THE OFFICIAL MAGAZINE OF THE OCEANOGRAPHY SOCIETY

Oceanography

CITATION

Dybas, C.L. 2018. Over the hump: Beleaguered in whaling days, humpback whales chart a new course in the Gulf of Maine. *Oceanography* 31(3):6–11, https://doi.org/10.5670/oceanog.2018.314.

DOI

https://doi.org/10.5670/oceanog.2018.314

BY CHERYL LYN DYBAS

OVER THE HUMP

Beleaguered in Whaling Days, Humpback Whales Chart a New Course in the Gulf of Maine

It's the longest day of the year, summer solstice, in Stellwagen Bank National Marine Sanctuary 32 km off Provincetown, Massachusetts. The sea is a promenade of humpback, finback, and minke whales.

Humpback fins and tails break the ocean's surface on all sides of the 15 m research vessel *Auk*. Aboard ship, an audience with front row seats watches more than 30 humpback whales perform a ballet. A calf born this year peacefully swims alongside its mother. Suddenly, it twirls up and out of the sea, pirouettes in a full breach, and sprays sparkling water droplets in all compass directions before slipping beneath the waves. Other humpbacks lob-tail, lifting their tail fins, or flukes, free of the water and curving them down in smacks on the surface.

Humpbacks (*Megaptera novaeangliae*) are baleen whales that filter-feed with "strainers" made of keratin inside their huge mouths. Adults range from 12 m to 16 m long and weigh about 36,000 kg. Humpbacks have distinctive body shapes, with long pectoral fins and knobby heads. Males "sing" complex songs lasting 10 to 20 minutes, which they repeat, sometimes for hours. The whale music may have a role in mating.

Found around the world, humpback whales migrate up to 25,000 km each year. Humpbacks feed in summer when they're in northern waters, then migrate to tropical or subtropical waters to breed and give birth in winter, when they live on fat reserves.

NET OF WHALE BUBBLES

What are humpbacks eating—and how do they get enough of it—to tide them over until the following summer? In the Gulf of Maine, the answer lies in a cloud of bubbles and a tiny fish.

The whales engage in bubble-netting, a recently discovered means of feeding on small fish such as sand lance, also called sand eels. One or more whales sound, or dive, then exhale together underwater. When their bubbles reach the surface, they form a large ring with seafoam in the center. The bubble ring becomes a net, trapping countless sand lance. Seconds later, one—then several—whales surface in the ring's center, huge baleen-lined mouths open, straining the water, or dragging, as marine biologists call it, for sand lance.

"Humpbacks have large flukes relative to their size, providing thrust for quick maneuvers," says David Wiley, a cetacean biologist and research coordinator at the Stellwagen Bank National Marine

Humpback whales often work in groups to corral elusive sand lance. Here, six whales emerge from a jointly created bubble net. *Image credit: Ilya Raskin; NMFS Permit #782-1719.*

Sanctuary. “Other baleen whales feed by rapidly swimming forward, but humpbacks are adapted for fine-scale movements that allow them to create bubble nets.”

Humpbacks release the bubbles while swimming in upward spirals, often during a behavior called double loops. Double loops starts with an ascending spiral to corral fish, then the smack of a fluke on the ocean surface and a second upward lunge to capture the corralled prey. The whales work in teams of two to 10 or more, emerging at the ocean surface in a boiling cauldron of open mouths. “The sequence is as complex as the tool use of apes in the forest,” says Wiley. He and colleagues reported bubble netting and double loops in 2011 in the journal *Behaviour.*

Further research has uncovered other new-to-science whale feeding behaviors such as bottom side-rolls and repetitive scooping. The findings are detailed in a 2014 paper in *Marine Mammal Science* coauthored by Wiley and others. In bottom side-rolls and repetitive scooping, humpbacks repeatedly dive to the seafloor, roll onto their sides, tilt their heads down, open their mouths, and expand their throat pleats. They then swim along the bottom, funneling in sand lance as they go.

Bottom side-rolls are common on Stellwagen Bank and in the Great South Channel, a deepwater passage between Nantucket, Massachusetts, and Georges Bank to the southeast.

Scientists wondered whether the whales were bottom side-roll feeding when they saw scars on the humpbacks’ jaws. Indeed, humpbacks bottom side-roll for extended periods wherever sand lance are common. Research conducted this summer is revealing new information on humpbacks’ bottom-feeding techniques.

IT ALL COMES DOWN TO SAND LANCE

What’s driving all the bubble netting and bottom feeding? Stellwagen Bank, with its sandy bottom and relatively shallow waters, is prime habitat for sand lance. The bank’s abundant sand lance, which travel in huge schools reaching the tens of thousands, offer the whales high-calorie meals. In one day, a whale might eat a ton of the fish.

At night, sand lance burrow into sandy sediments or form schools close to the seafloor. During the day, the fish often swim in dense mats along the seabed. The humpbacks’ recently discovered feeding techniques, especially side-rolling, result in efficient fish-catching when the whales

Humpback whales blow bubbles to form “fishing nets” that capture sand lance. *Image credit: NOAA/NEFSC/Allison Henry; MMPA research permit #17355*

SIDEBAR | Sand Lance: Newcomers to Fishery Management Plans

To explore the role of a tiny fish in the North Atlantic Ocean ecosystem, 55 scientists, natural resource managers, and conservationists attended a sand lance workshop in May 2017 at the Parker River National Wildlife Refuge in Newburyport, Massachusetts.

The participants concluded that research is needed into how climate change may influence the fish, and what effect possible offshore energy development or sand and gravel mining may have on sand lance.

"We have an opportunity to proactively manage a fish that's not currently targeted for commercial harvest in the US," says biologist Lynda Welch of the Maine Coastal Islands National Wildlife Refuge. She, Wiley, and Michelle Staudinger, science coordinator of the Northeast Climate Science Center at the University of Massachusetts Amherst, were co-organizers of the workshop.

"There's no active talk—yet—of a sand lance fishery," says Wiley, "but there's also no protection for sand lance or the 'ecosystem services' they provide."

For insights into what a fishery management plan for sand lance might look like, the scientists are reviewing harvest levels for species with similar ecosystem roles, such as herring and menhaden in the Northeast and Mid-Atlantic regions. "Management plans for these 'forage fish' must balance the needs of the fish with those of commercial endeavors," says Staudinger. "We'd like to see the same approach for sand lance."

The researchers say that US fisheries managers can learn from overharvesting of sand lance in the UK. Uncontrolled fishing for sand lance there led to crashes of seabirds such as black-legged kittiwakes, which depend on sand lance. To avoid a repeat, the UK sand lance fishery is now managed as several smaller subpopulations rather than one overall population. That allows biologists to change harvest levels based on the presence of seabirds, whales, and other sand lance-eating species.

The future for North Atlantic humpback whales, says Wiley, depends on a fish so small it's a mere glint in the sunlight.

(right) A Cory's shearwater with a sand lance in its bill. The slender body shape of sand lance makes the fish an ideal prey item for seabirds. *Image: NOAA/SBNMS*

(below) Feeding humpback whales concentrate sand lance at the surface, where the fish are also eaten by seabirds. *Image: NOAA/SBNMS; NMFS permit #782-1719*

are near the seafloor. One humpback the researchers studied side-rolled every 6 m. The maneuver netted 10 to 17 scoops of fish per dive.

Where sand lance are found in the Gulf of Maine, so, too, humpbacks. Although last summer's research cruise was scheduled to depart from Provincetown, the sand lance—and the whales—took up residence off a different Cape Cod port, Chatham. To keep up with the shifting scene, the scientists moved R/V *Auk* from its berth in Provincetown to a dock in Chatham. "We may be all about whales," says Wiley, "but they're all about sand lance. So we look at where sand lance are concentrated."

Adds Mike Thompson, a spatial ecologist at the Stellwagen Bank National Marine Sanctuary, "Whales, seabirds like shearwaters, and pretty much anything looking for a meal here is feeding on these fish. We're starting to understand that on Stellwagen Bank, it all depends on sand lance."

To track the fish, Wiley, Thompson, and crew use the SEABed Observation and Sampling System, or SEABOSS. This boxy eye-in-the-sea allows researchers to collect sediment samples and obtain videos of sand lance seafloor hangouts. Sand lance surveys are conducted at 44 stations on or near Stellwagen Bank at various times of year, including about a month before the whale cruise in June.

TO TAG A WHALE

R/V *Auk* serves as the mother ship of two smaller boats, the rigid-hulled inflatable boats (RHIBs) *Balena* and *Luna*. *Balena* ferries biologists to the center of a whale pod. There, in an attempt to place a tracking tag on a humpback, the researchers nose up to a whale whose flank, where the tag will be placed, is exposed.

The digital tag, or DTAG, is attached with a suction cup. This acoustic recording tag provides data on the whale's orientation (pitch, roll, and heading) and depth—50 times per second. The DTAG also records all sounds made and heard by the tagged whale, says Wiley. Visualization software called TrackPlot provides

fine-scale information on the behavior of the whale, including how, when, and where it feeds.

DTAGs remain on whales for anywhere from minutes to hours. "After they fall off, they're retrieved from the ocean, the data they've collected are downloaded, and the tags are ready for redeployment on other whales," Wiley says.

The scientists are also testing new suction-cup-attached tags called CATS, for customized animal tracking solutions. CATS tags carry two video cameras, along with accelerometers, gyroscopes, and sensors for temperature, light, and other variables. They observe the mechanics of whale feeding, as well as "see" other humpbacks in the same area as a tagged whale. It's important information, the researchers say, about marine mammals that until recently were on the US endangered species list.

How did humpback whales end up "listed"? The answer goes back more than a millennium.

Tens of millions of whales were harpooned during the thousand-year period of whaling, state biologist Joe Roman of the University of Vermont and colleagues in the September 2014 issue of *Frontiers in Ecology and the Environment*. The first records of commercial whaling date from 1,000 CE, when the Basques hunted North Atlantic right whales. A thousand years later, whale populations had bottomed out around the globe.

"The depletion of the great whales," writes Roman, "may be in the range of 90% or greater." Thirteen species are considered "great whales": 12 are baleen whales such as humpbacks and the thirteenth, the sperm whale, is the largest toothed whale.

HUMPBACKS ON THE COMEBACK TRAIL

To look at how well humpbacks off Massachusetts have recovered since whaling days, Wiley takes the helm of *Balena*. *Balena* is the tag boat; *Luna* is the chase boat that follows, at the ready, to keep track of a whale after it's tagged. Suddenly, a humpback surfaces near *Balena*'s starboard side. *Balena* is all systems go. Wiley steps to *Balena*'s gunwale and extends a 12-meter-long pole toward the whale; a CATS tag is mounted on its end. With luck, Wiley will be able to gently place the tag on the humpback. "We got it!" he yells as the whale disappears beneath the waves. *Luna* zooms along with this humpback, while *Balena* searches for the next one.

Soon, another shiny black dorsal fin breaks the surface, followed by another just to its side: a mother and calf. Several mother-and-calf pairs are in the area, which may be a nursery. "Look at this place," says Wiley as he half-turns from the wheel of *Balena*, "whales, just everywhere." The scientists estimate that there are currently 900 humpbacks in the Gulf of Maine, with the population increasing each year. Today it seems as if most of the whales are near Stellwagen Bank.

A PICTURE IS WORTH A THOUSAND DATA POINTS

To manage any species, write Phil Clapham and Colin Baxter in their book *Winged Leviathan: The Story of the Humpback Whale*, "you need to know some basic, and not-so-basic, things about it. How many are there in a population? Is the population increasing or declining? What are its boundaries, and how much mixing is there between different populations? Which habitats are most important for feeding, mating, and giving birth? Does the population suffer from inbreeding? What are the threats that may be inhibiting recovery? And how should recovery be defined?"

Biologists at Stellwagen Bank and Provincetown's Center for Coastal Studies collaborate on answering those questions for humpback whales in the Gulf of Maine. Each year they determine the status of as many humpback whales as possible, says Jooke Robbins, director of humpback whale research at the center. "We recognize individuals based on their unique fluke pigmentation and dorsal fin shape."

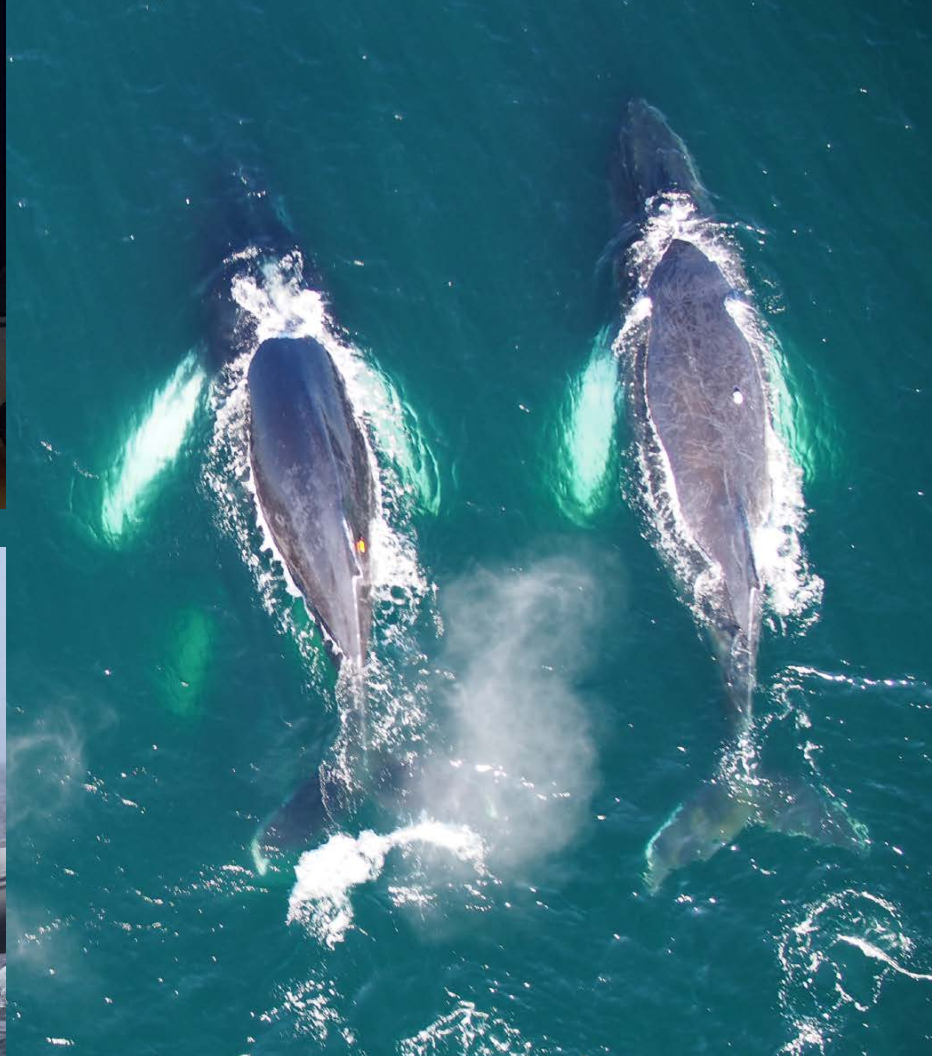
The black-and-white patterns of humpback flukes are as unique to whales as fingerprints are to humans. "High-quality photographs of the flukes confirm the identity of whales we've previously cataloged, and we add new whales as they're encountered," Robbins says. The researchers collect more than 23,000 images and identify some 500 humpbacks every year.

Using photo identification, biologists can estimate whether the Gulf of Maine's humpback population is increasing or decreasing. Photo identification also allows biologists to determine whether there are different stocks of populations, and to what extent they intermingle.

Based on the pattern on each whale's fluke, Stellwagen Bank's humpbacks are given names by a committee of marine biologists. Arlington, for example, has a white mark on the right fluke that looks like a small tombstone; Cassini has a dark strip on the right fluke that resembles the space between the two largest rings of Saturn; and Cosmos, whose white "star lights" stretch across both flukes. Fizz has white specks on both flukes; the marks could be the fizz in a dark-colored soda. Vanity's left fluke shows a likeness of a person holding a mirror. Yield has a triangular patch similar to a traffic sign on the left fluke.

Then there's Salt, who was first spotted in the mid-1970s. "Salt is the 'Grande Dame' of Stellwagen Bank," says Wiley. The female humpback has been sighted

Stellwagen Bank National Marine Sanctuary scientist Michael Thompson places a suction-cup-attached DTAG on the back of a humpback whale. These tags allow scientists to "see" what whales do below the surface. *Image: NMFS Permit #782-1719*



TOP LEFT. Scientists deploy the SEABed Observation and Sampling System (SEABOSS) to monitor sand lance distribution and abundance in the Stellwagen Bank National Marine Sanctuary. *Image: NOAA/SBNMS.* BOTTOM LEFT. Stellwagen Bank National Marine Sanctuary scientists follow tagged whales to match surface behaviors with underwater data from the whales' tags. *Image: NOAA/SBNMS; NMFS Permit #782-1719.* RIGHT. Tagged humpback whales swimming together. Scientists tag whales in the same feeding group to investigate cooperation and competition among whales foraging on sand lance. *Image acquired by Robert Wallace (Wallace Ocean Services) and Carolyn Miller (Woods Hole Oceanographic Institution) under NMFS Permit 17355-01 and FAA Exemption 12618*

and studied more than any other Gulf of Maine whale. Salt was named for the white scarring on her dorsal fin, which looks like a layer of salt, rather than for a pattern on her flukes.

"The photo-identification method created a revolution in whale research," state Clapham and Baxter in *Winged Leviathan*," allowing scientists to conduct long-term studies of living whales, rather than relying on carcasses supplied by the whaling industry."

RESEARCH BY HARPOON?

If all the animals in a population look the same, learning about that population can be a challenge. With land animals, scientists can capture and tag or mark them so they can be identified again. The method is called mark-recapture, even when an animal isn't ultimately "captured" but is sighted or detected in some way.

Take watching squirrels from a kitchen window. Without a way to mark them, a viewer wouldn't know if they're the same squirrels each time. Marking or tagging the animals is a way of tracking how often they appear, where they go, and how their behavior may be different from that of other squirrels.

In the early days of whale research, the need to identify individual animals turned scientists and whalers into colleagues—of sorts. In the 1940s, British scientists began marking humpback and other whales with what were known as discovery tags. The tags were some 30 cm long and made of stainless steel, with a number etched on the shaft of each tag. Using a shotgun, the tag was fired into a whale's body from a ship; the tag would be recovered at a later date when whalers killed the whale. Some tags were indeed retrieved, but many were never seen again.

"Some probably penetrated vital organs and killed the animals," write Clapham and Baxter. "These days, it is a very different story."

SCIENCE BY CROSSBOW

Today, whale researchers often take to the high seas not with shotguns, but with crossbows. They're collecting small skin and blubber samples for genetic analysis. Once a whale is sighted and within range, a stainless steel biopsy dart is discharged from a crossbow. Each dart is fitted with a flange or stop that regulates how far the dart can penetrate, and causes it to recoil after obtaining a sample. The dart's shaft allows it to float on the surface, where it can be retrieved.

Scientists from the Gulf of Maine to the

North Pacific and beyond have collected small biopsy samples from thousands of humpback whales. The tissues are providing information on the whales' health and genetic diversity. Biopsy samples are often the main source of data for investigating population structure—how a population is divided between males and females of different age groups—and for evidence of genetic bottlenecks due to the effects of whaling and other factors.

FIND A WHALE, AVOID A SHIP

With all these methods, says Wiley, researchers are working toward management plans that will protect humpbacks and other whales.

Take Whale Alert, an app that works on iOS and Android devices. Mariners can receive and transmit information on whale sightings and report distressed or injured whales to authorities, assisted by an easy-to-use whale identification guide.

"Whale Alert's goal is to reduce the risk of collisions between whales and ships, a major source of whale mortality," says Wiley. The app's development was led by Wiley and other Stellwagen Bank National Marine Sanctuary biologists, with support from the International Fund for Animal Welfare and the Marine Mammal Commission. The app may be downloaded from whalealert.org.

Whale Alert arrived in the nick of time. Stellwagen Bank's humpback, finback, and right whales had long shared space with other behemoths: cargo and other boats transiting Boston's shipping lanes. "You can imagine what happened," says Wiley. Too often, whales and ships collided in "ship strikes."

But Wiley and others saw a way out. A 12-degree northward shift in Boston's shipping lanes saved the day. The lanes once crossed the southern half of Stellwagen Bank National Marine Sanctuary in an area with as many whales' tails as ships' flags. "It wasn't easy to get the shipping lanes permanently moved," says Wiley, but transport companies ultimately supported the change. The scientists found that the shift could reduce ship strikes by 81%.

Ocean vessels also threaten whales in other ways. Underwater sound from ships' constant, low-frequency droning affects humpbacks' feeding behavior. Humpback whales on Stellwagen Bank intermittently stop eating when they're exposed to high levels of ship noise. "This reduction in foraging effort of individual whales could potentially lead to population-level effects," Wiley and others reported in the August 2016 issue of the journal *Biology Letters*.

Hazards also lurk beneath the waves. Whales often become tangled in bottom-set lobster traps, for example. Sometimes marine biologists can free a trapped whale, other times not. Stellwagen Bank scientists are working to keep whales and fishing gear far apart by determining where in the water column the two are most likely to become snarled.

ONCE AND FUTURE WHALES

"Whales have been around a great deal longer than we have," stated Phil Clapham in a 2016 Roger Revelle Commemorative Lecture sponsored by the US National Academy of Sciences and published in *Oceanography* in September 2016 (https://doi.org/10.5670/oceanog.2016.70).

"They've persisted over millions of years through major shifts in climate and in marine ecosystems," reflected Clapham. "They are also still here, rather improbably, despite centuries of whaling. Let us hope they can now survive the large-scale changes humankind has wrought upon this small blue planet we all share."

ABOUT THE AUTHOR

Cheryl Lyn Dybas (cheryl.lyn.dybas@gmail.com), a Fellow of the International League of Conservation Writers, is a contributing writer for *Oceanography* and a marine ecologist and science journalist. She also writes about science and the environment for *National Geographic, BioScience, Ocean Geographic, Canadian Geographic, National Wildlife, Yankee,* and many other publications.

A humpback whale lifts its pectoral flipper into the air. The significance of such behaviors remains a mystery. *Image credit: Ilya Raskin; NMFS Permit #782-1719.*