Alaska Whale
FOUNDATION

2022 RESEARCH REPORT

A LETTER FROM THE DIRECTOR

Alaska Whale Foundation (AWF) was founded in 1996 to support research on the unique behaviors of Southeast Alaska's endangered humpback whales.

This newfound team of biologists, educators, captains, and illustrators shared both enthusiasm and optimism as they watched humpbacks return to areas and in numbers that hadn't been seen since before the whaling era.

In those early days, AWF had the freedom to focus on curiosity-driven projects that shed light on the captivating lives of whales and, in doing so, they won over the support of others for marine conservation.

But gradually, our optimism gave way to concern. In late 2013, anomalously warm waters appeared in the Gulf of Alaska. Over the next two years, this "marine heatwave" dramatically altered marine ecosystems throughout the North Pacific and led to widespread seabird and marine mammal mortality. It soon became clear that we needed a better understanding of how ocean warming was impacting marine ecosystems. Equally, we needed long-term monitoring projects focused on critical oceanographic and biological processes to track changing ocean conditions and point to areas of concern.

So in 2016, with nearly two decades of experience conducting research in the region, AWF pivoted towards a comprehensive research program that focuses on whale health, in both Alaska and Hawaii, as well as the

physical, chemical, and biological processes that characterize their marine ecosystem.

This past fall, I met with AWF's Board of Directors to reflect on the first seven years of what we now call our Ocean Health Program (OHP). In many ways, the OHP has been successful:

- Thirty-three undergraduate interns have participated in the program and learned techniques they will need to become the next generation of marine stewards.
- Eight graduate students have incorporated data from the OHP into their graduate research projects, with two more prospective students set to join our team in 2023.
- Three universities – University of Hawaii at Manoa, University of Alaska Fairbanks and University of Alaska Southeast – are now formal research partners.
- In the last year alone, data from the OHP have been disseminated in two peer-reviewed journals, two international science conferences, and several science symposia open to the general public.
- National Geographic Society and Lindblad Expeditions, world leaders in science education and eco-travel, have strengthened their long-term supporters of our work.

Yet despite these academic achievements, the whales are not in the clear - far from it. Marine heatwaves are predicted to increase in both their frequency and magnitude and so, too, are their impacts on marine ecosystems. With that, the need for ongoing monitoring and focused research will only increase.

So rather than resting on our laurels, we are focusing on ensuring the OHP's long-term sustainability and success. We have begun restructuring our Board of Directors and, in the coming months we will hire staff to help communicate our research findings and programmatic achievements to our varied stakeholders. As well, we are developing a plan for how best to grow our field station and fleet of vessels to serve our research team in the coming years. All of this is to strengthen our commitment to conserving marine mammals and coastal ecosystems.

We have prepared the following report to provide a general summary of our program, with an emphasis on the results from our whale monitoring efforts in 2022. These results are preliminary; the goal is to provide a broad overview of the trends we observed on the foraging grounds in advance of the winter breeding season in Hawaii. As well, we highlight some of AWFs recent efforts to disseminate our results and introduce some of our new research initiatives. Ultimately, we hope this document will keep our collaborators informed and our supporters excited and engaged. As always, we look forward to another exciting year.

Sincerely,

Andy Szabo, PhD
Director, AWF

2022 WHALE PROGRAM REPORT

AWF began conducting dedicated humpback whale surveys in Southeast Alaska in 2016. Initially, these were part of a three-year collaborative project - Survey of Population Level Indices for Southeast Alaska Humpbacks (SPLISH) - with researchers from the National Oceanic and Atmospheric Administration's Auke Bay Laboratory, Glacier Bay National Park and Preserve, University of Alaska Fairbanks, and University of Alaska Southeast.

Each year during SPLISH, AWF conducted a single 2-week photo-identification survey in the waters of central Chatham Strait, Frederick Sound, and lower Stephens Passage to assess annual trends in whale abundance, distribution, and calf production.

The results from those initial years revealed troubling declines in whale numbers, record-low calf sightings and an increase in the number of whales in poor body condition, which have since been linked to the 2013-2016 Gulf of Alaska marine heatwave.

The SPLISH project ended in 2018, but by then it had become clear that continued monitoring was vital to tracking how whales were being impacted by changing ocean conditions. So, picking up where SPLISH left off, we began conducting whale surveys each month from June through September and expanded our study region to fill in many of the gaps where data were lacking (Figure 1). As well, we added several new whale health initiatives to the program. As a result, our research now benefits from a more comprehensive view of how Alaska's whales are doing.

A QUICK LOOK AT 2022:

The number of adult whales have remained largely stable since 2019. However, birth rates were low, and could remain low in 2023 as a result of whales being in poor body conditions in 2021.

So how did the whales fare in 2022? From late May to late-September, the AWF field team collected 1,672 photo-identification images of 531 unique humpback whales. This was comparable to 2019 and 2021, both in absolute terms (Table 1) and when viewed as an average daily count across each field season (Figure 2). However, when the data were corrected for year-to-year differences in effort by including only those dates and areas surveyed every year since 2016, we found that daily whale counts declined for the second year in a row following their peak in 2020 (Figure 2).

While this is not an encouraging trend, our estimates remain higher than in 2018 when the impacts of the marine heatwave on whale numbers were greatest. Moreover, because these effort-corrected data represent relatively narrow snapshots in time and space – i.e., 2 weeks from late July - early August in central Chatham Strait

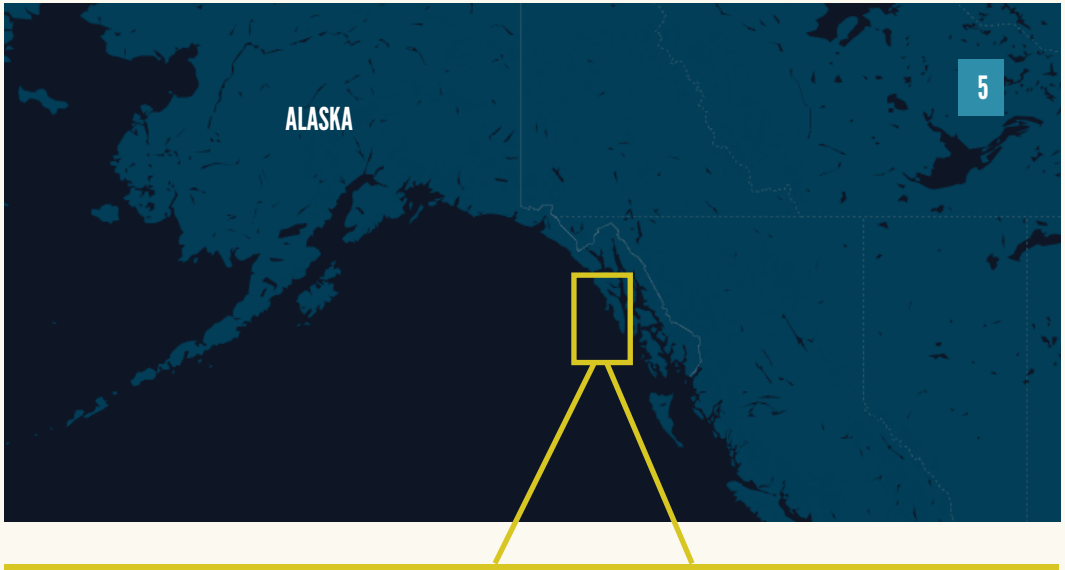


Figure 1. AWF's study region in Southeast Alaska

Figure 2. Average daily numbers of unique whales photo-identified across AWF's full field season (solid line) and during late July/ early August surveys in Chatham Strait and Frederick Sound only (dashed line).

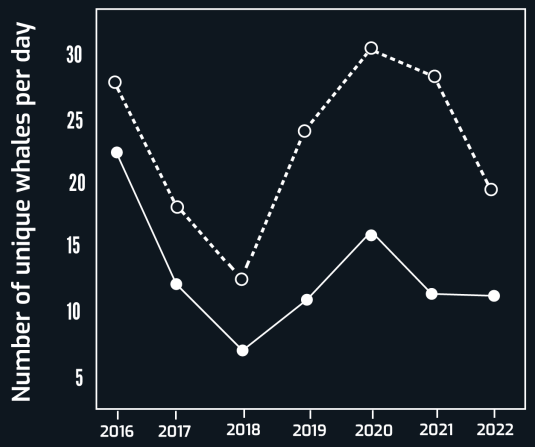


Table 1. Number of dedicated field days, photo-IDs, unique whales and calves each year since AWF launched its Ocean Health Program.

Year	Field days	Total IDs	Unique Whales	Calves
2016	5	124	110	2
2017	6	75	72	1
2018	32	317	220	2
2019	54	1327	578	22
2020	27	698	422	47
2021	49	1344	558	24
2022	45	1672	531	11

and Frederick Sound - year-to-year differences in abundance can reflect variation in the timing and magnitude of whale movements through the focal area rather than changes in the total number of whales visiting Alaska each year. This movement of whales can be seen in Figure 3. Within the area surveyed every year, we observed the highest number of whales during late August in 2022, which fell outside of the dates included in the effort-corrected analysis. Furthermore, our effort has been largely consistent since 2019, so the "all season/ all area" year-to-year comparisons for the most recent four years are likely valid, suggesting that the number of whales in our study region has generally remained stable since then.

It is important to note that nearly all the whales we observe during our surveys are adults. In theory, mortality could account for their decline from 2016-2018; however, the increase in adult whales in the years that followed could not have resulted from new births as it would take several years for those whales to reach adulthood. More likely, the "recovery" after 2018 reflects the return of whales to our study region that had moved elsewhere during the heatwave. The same could be driving much of the year-to-year fluctuations in abundance. Currently, AWF Research Associates Rhianna Thurber and Dr. Rocio Prieto Gonzalez are working to provide a more accurate picture of seasonal and annual movement and abundance trends by using more sensitive analyses (i.e., Mark-Recapture and Distance Sampling) and incorporating a more complete dataset from the entire study region.

Crude Birth Rate (CBR) – the number of calves divided by number of adults – provides another view of the population's health that is less impacted by uneven sampling effort and whale movement patterns. CBR continued to decline from a peak in 2020 to a rate similar to what we observed in the years immediately following the heatwave (Figure 4). Like declining whale counts, this is not encouraging; however, it

remains unclear as to whether this is a response to declining marine productivity, and therefore food (e.g., krill) availability to support gestation and lactation, or simply a brief downturn in reproductive activity after several comparatively high output years.

A whale's body volume, which reflects its blubber stores, can provide an indication of food availability and marine productivity. In 2018, AWF partnered with the Marine Mammal Research Program (MMRP; Hawaii Institute of Marine Biology, University of Hawaii at Manoa) to use Unoccupied Aerial Systems ('drones') and emerging aerial photogrammetric techniques (Figure 5) to non-invasively quantify whale body volume.

A preliminary analysis of average mid-season (i.e., August) body volume data suggest that 2022 was a good year with respect to whales' foraging success and, therefore, marine productivity (Figure 6). However, changes in marine productivity and its impact on body condition can take 1-2 years to influence CBR. This lag occurs because a female's decision to migrate to breed is linked to her body condition before she leaves: females in poor condition lack the blubber stores necessary to sustain themselves while fasting for several months on the breeding grounds. If a female does migrate and breed successfully, she will spend the subsequent year feeding in Alaska to support her developing fetus before returning to Hawaii once more to give birth. In this way, it is two years into this cycle before she returns to Alaska with her calf. Therefore, it is plausible that the low CBR we observed in 2022 was linked to poorer average whale body condition, and possibly lower pre-natal survival, in 2021.

Like our abundance estimates, mid-season body volume data represent snapshots in time; whale body condition could have improved (or declined) later in the season. As such, linking whale body volume to reproductive output and using those data to infer trends in marine productivity will require a more thorough analysis.

We use a variety of tools and techniques to gain insight into the health and behavior of whales.

Photo-identification

INSIGHT: Population size estimates, movement and residency patterns, long-term sighting histories

Suction-cup tags

INSIGHT: Underwater behavior, foraging rates, suckling rates, swimming energetics

Drone sampling

INSIGHT: Body condition, growth rates, energetic constraints

Transect Surveys

INSIGHT: Seasonal and annual trends in abundance and distribution, habitat use patterns

Tissue Sampling

INSIGHT: Stress hormone levels, pregnancy rates, shifts in diet, relatedness/stock structure

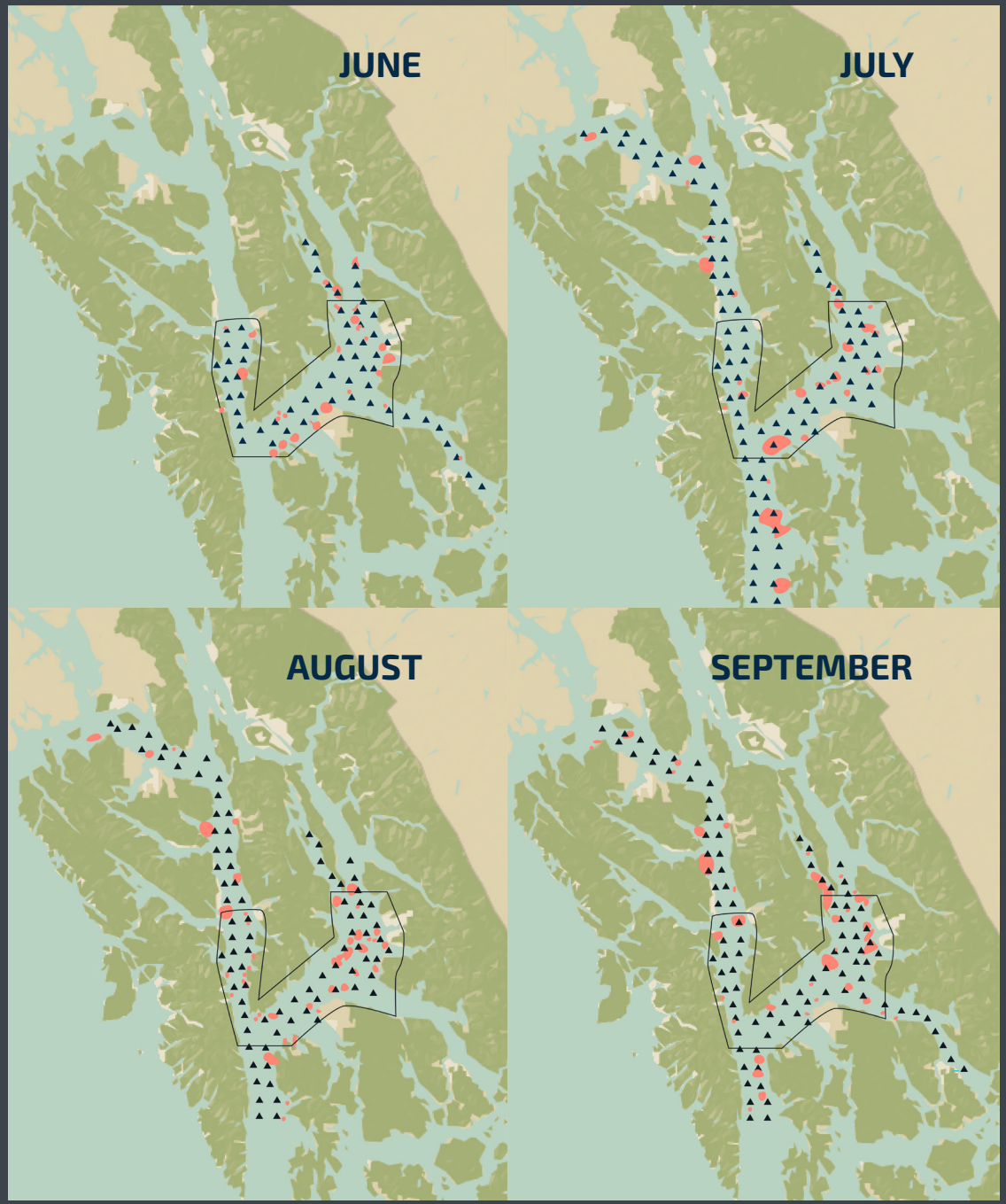
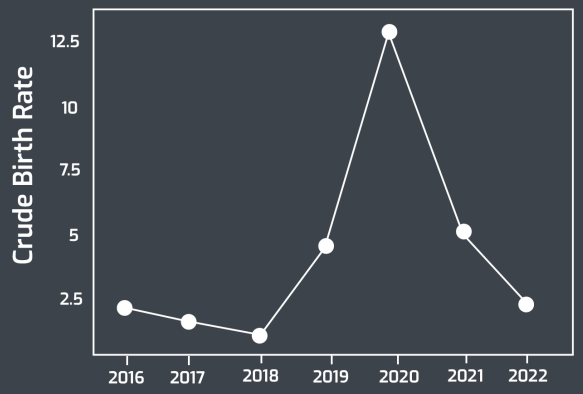


Figure 3. Distribution of whales (circles) from photo-identification efforts between June and September 2022. Circle size reflects group size. Triangles represent Point Count stations that were surveyed in each month and approximate spatial effort for that month; differences reflect variation in effort due to weather constraints. The area bound by the black polygon has been surveyed every year since 2016.

Figure 4. Crude Birth Rate (i.e., the number of calves / number of adults) in AWF's study region from 2016-2022.



Currently, AWF Graduate Research Assistant and MMRP PhD candidate Martin Van Aswegen is leading this charge. Specifically, Martin is using ~2,300 and ~4,700 body volume measurements collected over five years from Southeast Alaska and Hawaii, respectively, to link inter- and intra-annual variations in body condition to climate and oceanographic trends.

So in summary, the number of adult whales observed in our study area each year appears to have remained largely stable since increasing after 2018. However, there were comparatively few calves in 2022 and, because body condition can take two years to influence birth rates, the poor average body condition we observed in 2021 could result in further low birth rates in 2023. Ultimately, a formal analysis of the full suite of health data collected under the OHP, which is underway, will be necessary to provide a complete picture of whale heath.

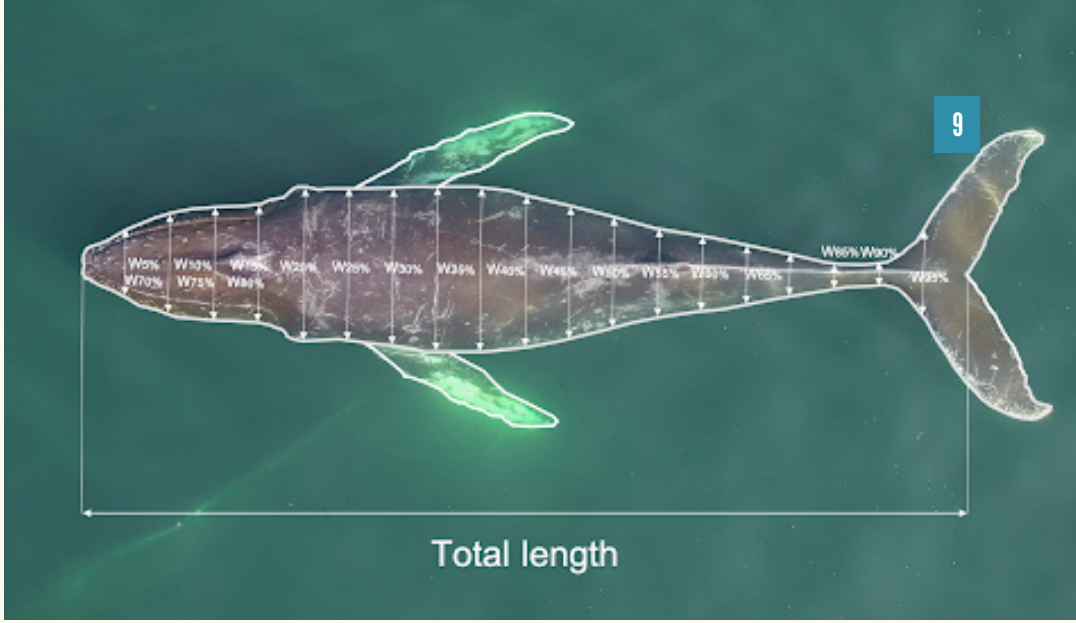


Figure 5. Aerial image of a surfacing whale showing measurement points for estimating the individual's length and width in 5% increments using aerial photogrammetry.

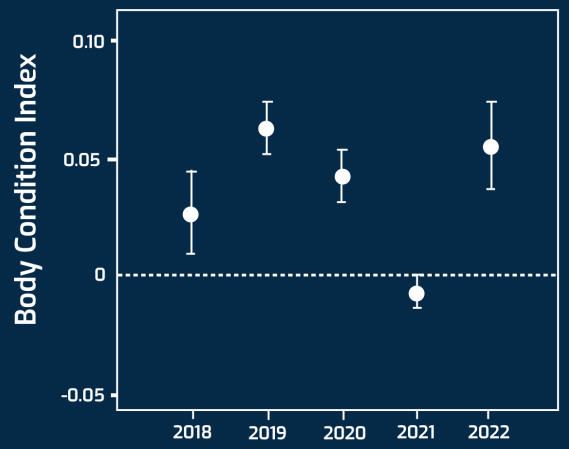


Figure 6. Mid-season (i.e., August) body condition index (BCI) estimates for non-lactating adult humpback whales between 2018-2022. A positive BCI indicates that an individual was in relatively better condition than an average individual of the same body length, whereas a negative body condition index indicates the individual was in relatively poorer condition.

Bubble-net Feeding Whales

Humpback whales are well-known for their bubble-net feeding behavior. Bubble-netting whales expel streams of air from their blowholes as they swim in a circular pattern, creating bubble cylinders (i.e., 'nets') that they use to corral and/or concentrate their prey. Humpbacks can deploy bubble-nets on their own, but in Alaska they often form cooperative bubble-netting groups of two dozen or more individuals.

AWF has been studying these groups for nearly three decades, starting with Dr. Fred Sharpe's doctoral research in 1993. Back then, Fred spent his summers in Alaska recording the group dynamics, acoustics, and underwater behavior of cooperative bubble-netting whales. Most of Fred's observations in those early years were recorded using now-obsolete video equipment.

As a result, much of the treasure trove of photo-identification data they contained remained either inaccessible or of insufficient quality for fluke matching and therefore could not be used to create a verifiable whale sighting database.

Until now, that is. Thanks to our increased capacity to work remotely, together with rapid growth in online data sharing and the advent of powerful image recognition software, we've reached a point where processing these data has become feasible.

This past year, two AWF interns – Annie Bartlett and Sonja Feinberg – supervised a team of 72 remote volunteers who were tasked with reviewing and extracting fluke images from over 200h of Fred's now-digitized field tapes. They then ran several thousand images through Happywhale.com, a remarkably efficient automated online fluke matching system, resulting in over 2,500 confirmed whale sightings spanning nearly 20 years. Thanks to Annie, Sonja and the team of volunteers' herculean efforts to process and integrate these data into our master sighting database, we now have a fascinating ~30-year window into the lives of these whales. One of the most remarkable findings to emerge from our preliminary analyses: many of the whales we first sighted in the early 1990s are still working together today. Aside from ourselves, we can't think of too many other species that show such strong and enduring bonds.

In 2019, we launched a collaborative effort with Lars Bejder (MMRP), Jeremy Goldbogen, (Stanford University), Ari Friedlaender (University of California Santa Cruz) and their respective labs to deploy CATSCam suction-cup tags on several of these well-known individuals. The non-invasive CATSCam tags are equipped with high resolution video cameras, hydrophones and a series of sensors that record the tagged whales' underwater behavior. Once deployed, they can stay on the animals for up to 24h until the suction cups fail and the tag floats to the surface. We then retrieve them using satellite and VHF tracking equipment and, once back in the lab, we can offload the data.

Since starting this project, we've deployed 51 tags on bubble-netting

whales in Alaska. The resulting data have demonstrated the ingenious ways that whales use bubble-nets as tools to concentrate their prey while minimizing the energetic costs associated with foraging. As well, they have revealed that only one, or rarely two, whales produce bubble-nets in each cooperative group and, rather than trading off, certain whales maintain that role within and between bubble-netting bouts.

In fact, one whale - SEAK 1391, aka Captain Hook – has been tagged on three separate occasions, over three years, with three different groups of whales, and every time he – and only he – blows the bubble-net. As far as we can tell, this is the only example of an animal manufacturing a tool (the bubble-net) and then using that tool for the benefit of its companions.

Moving forward, we are collaborating with Dr. Jessica Kendall-Bar (Postdoctoral Scholar, Scripps Institution of Oceanography) to look more closely at how these bubble-netting whales coordinate their behavior. Jessie uses three-dimensional movement path data from CATSCam tags to create realistic animations of marine animals (Figure 7). These animations can be used as scientific tools for exploring the tagged animal's underwater behavior. Jessie is creating an animation using data from five whales that we tagged feeding together in 2021 (Figure 8), including two animals that were producing the bubble-net.

The final animation will be the first time anyone has been able to visualize, using real data, how multiple whales work together while deploying bubble-nets to capture their evasive prey. Stay tuned to our website for a spring-time launch of Jessie's animation.

Figure 7. The whale “model” created by Jessie Kendall-Bar, which she will use in her upcoming whale animation.

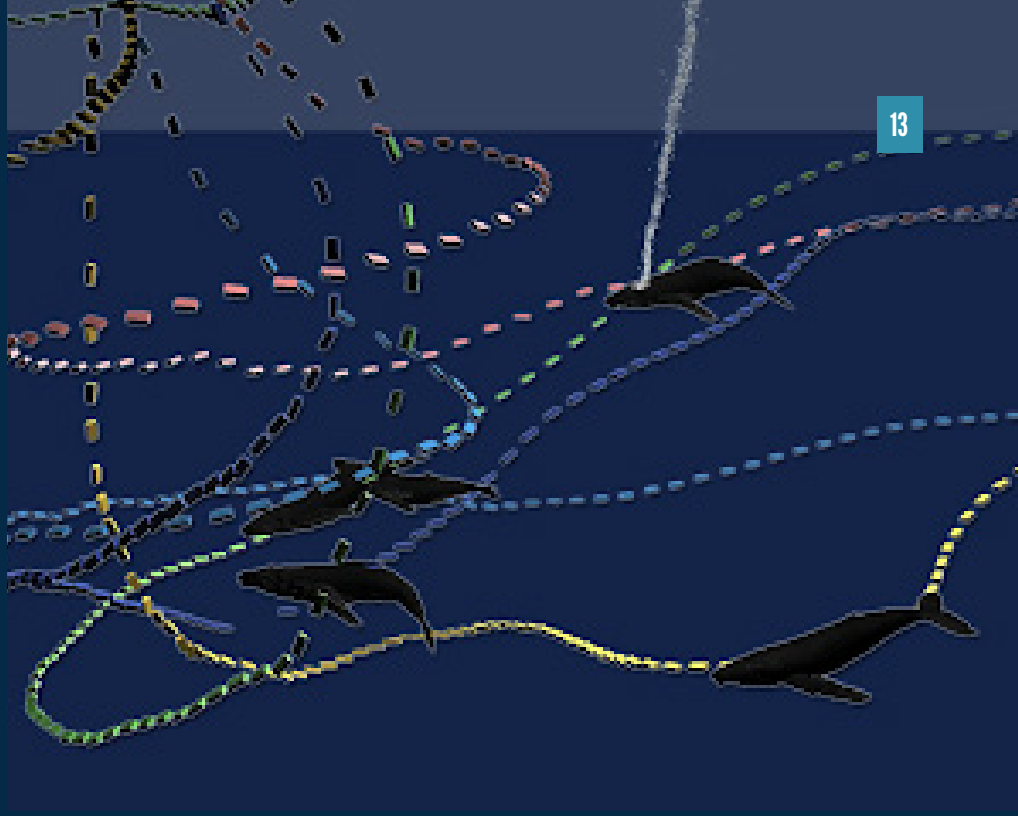


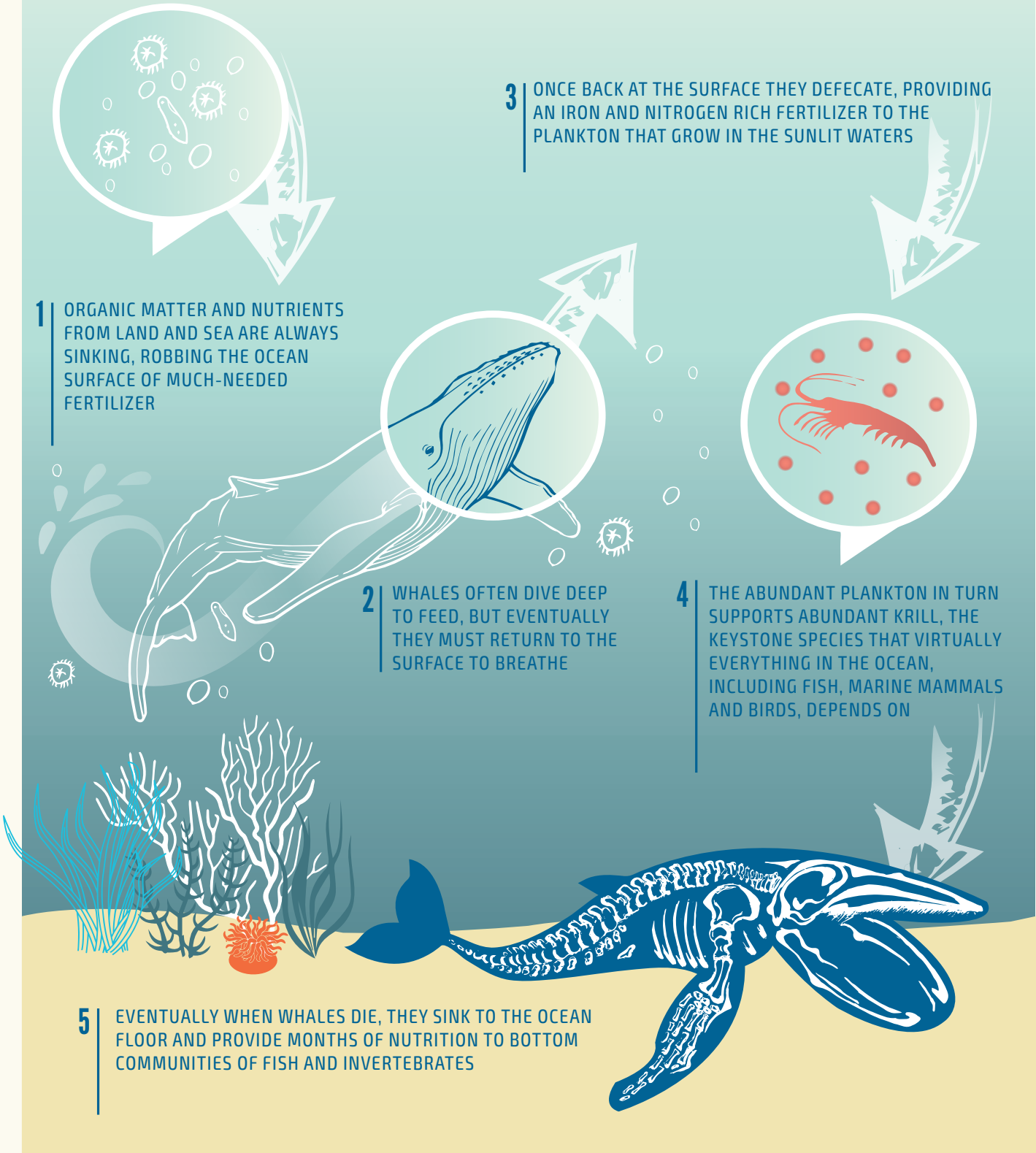
Figure 8. Movement paths of five bubble-netting whales tagged simultaneously in 2021. Note the position of the bubble-producing whale in the upper right. These data are being used to create a realistic 3D animation of the whales' underwater behavior.

Case study: The Whale Pump

A project by Dana Bloch
AWF Graduate Assistant/
University of Alaska Fairbanks MSc student

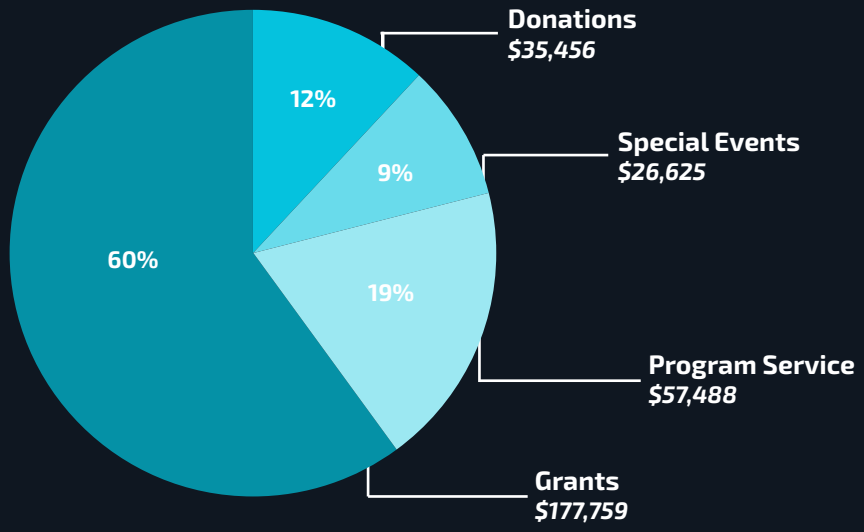
The “Whale Pump” refers to the important role that whales play in redistributing nutrients and carbon throughout the ocean. One way in which they do this is by defecating nutrient-rich fecal matter at the surface. Their ‘poop’ can then stimulate the growth of phytoplankton, the ‘plants’ of the sea, much like adding fertilizer to a garden.

Each summer, Dana Bloch collects whale poop to analyze its nutrient concentrations. She then fertilizes phytoplankton in the lab using the whale poop to estimate how much of the nutrients that it contains are ‘bioavailable’ (i.e., can be used by the phytoplankton). Ultimately, Dana hopes to estimate the contribution that humpbacks make to phytoplankton growth in Alaska and, in doing so, shed light on the important role that whales play in healthy ecosystems.

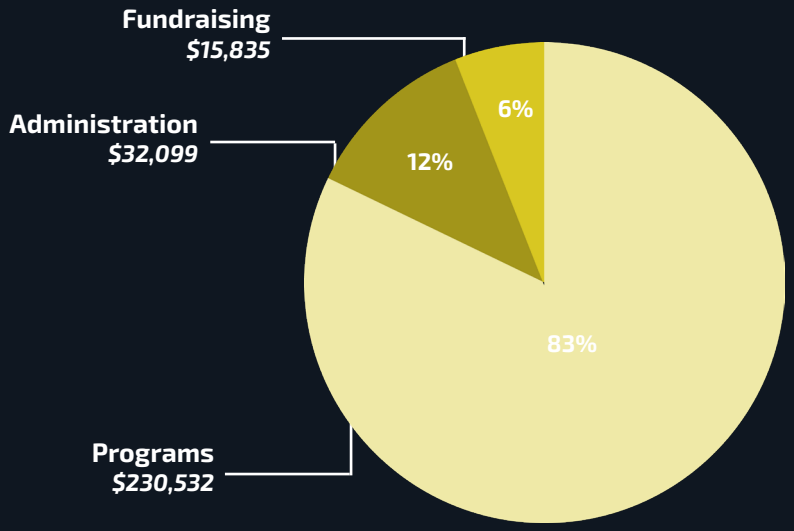


2022 FINANCIAL REPORT

REVENUE: $297,328



EXPENSES: $278,465



*Full financial statements available upon request.

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www.alaskawhalefoundation.org

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