl sampling indicated that Rainbow Smelt were the most abundant species occupying the uppermost 14 m of the water column, but Cisco were also present. Overall, the sled-based estimates were, on average, 2.5 times higher for the whole water column.

The team's findings show that the new sled can reduce bias in fish surveys by better sampling the surface waters. The ability to provide more accurate estimates of fish densities will lead to more informed decisions and sustainable management of Lake Superior fishes. Moreover, the ability of the hydroacoustic sled to sample large volumes of surface water rapidly and more accurately has significant implications for monitoring native coregonine populations and assessing restoration efforts throughout the Great Lakes.

The new hydroacoustic sled being deployed off the back deck of the USGS R/V *Kiyi* in Lake Superior, summer 2018. Photo credit: USGS



A comparison between the echograms, or hydroacoustic readouts, of the ship-based down-looking echosounder (right) and sled-based up-looking echosounder (left) along a 15-minute transect in August 2018 on Lake Superior. Blue blips are individual fish measured within the uppermost 30 meters of the water column. Image credit: USGS

Read more: *https://doi.org/10.1016/j.jglr.2020.08.010*.

Cisco Populations in Lake Superior—

Comparing Historical and Contemporary Numbers

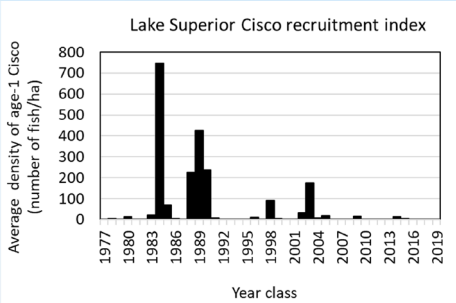
By Ben Rook (USGS, now GLFC), Mike Hansen (USGS retired), Cory Goldsworthy (Minnesota DNR), Brad Ray (Wisconsin DNR), Owen Gorman and Dan Yule (USGS), and Chuck Bronte (USFWS)

Lake Superior contains the largest populations of Cisco and the largest fisheries for Cisco in the Great Lakes today, even though the fishery is a fraction of what it used to be in the 20th century. Historical commercial landings during the first half of the 1900s indicated that Cisco were extremely abundant throughout Lake Superior. Subsequently, overfishing and perhaps interactions with nonnative species caused most populations to collapse by the 1960s. Increased binational fishery management, coupled with a few sporadic years of successful reproduction during the last 40 years, enabled Cisco populations to partially recover during the 1980s and 1990s, but fishery managers wonder whether current populations could be strengthened to more closely resemble the historic fishery.

Even though populations are now well below historical levels, some have argued that the sporadic nature of contemporary reproduction—e.g., 12 years of almost non-existent reproduction followed by a year of wildly successful reproduction—was typical even for historical populations. However, given the size and duration of the historical fishery, it seems unlikely that sporadic reproduction could have sustained the historical yields. Fortunately, data exist on the historical fishery and the fish harvested that can be used to test for differences between historical and contemporary populations. This could inform management decisions for the current fishery as well as restoration efforts in Lake Superior and elsewhere.

Our collaborative effort compared historical and contemporary Cisco populations in Lake Superior using simulated population models based on both observed historical and contemporary data. Simulations indicated that historical populations were much larger and had greater reproductive potential than contemporary populations. The magnitude and frequency of successful reproductive events were also greater historically, depending on the area, which likely led to the large annual catches and the nearly 50-year "heyday" of the fishery.

In addition, we suggest that ecosystem changes that occurred in Lake Superior between the historical and contemporary periods—specifically, the limitation of nutrient inputs due to the Clean Water Act and other legislation and changing land use practices (*See related story, page 23*)—may have contributed to the sporadic nature of reproductive success during the last 40 years. The productivity of Lake Superior as a whole was much higher during the peak years of harvest but has declined since the 1960s due to decreased nutrient inputs to the base of the food web. A similar decline in productivity has occurred in all the Great Lakes. As a result, recovery of Cisco to historical levels could be a challenge, and contemporary abundances in Lake Superior could be used to establish realistic goals for Cisco restoration in lakes with similar lake productivity.



Recruitment index for Cisco in Lake Superior, 1977-2019, showing the sporadic nature of Cisco reproductive success in recent decades. Image credit: USGS data release: *https://doi.org/10.5066/F75M63X0*.

Dressing Cisco, formerly known as "Lake Herring," at L.S. Booth Fish Company, Bayfield, Wisconsin, circa 1910–1919. Commercial fishermen targeted Cisco during the November-December spawning season. Millions of fish were harvested in a short period of time and the entire town helped process the catches. Teenagers would commonly attend school during the morning and be released at noon to work in Cisco processing sheds. Photo credit: Bayfield Heritage Association. Photographer unknown

See related story, page 23, for a description of a multi-agency effort to collate historical information on coregonine species throughout the Great Lakes.

Read more about the study, "Was historical cisco *Coregonus artedi* yield consistent with contemporary recruitment and abundance in Lake Superior?" *https://doi.org/10.1111/fme.12474*

Special thanks to contributors: Lori Evrard (USGS), Wendy Stott (USGS), and Beth Holbrook (Minnesota DNR).

Using eDNA to Describe Coregonine Diversity

By Bo Bunnell (USGS), Aubrey Maccoux-LeDuc (Bay Mills Indian Community), Chris Olds (USFWS), Jason Smith (Sault Ste. Marie Tribe of Chippewa Indians)

A primary task during the science planning phase of the Coregonine Restoration Framework is to describe contemporary distributions of coregonine species and map their use of habitat—especially critical ones such as spawning grounds. A collaborative group of DOI, Tribal, academic, and Nature Conservancy scientists are attempting to capture DNA fragments left behind by spawning fish and use it to identify coregonine spawning sites.

Two important coregonine species that have persisted in lakes Michigan and Huron are Lake Whitefish and Cisco, which are known as Otoonapii and Adikameg, respectively, in the Anishinaabemowin language. Lake Whitefish provide a nutritious food source and support several commercial, subsistence, and recreational fisheries, but their rate of reproduction has been declining in most areas of these lakes over the past decade. Cisco remain far below their historical densities in both lakes but have been slowly increasing in abundance and distribution, and a rehabilitation effort is underway in Saginaw Bay, Lake Huron (*See related story, page 17*).

A guiding principle of conservation and restoration science is that resilient and sustainable fisheries are built on highly diverse populations within a species and among the fish community. An example of within-species diversity is variation in the timing of spawning or the types of habitats used during spawning. Species with populations that use a variety of habitat types and spread their spawning effort across a longer season are more likely to thrive in the face of temporary or permanent changes in their environment.

In the past, Lake Whitefish and Cisco spawned in habitats ranging from deep offshore, to shallow coastal areas, to tributaries. However, over the last 150 years, tributaries have become among the most degraded habitats in the Great Lakes and their use for spawning has declined. For example, even back in 1882, C.W. Smiley attributed a 90% reduction in Lake Whitefish harvest at the mouth of the Oconto River in Green Bay, Wisconsin, to the destruction of critical spawning habitat near Oconto Falls, nearly 20 miles upstream. During the mid-19th century, rivers such as these were polluted by the deforestation of riparian habitat and the lumber mills that caused the river bottom to be "one mass of sawdust."

Over the past decade Lake Whitefish have returned to Green Bay tributaries, including the Oconto, to spawn and baby fish have been documented drifting downriver. Given that the Lake Whitefish fishery in Green Bay is one of the few areas of Lake Michigan where the rate of reproduction is still relatively strong, biologists and managers are hypothesizing that Lake Whitefish are again diversifying their use of habitat and rapidly expanding into the tributaries. The extent to which other tributaries throughout the Great Lakes are used by Lake Whitefish or Cisco for spawning today is not well documented despite evidence of widespread use in the past.

Lake Whitefish. Photo credit: USGS

Ultimately, eDNA detection of spawning coregonines could help fishery managers identify rivers where restoration efforts would have the best chance of success to enhance within-species diversity and the resilience and sustainability of these native fishes and the fisheries they support.

Special thanks for contributors: Nathan Barton (USFWS), Wendy Stott (Michigan State University), Matt Herbert (The Nature Conservancy), Jack Tuomikoski (Bay Mills Indian Community), Murulee Byappanahalli (USGS), and Ashley Moerke (Lake Superior State University).

eDNA

Biologists have commonly sampled environmental DNA (eDNA), which is DNA shed from an organism, to detect the presence of key species in the environment. In 2020, scientists from the USFWS, Bay Mills Indian Community, Sault Ste. Marie Tribe of Chippewa Indians, USGS and The Nature Conservancy collaborated to demonstrate whether eDNA can detect the presence of Lake Whitefish or Cisco in five tributaries of Lakes Michigan and Huron, some of which have known spawning populations. If the approach works, the long-term goal is to deploy the method across a larger number of tributaries across the basin, including those where spawning has been historically documented.

USFWS Biologists collect water samples for eDNA in the Thunder Bay River, Michigan. Photo credit: Chris Olds, USFWS

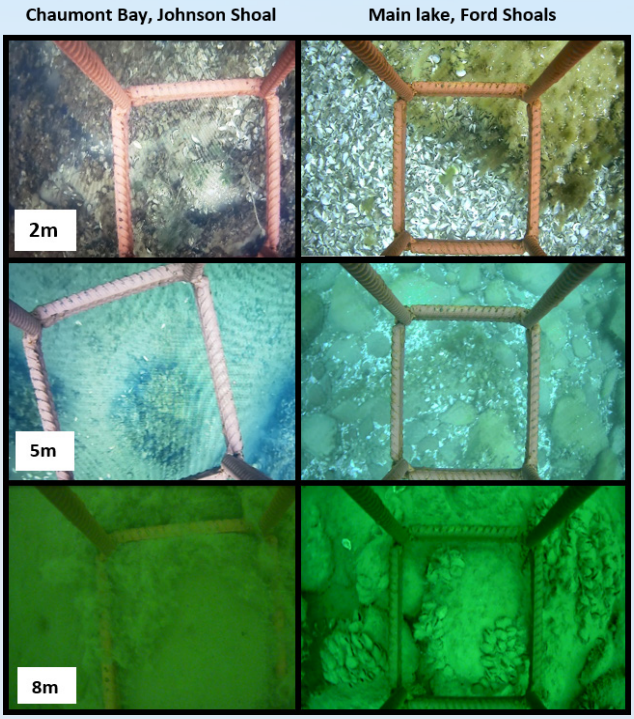
Understanding the Role of Habitat

By Brian Weidel (USGS)

The go-to tools for managing fisheries usually include stocking from fish hatcheries and restrictions on harvest. Improving fish habitat is an additional and potentially powerful tool that could be used for restoring coregonine species. This tool is often underutilized, partly because scientists have a poor understanding of how egg deposition and incubation relate to habitat.

A new collaborative project is underway across the Great Lakes basin to assess how habitat influences the success of Lake Whitefish and Cisco reproduction. Results will help managers understand whether and how degraded habitat is impeding coregonine restoration throughout the basin and develop more sophisticated approaches to improving lake habitats.

Species in the salmon family, such as coregonines, typically spawn on rock rubble of various sizes where their eggs can find protection in the spaces between the rocks for long incubation periods, which can last up to five months over the winter season. Previous studies in Lake Ontario have shown that soft habitats or rocky habitats that have been infilled may be less conducive to egg survival. Over the past few hundred years as the region experienced Western settlement and industrial development, sediment and nutrient runoff and the shells of invasive dreissenid mussels have led to the infilling of deeper rocky habitats. This is thought to have contributed to the decline of coregonines. While wave action in the shallower waters is detrimental to egg survival, it also keeps these shallower habitats clean, and years with high ice cover—which decreases wave action—often result in higher reproductive success. The impact of human induced changes on these habitats often interact, making for complicated fishery management decisions.



Lake Ontario substrate images from different depths at an embayment and main lake spawning site used by native fishes. Photo credit: USGS

This project addresses a direct question from Lake Ontario fishery managers on whether the lack of quality habitat may be limiting egg incubation success and whether this could be remedied by habitat restoration efforts. The study will consider how depth, substrate (i.e., type of lake bottom), physical disturbance, light, and sediment in Lake Ontario impact reproduction.

Concurrently, the team will conduct similar assessments in the Apostle Islands National Lakeshore in Lake Superior, which serves as a kind of "reference ecosystem" due to its relatively intact native fish community (*See related story, page 23*). The work will also overlap with other USGS acoustic telemetry studies on coregonine spawning behavior and will rely on an NPS lake-bottom substrate mapping effort which has identified previously unknown complex reef habitats in the Apostle Island region (*See related story, page 21*). The team will also work with the Bad River and Red Cliff bands of Lake Superior Chippewa Indians, USFWS, and Wisconsin Department of Natural Resources to ensure safe field work and avoid interference with commercial fishing. The work would not be possible without a multi-agency approach, leveraging the unique capabilities of each organization.

The results of the study could provide much-needed understanding of the degree to which spawning and egg incubation habitat limit coregonine reproductive success and how habitat restoration might help coregonine species throughout the Great Lakes.

Field sampling out on the ice. An earlier Cisco spawning ecology assessment operation in mid-February 2018 under the Lake Superior ice. The collaborative team used a vacuum pump to acquire Cisco eggs from the lakebed off Thunder Bay, Ontario. Photo credit: Dan Yule, USGS

A Great Lakes poem

HOMES to Many and Treasure to All

By Amanda Lawrence (USFWS Knauss Fellow)

Lake Superior with waters running frigid and deep
Of all the Great Lakes, half its water you keep,
Ontario, a lake where sometimes water appears white
At other times calcium carbonate reflects blue and green light,
Lake Michigan is home to the world's largest freshwater sand dunes
Covered in sand cherries that can run shades of purple to deep maroon,
Lake Erie's waters run warm and are teeming with life
At times blooms grow thick enough to cut through with a knife,
And over 30,000 islands Lake Huron's endless shores stretch
A graveyard of sorts, beneath lie one thousand shipwrecks,
From Green to Silver Bay and all the cites in-between
To all the nooks and crannies of this watershed unseen,
To the millions of birds migrating above, to the Sturgeon who migrate below
To the moose, bats and beavers who rely on the Great lakes to flow,
They allow us to thrive, from growing food to transportation
To the water we drink, to the immense beauty and recreation,
Together forming the largest freshwater system on Earth (by area)
The Inland Seas are a treasure in which no man can calculate worth

Cisco and a Lake Trout caught in Charlevoix, Michigan. Photo credit: Brad Briggs, public domain

Local partners support restoration efforts near Whitestone Point, Saginaw Bay, Michigan. Photo credit: USFWS

Commercial fishing vessels along the Leland River outlet to Lake Michigan in northern Michigan. Photo credit: Michigan Sea Grant, used with permission.

Explore Coastal Change in Alaska

By Ann Gibbs, Li Erikson, Rae Taylor-Burns, and Ann Tihansky (USGS)

A new geonarrative shows how USGS Coastal Change Hazards research is directly addressing the ability to understand, measure and project coastal change in permafrost regions. Explore the geonarrative here: *https://wim.usgs.gov/geonarrative/cch-alaska/*

USGS scientist Alex Snyder collects data atop the eroding permafrost bluff at Barter Island near the village of Kaktovik, Alaska in September 2016. Permafrost-dominated coasts of Alaska are changing rapidly as the result of coastal transgression and storm-surge flooding which can result in the loss of cultural sites and damage to infrastructure. Photo credit: Bruce Richmond, USGS

The presence of permafrost and seasonal ice makes coastal processes on Alaska's north coast unique compared to temperate coasts. In this region, the ground and sea have historically been frozen for much of the year, making coastlines strong and resistant to erosion. However, when the frozen ground (or permafrost) thaws, the coast can change quickly. Waves, warm water, and the sun all play a role in coastal change on Alaska's north coast. Some of the highest rates of shoreline retreat in the world (22 m, or 72 feet, per year) have been measured along Alaska's Beaufort Sea coast. As the amount and number of days when sea ice is present declines, the coast is left exposed and vulnerable to more frequent and higher waves and water levels that lead to increasing rates of coastal erosion and flooding.

USGS scientists are working to understand how coasts in Alaska have changed in the past and how they will change in the future. As Arctic temperatures increase, the extent and duration of sea ice decreases, and permafrost continues to thaw, the potential for coastal retreat in Alaska could keep increasing and even accelerate. USGS coastal change research can provide critical information for local communities, wildlife management agencies, and industries in Alaska so they can plan for future changes.

Coastal change is inevitable, but coastal management decisions that are guided by USGS CCH science and tools can help our society reduce risk and losses. Through the focused efforts on coastal change hazards and growing connections to other areas of USGS expertise and capabilities, we are fulfilling the vision of a Nation that prospers by using scientific knowledge to prepare for, mitigate, and respond to threats posed by our dynamic coasts.

The new geonarrative joins a series of educational, interactive webpages (geonarratives) that take you on a journey across our Nation's coastlines to learn about coastal change in various environments, become familiar with the hazards posed by these changes and understand how USGS science and tools can help coastal communities mitigate these risks and prepare for future change.

In these geonarratives, explore how barrier islands and shorelines move over time or how we forecast coastal change, learn how coral reefs make a difference in coastal protection, interact with our tools for visualizing coastal storm impacts on the California coast, or examine how permafrost and seasonal ice makes coastal change in Alaska unique.

Explore USGS Coastal Change geonarratives online

- Our Nation's Coasts: *https://wim.usgs.gov/geonarrative/cch-ourcoasts/*
- Barrier islands: *https://wim.usgs.gov/geonarrative/cch-bi*
- Shoreline Change: *https://wim.usgs.gov/geonarrative/cch-shline*
- Forecasting Coastal Change: *https://wim.usgs.gov/geonarrative/cch-rtstorms*
- Coral Reefs: *https://wim.usgs.gov/geonarrative/cch-reefprot*
- Coastal Storm Impacts: *https://wim.usgs.gov/geonarrative/cch-floodfut*
- Coastal Change in Alaska: *https://wim.usgs.gov/geonarrative/cch-alaska/*
- Coastal topic Geonarratives: *https://www.usgs.gov/products/maps/map-topics/coasts*
- Read more about the USGS Coastal Change Hazards Science: *https://www.usgs.gov/natural-hazards/coastal-marine-hazards-and-resources/science/coastal-change-hazards?qt-science_center_objects=0#qt-science_center_objects*

Energy Economics to Inform Decision Making

By Walter D. Cruickshank (BOEM)

Economics is a critical component of BOEM's work. A new issue (Vol. 17, Issue 2) of BOEM Ocean Science magazine, illustrates the important role that energy economic analysis plays in informing our policy and decision-making processes.

The Outer Continental Shelf (OCS) resources belong to all U.S. citizens, and OCS activities generate substantial revenues from lease sales, royalties on production, and rental fees. This share of revenue is intended to benefit the American public. In this issue, we explain how these funds are distributed.

As stewards of the Nation's OCS resources, we are also responsible for ensuring that the public receives fair market value for the rights to produce offshore energy and mineral resources. BOEM's analysis of offshore energy projects' total economic impact helps keep policymakers and the public informed on the economic activity associated with OCS energy development. In this issue we explain how BOEM evaluates costs and benefits. Economics is a study of choices—choices about how to allocate resources among competing uses or alternatives. People evaluate tradeoffs—the costs and benefits of activities—every day in their personal lives, especially when it comes to time and money.

The cover of BOEM's *Ocean Science* Vol. 17, Issue 2, 2020, "The Economics Issue."

Federal agencies must make these choices as well. We continuously evaluate the economic tradeoffs among different policy options for offshore resources. Our economic analyses on multiple topics are critical components of this process.

In this issue of Ocean Science, we invite you to explore:

- Tradeoffs: Evaluating Costs and Benefits at BOEM
- Predicting the Pattern of Oil & Gas Development in the Gulf of Mexico
- Sharing Outer Continental Shelf Revenues
- The Economic Impacts of Outer Continental Shelf Oil & Gas Activities
- Oil & Gas and Renewable Wind Energy: Leasing Processes and Auction Formats
- The Role of the Outer Continental Shelf in Domestic Oil and Gas Markets

Read *Ocean Science* online: *https://www.boem.gov/sites/default/files/documents/newsroom/ocean-science/BOEM%20Ocean%20Science%202020%20Issue%202.pdf*

New BOEM Director

By Tracey Moriarty and Stephen Boutwell (BOEM)

BOEM's new director, Amanda Lefton. Photo credit: Amanda Lefton

"I am honored to join the great team at the Bureau of Ocean Energy Management to carry out its critical mission, while implementing the President's ambitious agenda to tackle climate change," said Amanda Lefton, who was announced as BOEM's new Director on February 5, 2021.

On January 27, 2021, the President issued an Executive Order calling for DOI to identify steps to accelerate responsible development of renewable energy on public lands and waters. In response, DOI has initiated a review of processes and procedures as it re-invests in a rigorous renewable energy program.

"As we build back better, we have an important opportunity to begin to transition to a clean energy future to reduce greenhouse gas emissions and to create family supporting jobs," said Lefton.

One example includes Vineyard Wind's proposed project which would be located approximately 12 nautical miles offshore Martha's Vineyard and 12 nautical miles offshore Nantucket in the northern part of its lease area. BOEM recently completed the environmental review. If approved, Vineyard Wind 1 would be the first commercial scale offshore wind project in the U.S.

"Offshore wind has the potential to help our nation combat climate change, improve resilience through reliable power, and spur economic development to create good-paying jobs." said Lefton.

Learn more:
Press release: *https://www.boem.gov/newsroom/press-releases/boem-announces-amanda-lefton-new-director*

Vineyard Wind press release: *https://www.doi.gov/pressreleases/interior-completes-environmental-review-offshore-wind-project*

SHARE this with BSEE article on renewable energy MOA:

BOEM's renewable energy program overview: *https://www.boem.gov/renewable-energy/renewable-energy-program-overview*

BSEE's Renewable Energy program overview: *https://www.bsee.gov/what-we-do/renewable-energy*

BSEE and BOEM Formalize Offshore Renewable Energy Responsibilities

By BSEE

BSEE and BOEM agreed to a framework for coordination in regulating renewable energy activities on the OCS, December 22, 2020. The Memorandum of Agreement (MOA) clarifies the bureaus' roles and responsibilities and promotes the efficient use of resources to enhance the Nation's renewable energy production.

This MOA clarifies BSEE's role in developing the safety and environmental compliance functions of the program that are critical to BOEM's management of the program's planning and development.

The MOA follows a September 2020 Memorandum of Understanding between BSEE and BOEM that describes the general relationship between the bureaus and is one step closer to initiating the rulemaking process that would officially transfer relevant safety and environmental compliance regulations from BOEM to BSEE. Since 2009, BOEM has overseen the significant growth of renewable energy in the United States thanks to strong partnerships with BSEE, other Federal agencies, and state and local leadership.

Read the press release: *https://www.bsee.gov/newsroom/latest-news/statements-and-releases/press-releases/bsee-and-boem-formalize-offshore*

Learn more about BSEE and BOEM's renewable energy programs:

https://www.boem.gov/renewable-energy/renewable-energy-program-overview www.bsee.gov/what-we-do/renewable-energy and www.boem.gov/renewable-energy.

New Center for Marine Acoustics

By William Y. Brown (BOEM)

On December 11, 2020, BOEM announced the creation of the Center for Marine Acoustics (CMA).

The ocean is vast and full of sounds. Many are naturally occurring while others are anthropogenic (man-made). When these anthropogenic sounds are unwanted, we call them noise. BOEM manages energy and mineral resource development on the Outer Continental Shelf subject to environmental safeguards, and noise is high on the list of issues we need to understand and address to protect ocean life.

The ocean is vast and full of sounds. For many species, relying on visual cues is not enough for survival. Ocean species, such as marine mammals, sea turtles, fish and invertebrates, often listen to and process acoustic cues to help them survive—to find food, avoid danger and communicate with each other across hundreds and even thousands of miles.

People have also harnessed sound to help them understand the ocean environment and its resources. We use geophysical surveys to search for hydrocarbons, site wind facilities and study geological faults and predict earthquakes. Naval sonars strengthen national security and protect us from enemy threats. We also make sound incidentally through activities such as commercial shipping and fishing, recreational boating and sand mining.

When these anthropogenic (human-generated) sounds are unwanted, they are generally referred to as noise. Current science shows us that sound may adversely impact marine life. Some sounds interfere with communication between animals and interrupt important biological behaviors (courtship, nursing, feeding and migration).

In more extreme instances, exposures to sounds at high levels or for extended periods of time can lead to physiological effects, including hearing loss or mortality. The impacts to marine life are challenging to predict because they depend upon the acoustic qualities of the sound source, the oceanographic conditions in which the sound is produced and the behavioral context in which the animal receives the sound.

BOEM's new CMA is an initiative that will strengthen BOEM's role as a driving force within the regulatory community on sound in the marine environment. Image credit: BOEM

Scientific research and applications on sound are a long-term priority for the bureau and its stakeholders, including federal partners, the industries we regulate, the research community, environmental NGOs, and the public. We have invested more than $95 million in protected species and acoustics-related research since 1998, and this research and our engagement in environmental reviews have significantly improved scientific understanding of how anthropogenic noise affects marine life. But we want to do more, and that's why I'm so pleased to announce the creation of BOEM's CMA in this month's *Science Note*.

See CMA page 31

CMA continued from page 30

The CMA is an initiative that will strengthen BOEM's role as a driving force within the regulatory community on sound in the marine environment.

Staffed by highly skilled and knowledgeable acoustics and modeling experts, the CMA will address both naturally occurring sounds and sounds generated by the industrial activities that we regulate, including offshore oil and gas, renewable energy, and marine minerals development. The CMA will augment and focus our marine acoustics expertise on cutting-edge research and applications, including studies of sound source impacts and customized underwater acoustic impact models to inform agency decision-making. It will make sure we are fast, nimble, and forward-thinking on marine acoustics. Most important, we expect the CMA to establish BOEM as a trusted voice on marine acoustics. This includes being a trusted source for research to understand the biological impacts of machine-made sound, models for characterizing impacts, and standards for drawing the line between what levels of noise are acceptable and what levels are not. We expect that every person and organization with concerns about ocean noise will come to trust and rely on the CMA for accurate, dependable, transparent, and scientifically rigorous data and information on acoustics.

Dr. Jill Lewandowski, the CMA Director and Chief of BOEM's Division of Environmental Assessment, and I are excited to share this new development and we encourage you to learn more about the new CMA and what we have already accomplished. We also welcome your ideas to address the CMA's data gaps and information needs. Please send any comments to BOEMPublicAffairs@boem.gov.

Learn more: *https://www.boem.gov/center-marine-acoustics*

A New Shorebird Management Manual

USFWS Supports the Coalition for Shorebird Conservation

By Danielle Smaha (Manomet) and Ann Tihansky (USGS)

Shorebirds are undergoing one of the most dramatic declines of any bird group worldwide. Recent studies show that we have lost more than one-third of all coastal shorebirds since 1970.

Manomet developed a new Shorebird Management Manual with guidance from The Shorebird Management Manual Steering Committee, a group of shorebird experts, contributing authors, and the cumulative work of hundreds of conservation scientists, ornithologists, and land managers, including members from USFWS, USGS along with academic experts, state resource managers, and international conservation groups. The new manual updates the first version by Doug Helmers published in 1992.

Shorebirds face many challenges, including habitat loss and degradation, human disturbance, unregulated and illegal hunting, increasing predation, and climate change. These challenges are greater than any single organization can address alone. That means the most important thing we can do to safeguard shorebird populations is to build coalitions that work together to address these threats. Manomet's Coalitions for Shorebird Conservation

See Manual page 32

Conserving Shorebirds in the Atlantic Flyway

Shorebird conservation takes many partners. In this geonarrative, learn how partners are addressing threats to shorebirds and working to meet the Atlantic Flyway Shorebird Initiative's conservation goal of increasing focal shorebird populations 10% by 2025.

Explore the geonarrative: *https://fws.maps.arcgis.com/apps/MapSeries/index.html?appid=87690c02be3c4c0094bc59cfbfa5ed28*

Learn more: *www.atlanticflywayshorebirds.org*

The Whimbrel (*Numenius phaeopus*) is one of the largest shorebirds in the Atlantic Flyway and is notable for its long curved bill, which it uses to probe crabs on beaches and in tidal flats. Whimbrels can often be found in salt marsh meadows during migration. Photo credit: Pete Richman, Creative Commons

The Coalition for Shorebird Conservation

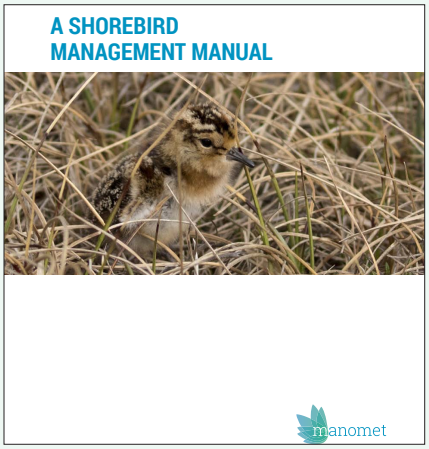
Since Manomet's beginnings as a bird banding operation in 1969, its science and research have expanded to focus on ecosystem management and resilience, shorebird conservation, and educating tomorrow's leaders about the importance of the natural world. Diversity, science, and climate change are the fundamental principles driving Manomet's work today.

Manomet launched the Coalitions for Shorebird Conservation approach to stabilize and rebuild shorebird populations and safeguard their vital habitats, to accelerate and support targeted conservation efforts at 13 of the most important shorebird sites in the Americas. At each location, coalition activities are improving the quality and quantity of critical shorebird habitats and increasing local capacity for conservation action.

Through this targeted approach to site conservation, Manomet is helping these sites bridge the divide between local and global action, to inspire and to inform coordinated and comprehensive shorebird conservation in the Americas.

Learn more: *https://www.manomet.org/project/coalitions-for-shorebird-conservation/*

Read the manual. You can download the full manual here: *https://www.manomet.org/wp-content/uploads/2021/01/Iglecia_and_Winn_2021_AShorebirdManagementManual-012021-web.pdf*
Read more: *https://www.manomet.org/publication/manomet-releases-shorebird-management-manual*



Manual continued from page 31

approach connects site-based and hemisphere-scale conservation planning and action.

"Through Monica Iglecia's hard work and dedication, combined with significant contributions from many other experts, we have compiled this overview of management approaches and shorebird ecology to help inspire and guide beneficial habitat improvements everywhere these birds go," said Brad Winn, Director of Shorebird Habitat Management.

"As we have developed flyway-scale conservation frameworks for shorebirds, a common theme is the continued education and outreach to land managers on the when, how, and where to improve and expand habitats for shorebirds. The revised manual will be a great resource for all land management agencies who want to improve their management for shorebirds. USFWS staff from the NWRs and Migratory Birds Program served on the steering committee and contributed to the development of the manual," said Brad Andres, USFWS National Coordinator, U.S. Shorebird Conservation Partnership and a member of the Shorebird Management Manual Steering Committee.

The manual includes 13 case studies in habitat management from across North, Central, and South America. These real-world scenarios, written by field experts, focus on strategies to improve shorebird productivity and survival within the Americas, south of the Arctic. Each case study includes:

- information on the species benefitted;
- the threats at the site;
- the actions taken to protect shorebirds at the site; and,
- outcomes and advice.

Through the use of the updated Shorebird Management Manual—a good foundation of information about shorebirds and overview of management actions—the coalition of experts and partners hope it can be adapted and applied to reduce the impacts of threats to shorebirds wherever they fly.

Read the manual. You can download the full manual here: *https://www.manomet.org/wp-content/uploads/2021/01/Iglecia_and_Winn_2021_AShorebirdManagementManual-012021-web.pdf*

Read more: *https://www.manomet.org/publication/manomet-releases-shorebird-management-manual/*

A snowy plover and chick. Photo credit: Florida Fish and Wildlife Conservation Commission

Conserving Coastal Farmlands

By Amanda Lawrence (USFWS-Knauss Fellow)

Whidbey Island within Washington State's Puget Sound includes rugged coastal lands beaches, and farmland. Photo credit: Amanda Lawrence, USFWS

Agriculture is the foundation on which our society thrives. Not only does agriculture provide the world with food, it also provides us the fabrics and the materials we wear and use on a daily basis. Land is vital for agriculture, just as conservation is vital for healthy lands. The Agriculture Improvement Act of 2018, known as the Farm Bill, is a U.S. policy that supports both agricultural production and conservation on private lands across the country. The Farm bill provides billions of dollars annually for voluntary habitat conservation in partnership with our nation's farmers, ranchers, and non-industrial forest landowners.

The U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) provide financial and technical assistance to producers and landowners helping them to implement sustainable land management practices. This assistance is distributed through different Farm Bill conservation programs, which use different types of financial incentives and conservation practices to conserve soil, water and wildlife habitat. Programs are based on land type and the producer's agricultural operation objectives as well.

The USFWS Coastal Program works with willing partners to help them conserve coastal habitats.

Another example of habitat conservation that uses combined assistance from both the Coastal Program and Farm Bill conservation programs is fish passage. One obstacle to fish passage is undersized road culverts, which not only obstruct fish passage, but can amplify natural hazards such as flooding. In Maine, the Appalachian Mountain Club, NRCS, and the Coastal Program have worked with private landowners to replace undersized culverts with bridges – restoring fish passage and decreasing flood risks to the surrounding communities and infrastructure. These projects were carried out with the assistance of the NRCS' Environmental Quality Incentives Program (EQIP). In Washington State, partners restored fish passage for Chinook salmon to the important nursery habitat of Dugualla Bay. Together, private landowners, Whidbey Camano Land Trust, NRCS, USFWS Coastal Program and others not only enhanced wildlife habitat, they also improved hydrology and water quality in the area that benefited agricultural activities.

These conservation benefits don't stop with fish, it also helps many bird species! Through collaborative efforts of many willing Texas ranchers, NRCS, the USFWS' Partners and Coastal Programs, and others, coupled with support from Farm Bill programs, restored and protected more than 2,000 acres of coastal prairies, wetlands and marshes in Texas. These habitats are home to many at-risk species, including the endangered Aplomado falcon (*Falco femoralis*), Attwater's prairie chicken (*Tympanchus cupido attwater*) and Whooping crane (*Grus americana*) and are used as wintering habitat for migrating waterfowl.

Together, USFWS and partners support enhancing land use in ways that benefit both agricultural operations and wildlife.

This Farm Bill brochure explains programs: *https://bit.ly/3hJxrV7*. The Coastal Program also provides financial and technical assistance for conservation projects that use Farm Bill assistance.

Learn more: *www.fws.gov/coastal*.

Learn more about the Farm Bill conservation programs: *https://bit.ly/38iv34u and https://www.fsa.usda.gov/programs-and-services/conservation-programs/index*.

Reducing Cruise Ship Impacts in the Arctic

This article is an excerpt from:

https://www.nps.gov/articles/000/cruise-ship-standards-of-care.htm

By Deanna Ochs (NPS)

The sun sets over the Arctic Ocean. Photo credit: Jessica K. Robertson, USGS

Arctic sea ice is melting at unprecedented rates. This is expected to result in dramatic increases in cruise ship tourism through the Bering, Chukchi, and Beaufort seas, and their coastal communities. Cruise ships, which can hold thousands of passengers and crew, produce relatively large volumes of waste which in turn can impact air and water quality. Unlike other vessels that might be routed to minimize impacts to marine wildlife or coastal communities, cruise ships actively seek out areas with sensitive resources, such as ice-dependent seals, polar bears, and large whales, as well as areas of cultural significance. These activities increase the potential for a variety of impacts, including wildlife collisions and disturbance, and interference with subsistence activities.

As stewards of several Arctic parks and the Shared Heritage Beringia Program, the NPS has a responsibility and vested interest in ensuring that cruise ship practices are consistent with protecting these resources. The NPS partnered with the Wildlife Conservation Society's Arctic Beringia Program and the University of Alaska Fairbanks to assemble ideas for adaptable, sustainable, and culturally sensitive cruise tourism practices in Arctic Alaska. Representatives from various indigenous interests, scientists and maritime cruise industry was critical to the process. The project began just prior to the largest luxury cruise ship's voyage through the historic Northwest Passage in August 2016. The inaugural passage of the 1,100-passenger ship, *Crystal Serenity*, signaled a new level of large cruise ship tourism in Arctic Alaska.

Best Practices for Cruise Ships recommends that ships remain at least 100 m from marine mammals, such as the Pacific walrus, and limit vessel speed and observation time. Photo credit: Sarah Sonsthagen, USGS

In the spring of 2016, organizers initiated the project by facilitating a meeting of the Arctic Waterways Safety Committee (AWSC). The AWSC seeks to bring together, "… local marine interests in the Alaskan Arctic in a single forum, and to act collectively on behalf of those interests to develop best practices to ensure a safe, efficient, and predictable operating environment for all current and future users of the waterways." This meeting provided a forum for all parties to communicate their interests and values regarding the impacts of cruise operations and potential mitigation strategies, and to consider existing guidelines for research cruises in Alaska.

The group developed a draft document entitled, "*Best Practices for Cruise Ships Operating the Bering, Chukchi, and Beaufort Seas*" that was based on meeting discussions and follow up discussions with industry experts building on experience and laying out best practices for cruise ships that have overnight accommodations for 50+ passengers passing through Arctic waterways above 60 degrees N latitude. The document provides a summary of voluntary guidelines and highlights existing standards for minimizing conflict and avoiding impacts to communities and wildlife in the early stages of a rapidly growing industry. It offers parameters for multiple areas of concern, including local engagement, emissions and discharges, and oil spill prevention and response. Recommendations include developing Community Service Agreements with affected villages that include input into voyage planning, communications during a voyage, and opportunities to learn from experience. It also includes following preset standards for food and sewage disposal, having an emergency oil pollution plan, and maintaining a minimum distance of 100 m from marine mammals. The group submitted the draft to the AWSC for consideration in March 2019, where it remains under review.

As the climate continues to warm, cruise ship tourism in Arctic waters will undoubtedly increase. Establishing these guidelines at the outset of this budding industry will be a key part of responsible stewardship in managing resources and minimizing potential detrimental impacts.

Connect with Regional Partnerships

Regional organizations help identify priority topics, bring partners together and coordinate activities to address coastal and ocean challenges. Here are links to help find regional resources.

The **Northeast Regional Ocean Council (NROC)** is a state and federal partnership that facilitates the New England states, federal agencies, regional organizations, and other interested regional groups in addressing ocean and coastal issues that benefit from a regional response. It is NROC's mission to provide a voluntary forum for New England states and federal partners to coordinate and collaborate on regional approaches to support balanced uses and conservation of the Northeast region's ocean and coastal resources.

NROC was formed in 2005 by the Governors of the New England states—Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut—to serve as a forum for the development of goals and priorities and address regional coastal and ocean management challenges with creative solutions. Recognizing the importance of the national role in these regional issues, NROC was expanded to include federal agencies as members of the Council. In addition to its members, NROC works with bordering states and countries as needed.

NROC's current efforts are focused on three issue areas:

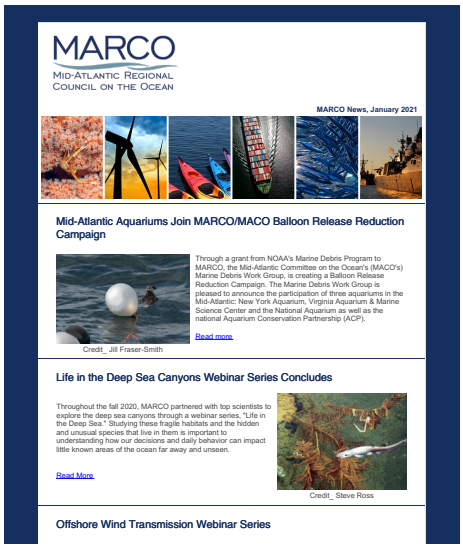
- Ocean and Coastal Ecosystem Health
- Coastal Hazards Resilience
- Ocean Planning

The Northeast Ocean Data Portal is decision support and information system for managers, planners, scientists, and project proponents: *https://northeastoceandata.org/*

The Northeast Ocean Plan provides a blueprint to manage New England's ocean environment, ensuring a balance between protection and sustainable use of our region's natural bounty. *https://neoceanplanning.org/*

Read the plan: *https://neoceanplanning.org/plan/*

Learn more: *https://www.northeastoceancouncil.org/*



Connect with MARCO by subscribing to the MARCO newsletter. Visit: *MidAtlanticOcean.org* or email: *info@midatlanticocean.org*

Mid-Atlantic Regional Council on the Ocean (MARCO) was established in 2009 by the Governors of New York, New Jersey, Delaware, Maryland, and Virginia. MARCO provides a forum for coastal Mid-Atlantic states to collaborate on shared regional priorities related to marine habitats, renewable offshore energy, climate change adaptation, and ocean water quality. MARCO initiated and oversees the Mid-Atlantic Ocean Data Portal to assist the region with ocean planning efforts.

Mid-Atlantic Ocean Data Portal: *https://portal.midatlanticocean.org/*

Mid-Atlantic Committee on the Ocean (MACO)

MACO is a committee established by MARCO to foster collaboration among states, federal agencies, the Mid-Atlantic Fishery Management Council (MAFMC), and federally recognized tribes, and to engage stakeholders. The purpose of MACO is to enhance the vitality of the region's ocean ecosystem and economy through increased communication and collaboration.

The **West Coast Ocean Alliance (WCOA)** is a regional partnership including the States of California, Oregon and Washington, Tribes, Federal agencies and the Pacific Fishery Management Council. Together these governments are focused on enhanced management and coordination for the ocean along the West Coast of the U.S.

Goals and objectives include:

- Compatible and Sustainable Ocean uses
- Effective and Transparent Decision-Making
- Comprehensive Ocean and Coastal Data
- Increased Understanding of and Respect for Tribal Rights, Traditional Knowledge, Resources and Practices

The WCOA released the West Coast Tribal Engagement Guidance Document in the summer of 2020. A webinar on Federal-Tribal Engagement was held on December 8, 2020. The document, a short statement on its intended use, and a recording of the webinar are available: *https://westcoastoceanalliance.org/tribal-engagement*.

Learn more: *https://westcoastoceanalliance.org/*

The Surfing Bison

America's Offshore Critical Mineral Resources

New USGS/BOEM Marine Minerals Fact Sheet

https://www.boem.gov/sites/default/files/documents/marine-minerals/fact-sheets/Critical-Mineral-State.pdf

By BOEM and USGS

The United States has potential offshore critical minerals to supply our strategic need, but they are currently an underexplored and untapped resource. The United States is wholly import dependent for 17 of the 35 minerals defined as critical by the USGS. To address this shortfall, the United States is pursuing A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals published in response to Executive Order 13817. For its part BOEM is leading the development of a National Offshore Critical Mineral Inventory to address the potential for offshore critical minerals.

While the need for critical minerals in the manufacturing of cell phones and other consumer products is well known, there is growing domestic demand for critical minerals in high-tech industry, transportation, and defense applications. Image credit: BOEM

BOEM, USGS, and NOAA are working closely together to leverage available funds and coordinate Federal offshore critical mineral activities. The National Ocean Mapping, Exploration, and Characterization Council (NOMEC), formed as a result of the November 2019 Presidential Memorandum on Ocean Mapping, will coordinate interagency activities and working groups and support collaboration with nongovernment partners and stakeholders.

Five main categories of marine deposits contain critical minerals:

- **nearshore minerals**
- **phosphorites**
- **manganese nodules**
- **ferromanganese crusts**
- **hydrothermal deposits**

Critical Minerals Occurring Offshore

Yellow = Occur in marine minerals within the US Exclusive Economic Zone

- Aluminum (bauxite)
- **Antimony**
- Arsenic
- Barite
- Beryllium
- **Bismuth**
- Cesium
- Chromium
- **Cobalt**
- Fluorspar
- **Gallium**
- **Germanium**
- Graphite (natural)
- Halfnium
- Helium
- Indium
- **Lithium**
- **Magnesium**
- **Manganese**
- **Niobium**
- **Platinum group metals**
- Potash
- **Rare earth elements**
- Rhenium
- Rubidium
- **Scandium**
- Strontium
- Tantalum
- **Tellurium**
- **Tin**
- **Titanium**
- Tungsten
- **Uranium**
- **Vanadium**
- **Zirconium**

The types of critical minerals that occur in offshore deposits are used in transportation **(lithium, cobalt, manganese)** and defense and national security **(germanium, rare earth elements)**