The Gray Whale Cycle

A journey following the southward migration of gray whales in 2019

Becci Jewell

Supported by The David Henderson Inspiring Journey Grant

Summary

Each year gray whales in the eastern Pacific undertake a remarkable journey, travelling from their cold, rich feeding areas in Alaska to the warm lagoons of Baja where they calve and mate. A few months later they make the return journey, a round trip of approximately 10,000 miles, and the cycle begins again; an endurance event of epic proportions. Theirs is one of the longest migrations on earth and I followed their journey to better tell their story.

I joined the whales as they swam from Alaska towards Baja, cycling the coast alongside them and connecting with the people and communities whose lives they touch, from kayaking guides to whale watching captains, scientists to surfers, fishermen to fire fighters. I saw the joy they bring to the lives of those who glimpse them and gained a better understanding of the latest scientific findings and opinions, the research questions still to be addressed and also of the myriad threats they face, inextricably linked and cumulative. Gray whales are currently in the midst of an Unusual Mortality Event, the second they've experienced in recent years. Now's the time to consider the challenges they – and so many other ocean species – face.

The David Henderson Inspiring Journey grant from the Institute of Marine Engineering, Science and Technology (IMarEST) made The Gray Whale Cycle happen. Without the grant, established in the memory of David Henderson who worked for the IMarEST from 2008 until his untimely death in 2016, this journey may well have stayed as an ambition to be pondered, and even planned, but never completed. For the adventure of a lifetime that David's grant inspired and sustained, I am profoundly grateful.

About the author

Becci's background in marine mammal science has seen her studying the diet of Cape fur seals in South Africa, humpback dolphins in Kenya, the abundance and distribution of pilot whales in the Mediterranean and the effects of anthropogenic sound on populations of whales and dolphins worldwide. Since finishing her PhD in 2013, Becci has worked as a marine mammal observer during scientific surveys to assess cetacean abundance, offshore wind farm installation, seismic surveys for scientific research and oil and gas exploration, and various other projects generating anthropogenic sound. When not spending weeks at sea, Becci loves exploring the UK as well as further afield. Having survived The Gray Whale Cycle, Becci is keen to undertake more self-propelled journeys, to keep indulging her love of the oceans and to learn more about the issues currently affecting them.

Becci Jewell

Contents

1. Introduction

Gray whales *(Eschrichtius robustus)* are found in the western and eastern Pacific Ocean (Fig. 1.1) and, globally, are listed as 'least concern' by the International Union for Conservation of Nature (IUCN) (Cooke 2018). This hasn't always been the case. In the eastern Pacific they were hunted almost to extinction in the 18th and 19th centuries, largely in the breeding lagoons of Baja but also from whaling stations up and down the coast. Since the cessation of commercial whaling in the 20th century, gray whales have increased in number in the eastern Pacific and in 1994 they were removed from the US Endangered Species List. Analysis of shore-based counts in 2015/2016 suggested the eastern Pacific population now numbers 26,960 individuals (Durban et al. 2017).

This doesn't tell the full story though; only one of three known breeding populations definitely remains. Whilst the eastern Pacific population has rebounded from whaling, the north Atlantic breeding population is extinct and the IUCN's 2018 gray whale assessment categorises the western Pacific breeding population as endangered and 'possibly extinct' (Cooke 2018). Although a small number of gray whales still feed off Sakhalin Island, Russia each summer, some of these whales are known to migrate to Baja suggesting they're part of the eastern population rather than remnants of the western population. Whether an Asian breeding area is still utilised is not known.

And whilst the eastern Pacific population has rebounded, they are in the throes of their second Unusual Mortality Event in as many decades and experiencing poor calf production, elevated stranding rates and high numbers of emaciated animals.

Historically, commercial whaling has been the biggest threat faced by gray whales in the Pacific Ocean. Whilst subsistence whaling continues at low levels, the main threats faced by gray whales today are entanglements in fishing gear, ship strikes, disturbance, ocean noise and variability in oceanographic conditions.

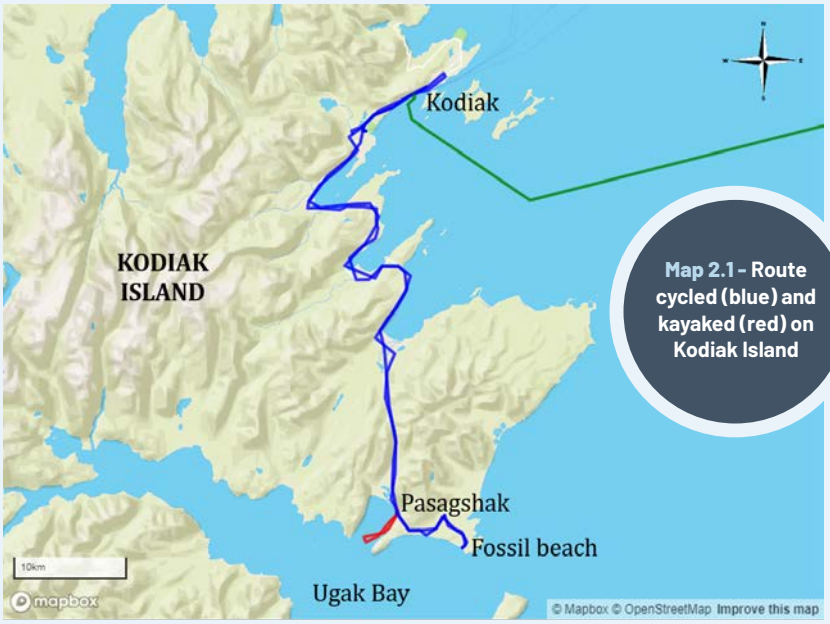
Figure 1.1 - The extant (orange) and extinct (red) distribution of gray whales (from IUCN website)

2. Findings from my journey

Meeting the Pacific Coast Feeding Group

Most eastern Pacific gray whales spend their summer months feeding in the Bering, Beaufort and Chukchi seas, sieving amphipods from mouthfuls of mud sucked from the sea floor before the sea ice returns. As the autumnal days shorten and temperatures drop, the gray whales begin moving south to warmer waters, many of them passing through Unimak Pass in the Aleutian Islands, back into the Pacific Ocean where they follow the coastline to Baja, Mexico.

A small proportion (~1 %) of the population, however, doesn't journey so far north. Instead they feed off the coast of the Pacific northwest during the summer months and are known as the Pacific Coast Feeding Group (PCFG). The International Whaling Commission's (IWC) working definition of the PCFG stretches from 41°N (northern California) to 52°N (northern Vancouver Island) and the latest estimate of abundance for this range was 243 whales in 2015 (Calambokidis et al. 2017). Although beyond the IWC's definition of their geographical range, Kodiak Island, Alaska is also considered a feeding ground of the PCFG and gray whales have been observed off Ugak Bay not just in the summer (Gosho et al. 2011) but also year-round (Moore et al. 2007).



Map 2.1 - Route cycled (blue) and kayaked (red) on Kodiak Island

Figure 2.1 - Pasagshak Bay (above) and a gray whale seen from shore (below)

Pasagshak Bay, part of Ugak Bay, is a hilly 40-mile cycle from Kodiak where my journey had started on the 24th September (Map 2.1). The area is sparsely populated amd mountainous with a formidable jagged coastline and wild weather. A gap in the weather resulted in my first gray whale sightings of the trip, both from shore and – even better –from a kayak. These whales looked to be in good condition, ready to soon begin their migration.

The existence of the PCFG could have management implications. Should the PCFG be demographically distinct and constitute a separate stock from the remainder of the population in the eastern Pacific – an issue that is contested and unresolved (e.g. Frasier et al. 2011, Scordino et al. 2011, Weller et al. 2013) – this smaller population may be vulnerable to natural and anthropogenic perturbations and require greater protection.

Avoiding ship strikes on the Alaska Marine Highway

By beginning my journey in September, a little ahead of the gray whale's southward migration, I could catch the last ferry of the year from Kodiak to Bellingham, Washington, a six-day journey covering 1,935 miles (Map 2.2). From the warmth of the *M/V Kennicot* I saw humpback whales, killer whales, dolphins and sea lions as we cruised through the sheltered waters of the Inner Passage (Fig. 2.2).

Knowing the area is a hotspot for marine mammals, the Alaskan Marine Highway Service (AMHS) has measures in place to minimise the risk of disturbing, or colliding with, marine mammals. Christy Harrington, an environmental specialist with AMHS, explained how whale sighting information is shared with the vessels' Captains, who ensure that any whales seen are passed at a safe distance. A pilot study, run in conjunction with the National Oceanographic and Atmospheric Administration (NOAA), is currently trialling the use of apps to share and view whale sighting information in real time in the hope of reducing the risk of collision. NOAA has also been developing the technology to share whale sighting information via the Automatic Identification System (AIS) used by ships, providing another means of information transfer.

Map 2.2 - Route travelled by the *M/V Kennicot* from Alaska to Washington

Although ship strikes in the Inner passage more often involve humpback whales than gray whales, ship strikes are still a credible threat to gray whales. Of 152 gray whale deaths and 148 suspected deaths of seriously injured gray whales between 1924 and 2015, 19% were attributed to ship strikes (Scordino et al. 2017). Scordino et al's review of non-hunting, human caused injuries and mortality of gray whales in the North Pacific found a general peak in the 1980s (Fig. 2.3) and a peak in ship strike mortality in the 1970s (Fig. 2.4).

Figure 2.2 - Sailing the Inner Passage aboard the *M/V Kennicott* (left) and one of the killer whales seen there (right)

2. Findings from my journey

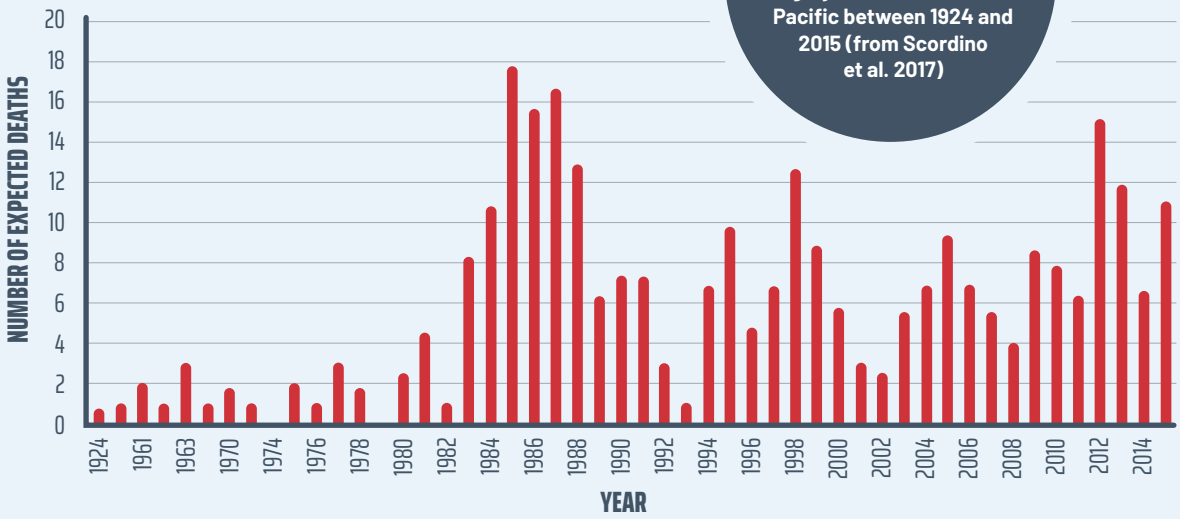


Figure 2.3 - The expected number of non-hunting, human caused injuries and mortality of gray whales in the North Pacific between 1924 and 2015 (from Scordino et al. 2017)

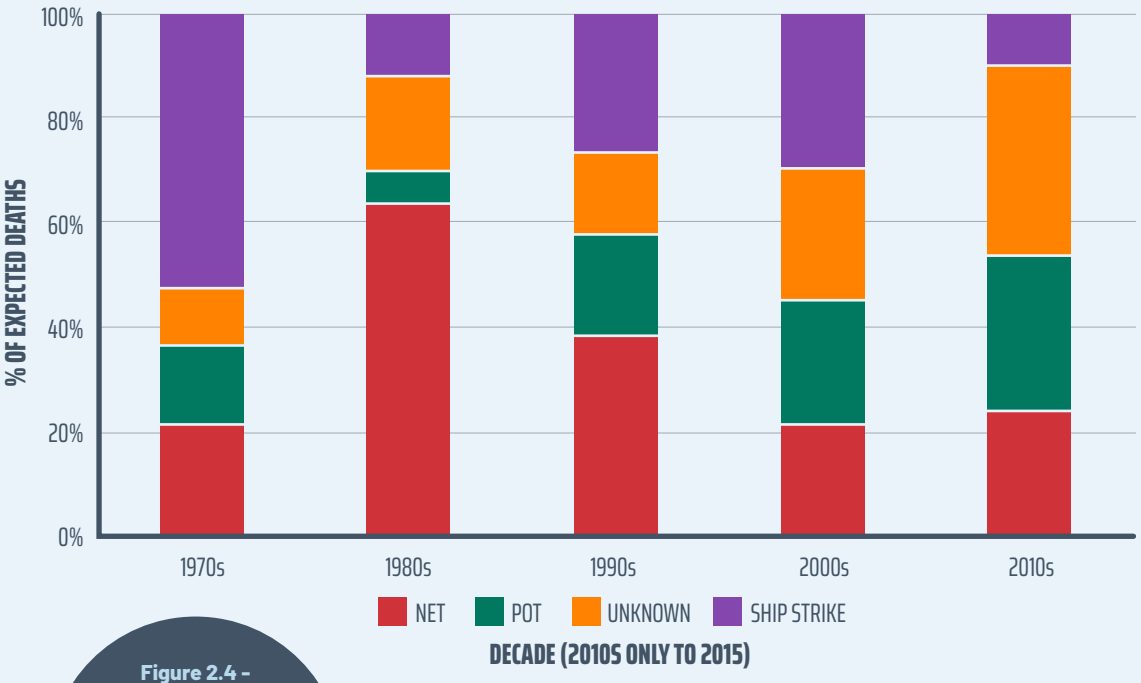


Figure 2.4 - Percentage of expected deaths from net, pot and unknown entanglements and ship strikes by decade (from Scordino et al. 2017)

Whaling in Washington

Whaling has been a key component of the identity of the Makah tribe of the Olympic Peninsula, Washington for at least 1,500 years. The Makah – or 'People Who Live Near the Rocks and the Sea Gulls' – historically occupied five villages on the peninsula, one of which, Ozette, was buried by a mudslide around 1700 that preserved whale bones, harpoon barbs and other whaling artefacts. In 1855 the Makah tribe signed the Treaty of Neah Bay, ceding 300,000 acres of their land to the US government but preserving their right to continue whaling. By the 1920s, however, commercial hunting by non-native whalers had devasted the gray whale population, leaving the Makah tribe with little choice but to cease whaling.

Map 2.3 - Route cycled through Washington

When the gray whale population had recovered sufficiently to be removed from the US Endangered Species Act list in 1994, the Makah tribe then sought permission to resume subsistence whaling. Their request to harvest up to five whales a year for cultural and subsistence purposes was approved by the International Whaling Commission and National Marine Fisheries Service and in 1999 they caught their first whale in seventy years. The skeleton of this whale is now displayed in the Makah Cultural and Research Centre museum in Neah Bay alongside countless fascinating artefacts retrieved from the mud in Ozette.

However, the United States federal court soon ruled that the tribe must also obtain a waiver from a moratorium on taking marine mammals in the United States Marine Mammal Protection Act, a complex process involving a comprehensive environmental review of the hunt, extensive scientific review and opportunities for public comment. Twenty years on and it seems a decision may be imminent. Following a hearing in November 2019 on the proposed waiver to allow the Makah to resume hunting of gray whales, a 45-day public comment period commenced in spring 2020 and a final decision is expected this year.

South of Neah Bay, the small reservation of La Push (Fig. 2.6) is home to the Quileute tribe, a nation with a long history of harvesting whales, seals and fish as well as hunting and

Figure 2.5 - Neah Bay, on the tip of the Olympic peninsula, 70 winding miles from Port Angeles, is home to the Makah tribe. Hobuck beach, near Neah Bay (far left) and a gray whale blow seen from there (left)

2. Findings from my journey

gathering from their rain-soaked coastal forests. Archaeological, historical and ecological data all indicate that the Quileute hunters were exceptional seamen, navigators and whalers, hunting gray, humpback and fin whales – and possibly North Pacific right whales, blue whales, sperm whales and killer whales too – perhaps even further than 30 miles from shore (Robertson and Trites 2018).

The Quileute people no longer hunt whales but continue to honour the importance of gray whales with an annual 'Welcoming of the Whales' ceremony as the gray whales reach La Push on their northward migration each spring. The ceremony includes prayers, singing and dancing and an offering of salmon, paddled out to sea on a raft by students of the Quileute Tribal School.

Figure 2.6 – La Push, home of the Quileute tribe

Oceanographic conditions in Oregon

Assessing the health of whale populations is challenging. Scientists at Oregon State University's Marine Mammal Institute in Newport have been taking to the water, and to the skies, to do just that. Using drones to photograph whales, Lemos et al. (2020) found that the body condition of gray whales feeding in Newport and Port Orford declined between 2016 and 2018 (Fig. 2.7). The decline was correlated with an upwelling index in previous years, with years of poor body condition following years of weak upwelling. They also found significant variation in body condition between demographic units and reproductive phases of females with calves and pregnant females being in significantly better condition than lactating females (Lemos et al. 2020).

Discussing these findings in relation to the Unusual Mortality Event (UME) of 2019, Lemos et al. (2020) hypothesised that the 2019 UME may indicate that gray whales can withstand one, or even two, years of poor prey conditions but that three years exceeds their resilience and resulted in high mortality. Not only did they observe a decline in body condition but also fewer calves in 2017 and 2018. A similar trend has been documented before; fewer calves were observed in years following feeding seasons cut short by ice cover in the Bering and Chukchi seas (Perryman et al. 2002).

Map 2.4 - Route cycled through Oregon

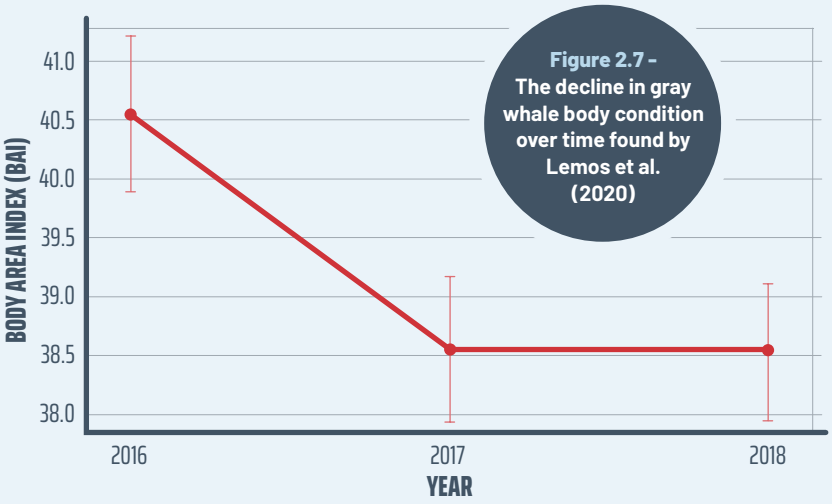


Figure 2.7 - The decline in gray whale body condition over time found by Lemos et al. (2020)

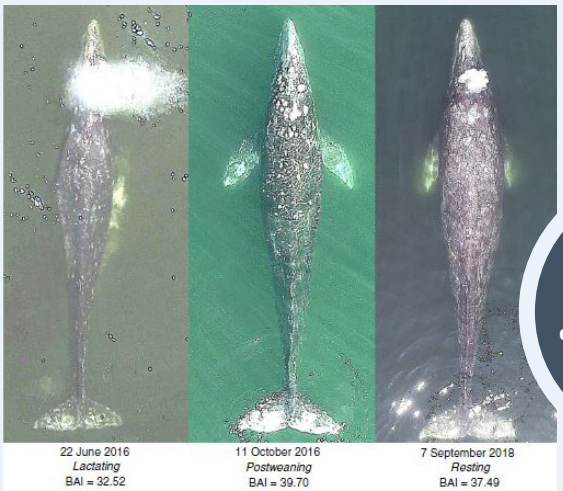


Figure 2.8 - Variation in body condition of a female gray whale during different reproductive phases (from Lemos et al. 2020)

2. Findings from my journey

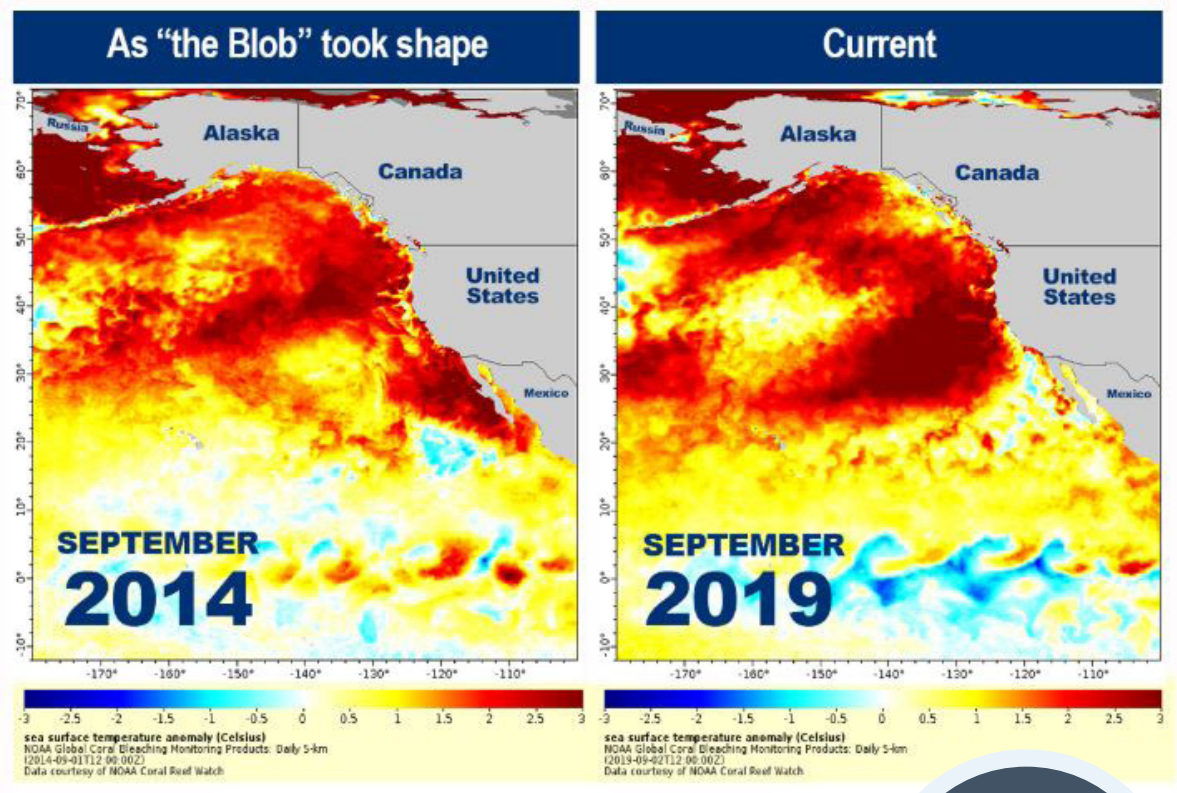


Figure 2.9 – Sea surface temperature anomaly maps with above average temperatures shown in orange and red (from NOAA website)

In addition to the weak upwelling from 2016 to 2018, other oceanographic measures varied over a similar time frame including record breaking El Niño conditions (bringing elevated sea surface temperature and reduced primary productivity), a positive Pacific Decadal Oscillation phase (associated with reduced upwelling), a negative North Pacific Gyre Oscillation phase (also associated with reduced upwelling) and the occurrence of 'the Blob', a record marine heatwave that peaked in the northeast Pacific in 2014 and 2015 and saw water temperatures more than 2.5°C above average (Tseng et al. 2017). The heatwave disrupted marine ecosystems along the west coast of America, resulting in dramatic changes to primary productivity, altered species composition and distribution, and increased concentrations of the neurotoxin domoic acid in the marine environment. Driven by increases in mean ocean temperature, marine heatwaves are becoming more frequent and lasting longer (Oliver et al. 2018) and, at the time of my visit to Oregon, another marine heatwave reaching from Alaska to California – the second biggest of the last 40 years, after 'the Blob' – appeared to be developing (Fig. 2.9).

Port Orford, 150 miles south of Newport, is home to the Port Orford Field Station, part of Oregon State University's Marine Studies Initiative (Fig. 2.10). The field station is used as the base for an ongoing study of the foraging behaviour of gray whales in Port Orford. Underwater GoPro footage collected to record the availability of the gray whales' prey has also documented the recent decline in kelp forest and the dramatic increase in purple urchin numbers occurring in parts of Port Orford, a phenomenon occurring all along the coast of the northwest Pacific. In 2014, concurrent with the increased water temperatures, a loss of sea stars and an explosion of purple urchin, >90% of the historically persistent bull kelp forests in northern California were lost (Rogers-Bennett and Catton 2019). Kelp forests are an incredibly

ecologically dynamic and biologically diverse habitat supporting many species through the supply of energy (directly and indirectly) and the physical habitat they provide.

As a voracious predator of sea urchins, sea otters are a keystone species that helps maintain healthy kelp forest ecosystems. In areas where sea otters were extirpated by the fur-trade and have not returned, for example Oregon and northern California, other predators such as sea-stars, sheephead fish and spiny lobsters help to keep sea urchin numbers in check. However, in many places sheephead fish and spiny lobster numbers have been depleted by fishing, and sea-stars recently suffered a catastrophic decline from sea-star wasting disease (SSWD). SSWD has caused rapid and widespread declines in multiple sea-star species from Baja to Alaska. One species, the sunflower star (*Pycnopodia helianthoides*) has declined by 80 to 100% from California to Alaska (Harvell et al. 2019). The absence of these predators has further reduced the resilience of the kelp forest ecosystem with kelp loss being greatest in areas where fishing has reduced the number and size of these predators (Eisaguirre et al. 2020). Conversely, inside marine protected areas where fishing was prohibited, larger and more abundant urchin predators were able to regulate the urchin populations sufficiently to result in kelp growth (Eisaguirre et al. 2020). The recent and rapid decline of kelp forests experiencing the synergistic effects of multiple stressors is another example of the importance of marine biodiversity in maintaining ecosystem resilience and stability.

Figure 2.10 – Port Orford (top) is just one location along the Pacific coast that has seen significant declines in bull kelp (middle top) and population explosions of purple urchins (middle below). Otters (right) were extirpated from Oregon by the early 1900s

2. Findings from my journey

Map 2.5 – Route cycled (blue) through California, plus some travel by car (orange) and train (pink)

Figure 2.11 – An adult male gray whale stranded at Patricks Point, California

Another Unusual Mortality Event

Whilst in northern California, an overheard conversation in a café informed me I had just cycled past a recently stranded gray whale. Unable to miss such an opportunity, I backtracked to Patricks Point State Park and arrived in time to see the Humboldt State University's Marine Mammal Stranding Program team recording morphometric data and gathering samples. The whale's blubber thickness was measured in multiple locations to assess body condition. While some areas had 10 cm of blubber, other areas had less, leading to an on-site assessment that the whale was 'borderline emaciated'.

In early 2019, scientists in Baja noticed that many of the whales arriving at the breeding lagoons appeared to be underweight. Unusually high numbers of strandings were then reported from Mexico to Alaska as the whales returned north towards their feeding grounds that spring (Fig. 2.12) and in May 2019 NOAA announced an Unusual Mortality Event (UME). By the end of 2019, 215 whales had been reported stranded in the US, Mexico and Canada. In 2020 (to 12th May), a further 111 gray whales have been reported, with 87 of these in Mexico. Some, but not all, were found to be emaciated; experts are investigating these strandings for further indications of their cause.

The previous UME in 1999 and 2000 lasted two years, during which time 651 whales were reported stranded from Baja to Alaska (Fig. 2.13). Limited examinations of stranded whales at that time didn't find a common definite cause. As mentioned previously, Lemos et al. 2020 found that gray whales feeding off the coast of Oregon between 2016 and 2018 displayed poor body condition following multiple years of unfavourable feeding conditions, as indicated by various oceanographic indices describing water temperature, upwelling and primary productivity. However, these oceanographic indices had not indicated similarly poor feeding conditions prior to the 1999-2000 UME; upwelling conditions, although variable, had been stronger prior to 1999.

Perhaps the 1999-2000 UME had a different cause. A record number of gray whales migrated south past Granite Canyon, central California in the year before the UME and the population was estimated to number 29,758 individuals (95% confidence interval 24,241 to 36,531), the highest since the survey began in 1967/68 (Rugh et al. 2005). This lead Rugh et al. (2005) to suggest the population was reaching the environment's carrying capacity.

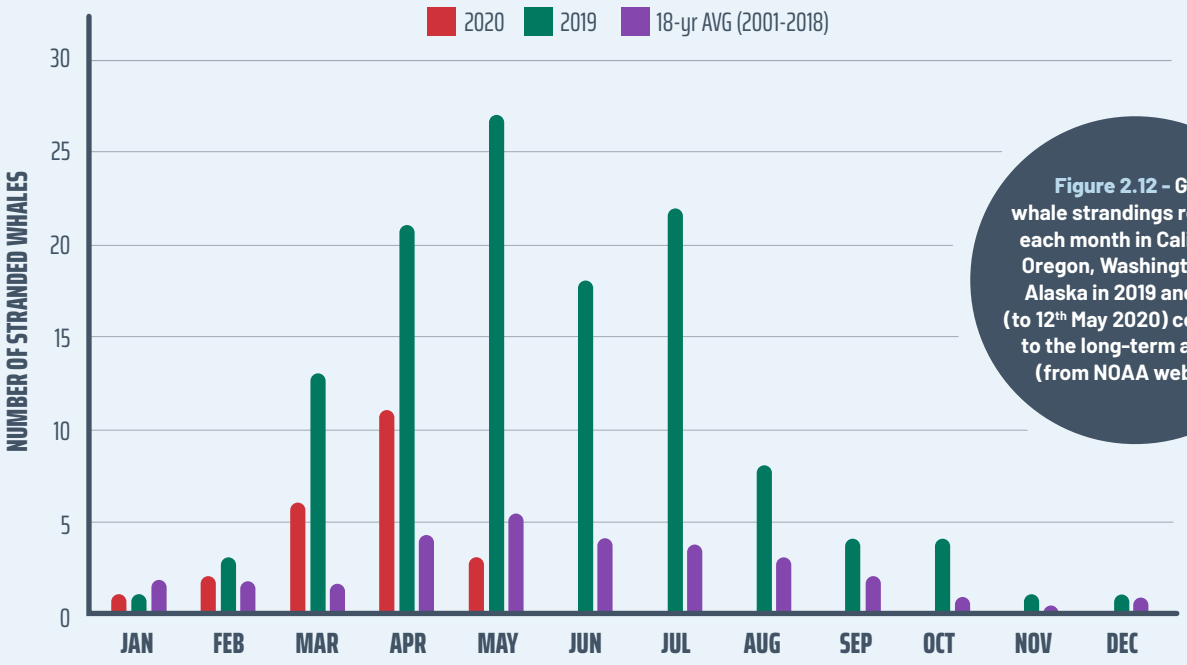


Figure 2.12 - Gray whale strandings reported each month in California, Oregon, Washington and Alaska in 2019 and 2020 (to 12th May 2020) compared to the long-term average (from NOAA website)

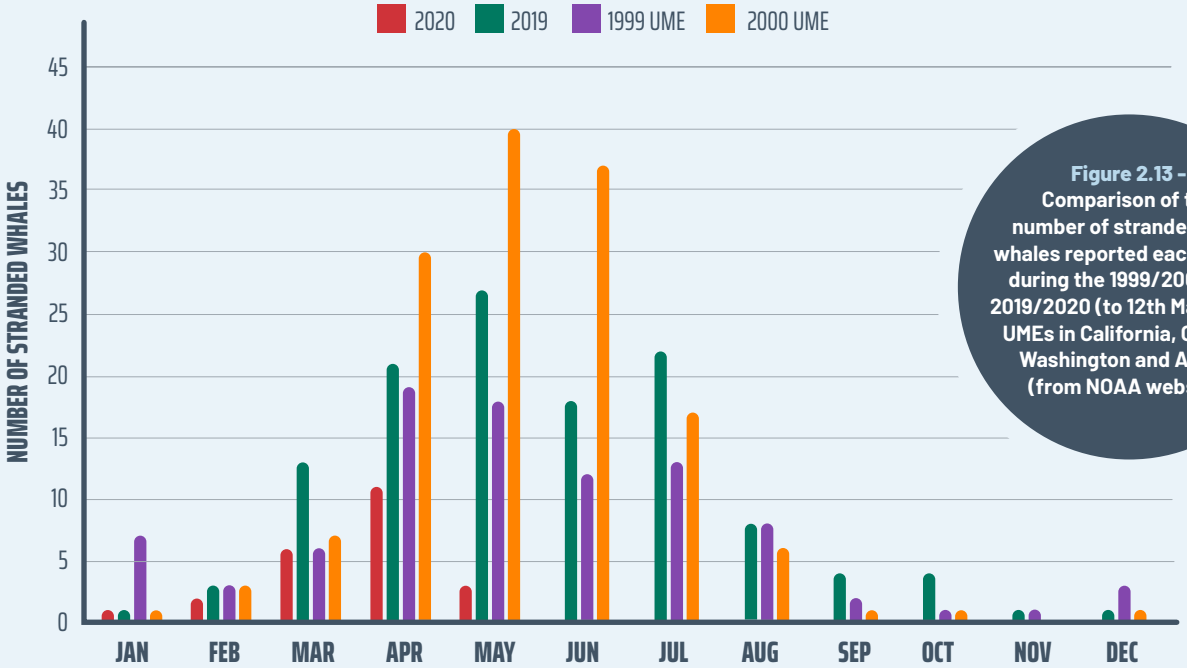


Figure 2.13 - Comparison of the number of stranded gray whales reported each month during the 1999/2000 and 2019/2020 (to 12th May 2020) UMEs in California, Oregon, Washington and Alaska (from NOAA website)

Lending further support to this theory, the biomass of amphipod prey in the northern Bering Sea in 2002-2003 was nearly 50% lower than at peak times in the 1980s, a reduction thought to have been attributed to predation by gray whales (Coyle et al. 2007). The peak in gray whale abundance, reduced prey biomass and elevated mortality rate suggest the 1999-2000 UME was a result of gray whales reaching the carrying capacity of the environment.

2. Findings from my journey

Gray whales and coastal fisheries

Travelling close to shore brings gray whales into contact with fishing gear and entanglements result. Once wrapped around the whale's flukes, the body or across the whale's jaw, there is little the whale can do to free itself. The ropes, with the additional weight of buoys, nets or pots, can cause flesh injuries and even amputation, slow the animals down and impede foraging. If the whale remains entangled, their condition will likely deteriorate, they become susceptible to infection, and may succumb to starvation, drowning or disease.

Eight gray whales were reported entangled in fishing gear off the coast of California, Oregon and Washington in 2019; seven were live entanglements and one was a dead animal found entangled. Overall, whale entanglements off the west coast of the US have increased since 2014 with humpback whales accounting for the biggest increase (Fig. 2.14). Unprecedented numbers of whale entanglements between 2014 and 2016 were attributed to the effects of 'the blob', the unusually high sea surface temperatures that altered upwelling and prey distribution, shifting foraging whales closer to shore (Santora et al. 2020).

Of the eight gray whales reported entangled last year, two were entangled in gillnet, one in commercial Dungeness crab fishing gear, one in a mooring line and four in unknown gear. Over time, the type of fishing gear in which gray whales are most likely to get entangled has changed from nets in the 1980s and '90s to pot fishing gear in the 2000s and to 2015 (Scordino et al. 2017). This could reflect a change in fishing effort, a change in the abundance and distribution of whales or a combination of both.

The entanglement of whales in fishing gear has severe implications for the fishing industry as well as the whales. Dungeness crab (Fig. 2.15) range from Alaska to California and are highly sought after both recreationally and commercially. In 2019, the commercial Dungeness crab fishery brought in over $16 million at the docks in southeast Alaska and $66 million in Oregon and was similarly lucrative in Washington and California. The crabs are caught in baited crab pots placed on the seabed in coastal waters, and the pots are marked with floating buoys attached to ropes. It's these vertical ropes that whales most often become entangled in. In 2019, California's Dungeness crab fishery was closed two months early in spring because of the risk of wildlife

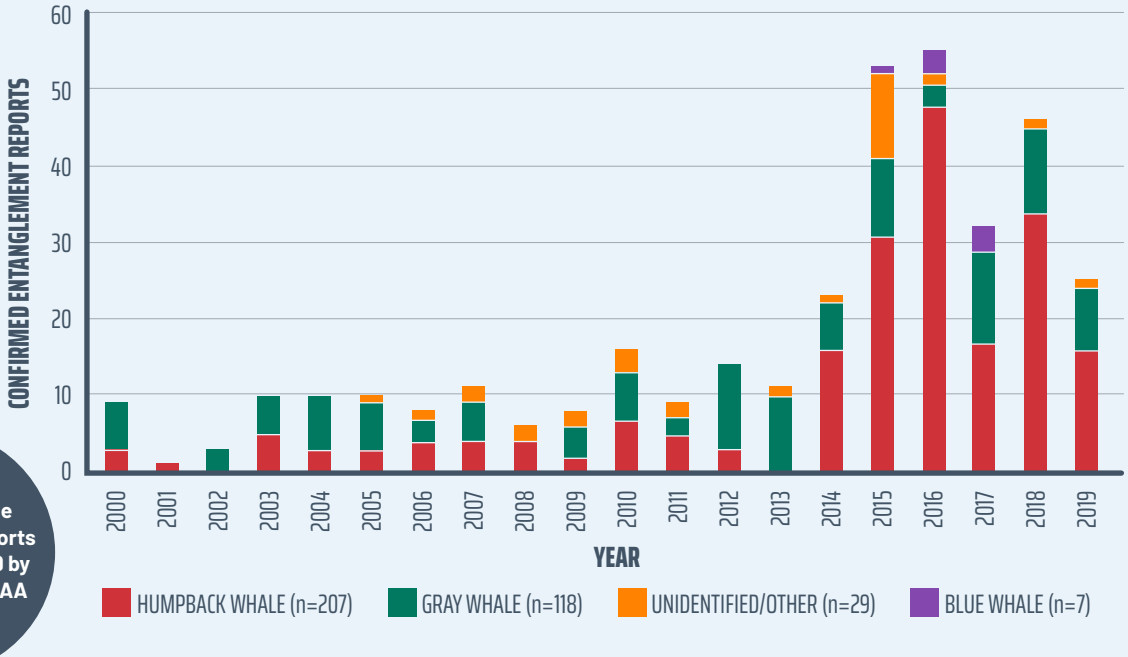


Figure 2.14 - Confirmed whale entanglement reports from 2000 to 2019 by species (from NOAA website)

Figure 2.15 - Dungeness crab (left) and a crab pot (right)

entanglement in the crab pot lines whilst the opening of the next season was delayed, threatening the stability of the fishery and the coastal communities it supports.

A number of steps are being taken to mitigate the risk of whale entanglement in crab pots. The Oregon Whale Entanglement Working Group has been undertaking regular aerial surveys to gain a better understanding of whale distribution in coastal waters. This information will help map high risk entanglement areas and allow fishermen to target lower risk areas. Gear modifications are also being investigated. Rope-less gear would require sophisticated GPS tracking of pots and may be prohibitively expensive. Timed releases on the recovery rope and marker buoy of pots, however, would reduce the amount of time that the ropes pose a threat to marine wildlife and are considered a high-ranking option (Lebon and Kelly 2019).

NOAA Fisheries collate records of entangled whales and also oversee the Large Whale Entanglement Response Network, a network of trained responders operating under a NOAA permit allowing them to approach whales for the purpose of disentanglement. Of the eight entangled gray whales in 2019, a response was initiated for two whales, one of which was freed of some but not all gear, and one which could not be freed. More recently, in April 2020, the successful disentanglement of an adult gray whale entangled in Dungeness crab fishing gear off the coast of Port Angeles, Washington was filmed by Komo News (Fig. 2.16).

Figure 2.16 - An aerial photo of an entangled gray whale in Washington State in April 2020 (image from Komo News)

2. Findings from my journey

Resource use and climate change

Even as the impacts of climate change become more tangible – with more frequent extreme weather events, retreating glaciers, larger wildfires and the world's oceans becoming warmer and more acidic – carbon emissions continue to rise globally. Many countries are falling short of the reductions needed to meet the United Nations Paris Agreement's target of keeping global warming below 2°C, threatening terrestrial and marine ecosystems alike.

Single-use items such as plastic bottles, disposable dinnerware, drinking straws and plastic bags not only use valuable resources and energy to produce but often persist in the environment for a long time afterwards. Plastics tend to break up, rather than break down, producing microplastics that accumulate up marine food chains causing physical damage, pathogen exposure and ecotoxicological effects (Avio et al. 2017).

Figure 2.17 - Another example of excessive packaging that'd soon become waste

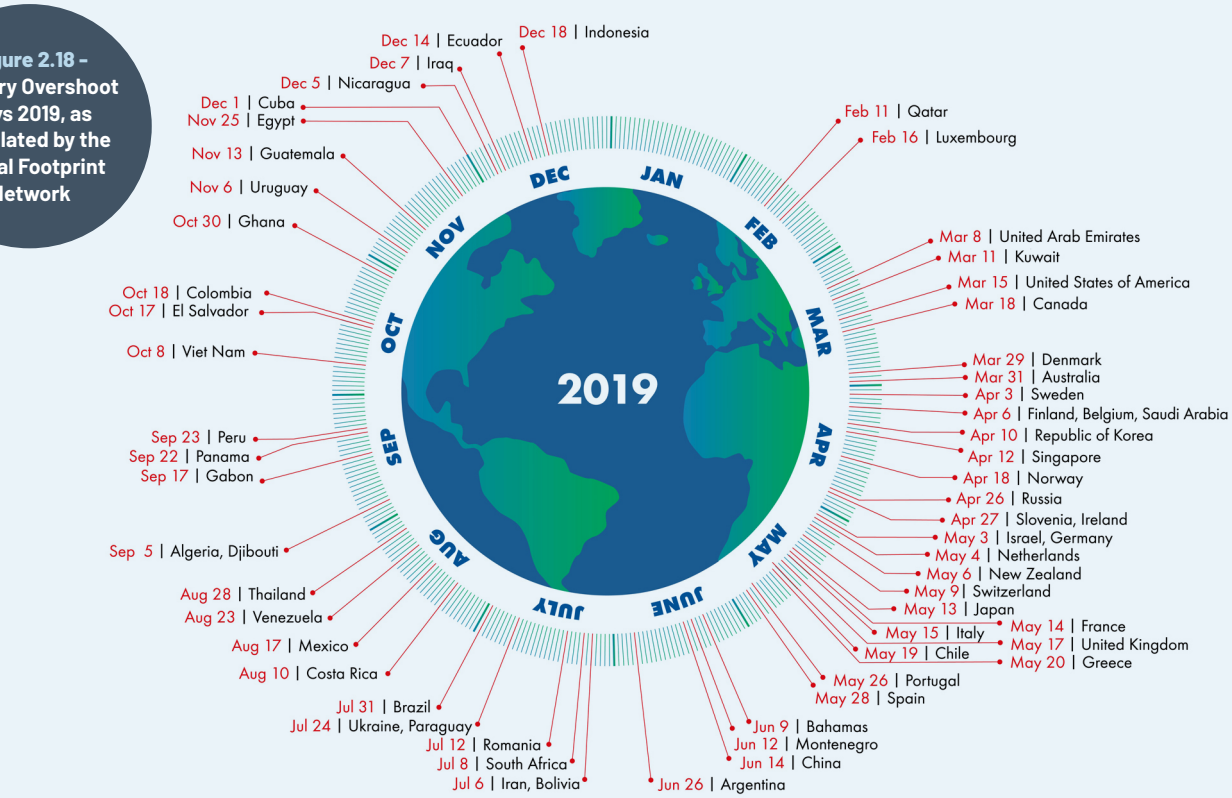
Avoiding single-use items during my journey was difficult from the outset; cafes often served food and drinks in single-use containers even for customers eating on their premises. Everything seemed to be designed 'to go', to be served in your vehicle, used and discarded, and there were few plastic-free options. A prime example was the serving of individual slices of bread each wrapped in plastic in a hostel in Santa Monica, offered near a notice board declaring the hostel's environmental credentials (Fig 2.17).

These observations are in keeping with the Global Footprint Network's calculations of Earth Overshoot Day, the day of the year in which humanity's consumption of the Earth's resources overshoots what the planet can replace in a year. These calculations incorporate metrics such as the number of trees felled, fossil fuels burnt, waste produced, quantity of seafood harvested and carbon emissions, but miss many less quantifiable measures like mass species decline and water contamination.

Globally, Earth Overshoot Day fell on July 29th in 2019, three days earlier than the previous year and two months earlier than 20 years ago. However, the Overshoot Day of the United States fell considerably earlier on March 15th (Fig. 2.18). If the world's population consumed resources and produced waste on the same scale as the US, it would take five Earths to sustainably meet those needs.

Although some countries perform better than others, this is clearly a global issue and a move towards more sustainable consumption of resources is desperately needed.

Figure 2.18 – Country Overshoot Days 2019, as calculated by the Global Footprint Network



EARTH OVERSHOOT DAY

Source: Global Footprint Network National Footprint Accounts 2019

Global Footprint Network
Advancing the Science of Sustainability

3. Summary

Pressure is mounting on the marine environment. Nearshore ecosystems are experiencing oceanographic changes, fishing pressure, multiple sources of pollution and the long-term effects of historical hunting. Reduced biodiversity undermines the stability of these ecosystems, making them less able to cope with the rapidly changing environment.

For the gray whales, one of the impacts of global climate change and marine heatwaves is changes to the availability of their prey, the energy source for their ocean-wide migration. Changes in the distribution of their prey, or a need to forage in unfamiliar waters, may expose them to unfamiliar waters where they must avoid ships and fishing gear, often in a noisy environment. When a dead whale then washes ashore, emaciated, with a high parasite load and signs of a ship strike, what was the cause of death amongst these multiple stressors?

At present the gray whale population in the eastern Pacific is large but the ongoing UME confirms that the whales are not infallible whilst numerous examples from the world's oceans show how rapidly the status of populations and ecosystems can change.

As my knowledge of the whales grew during my cycle so did my concern. Learning more about the recent marine heatwaves, the plight of other marine mammals along the Pacific coastline, the impact of anthropogenic activities on nearshore waters and the species that inhabit them was a fascinating but sobering experience. There was positive news too: the use of tools such as drones and satellites to shed light on the whale's lives, the use of apps and AIS to share whale sighting information in real time to reduce the risk of ship strikes, the efforts being made to reduce temporal and spatial overlap of fishing effort and whale distribution, and the dedication of the teams working on these matters, were all encouraging.

As I met people on the road it was apparent that the interest and concern for the marine life, particularly the whales, isn't limited to scientists but extends to the wider public. There seems to be a disconnect though, between our actions and their futures. Individual choices, from questioning the sustainability of the fisheries we support, to avoiding single use plastics, choosing greener transport, and electing local leaders and governments who support environmental matters, all make a difference. We all have our part to play in the conservation of the world's oceans and it's time to take that seriously.

4. Figure List

List of Figures

List of Maps

5. References

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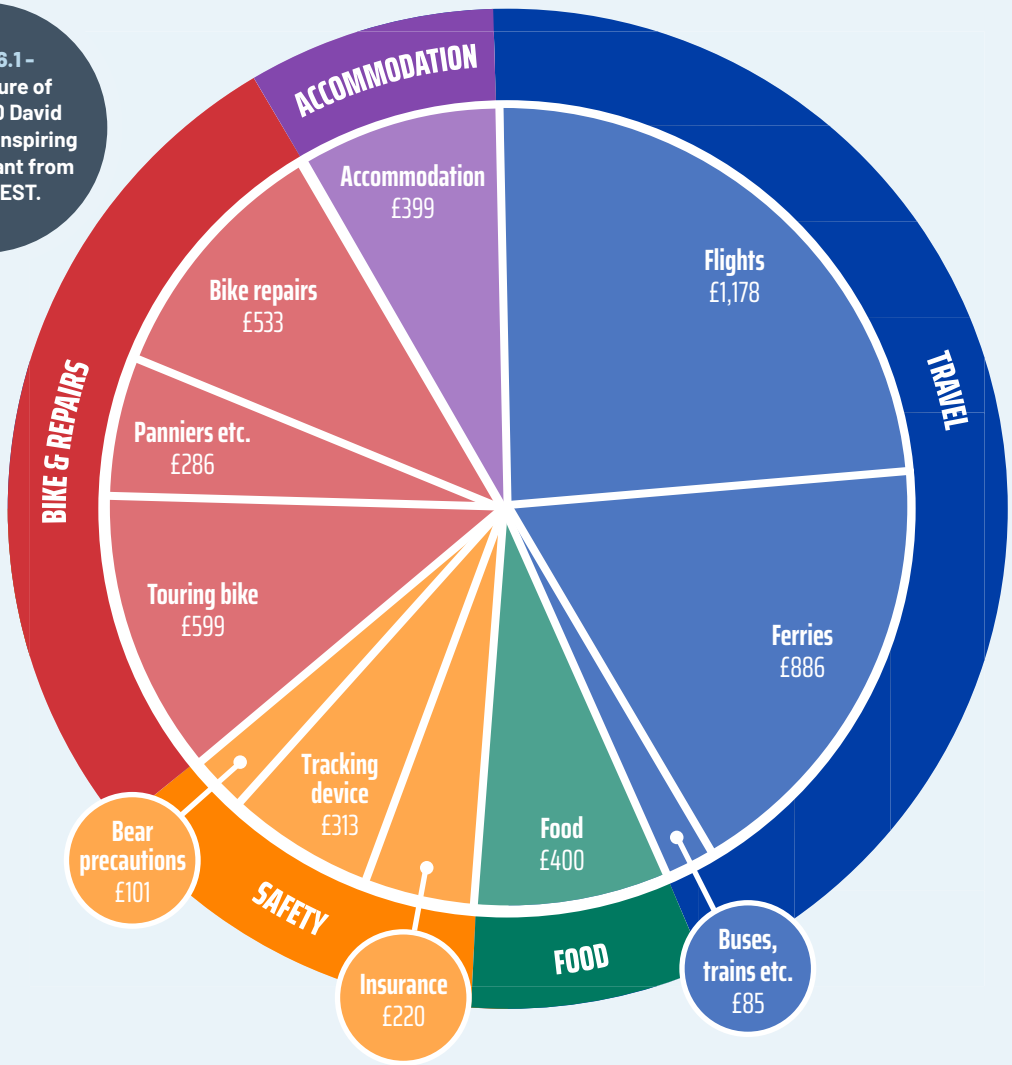
6. Appendix – budget expenditure

As previously mentioned, the David Henderson Inspiring Journey grant from the IMarEST made The Gray Whale Cycle possible. Without the grant I am not certain my journey following the southward migration of the gray whales would have been undertaken. I am immensely thankful to David Henderson's family and the IMarEST for having chosen to support The Gray Whale Cycle.

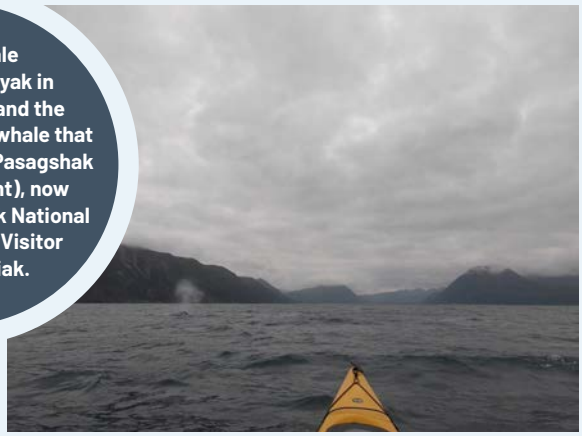
The grant covered all of the travel expenses of the journey, including flights, ferries, buses and trains, plus many of the other major costs including: purchasing a touring bike and the waterproof panniers necessary to carry my camping gear, safety equipment that gave me peace of mind and a means of calling for help from even the most remote locations, and also sizeable proportions of my food and accommodation expenditure (Fig. 5.1).

Figure 6.1 – Expenditure of the £5,000 David Henderson Inspiring Journey grant from the IMarEST.



7. Appendix – more from the road

Alaska



A gray whale seen from a kayak in Ugak Bay (left) and the skeleton of a gray whale that washed ashore in Pasagshak Bay in 2000 (right), now displayed in Kodiak National Wildlife Refuge Visitor Centre, Kodiak.

A Pacific white-sided dolphin approaching the *M/V Kennicot* in the Inner Passage, British Columbia (left), and fishing vessels tied up near Yakutat, apparently the first Alaskan town to have a surf shop (right).

Washington

After disembarking the ferry in Bellingham, I had a 40-mile cycle to Anacortes to catch another ferry to San Juan island where I spent a great couple of days learning about the Salish Sea, visiting Lime Kiln State Park and The Whale Museum in Friday Harbour, and seeing some of the island's wildlife, including a fox (right).

7. Appendix – more from the road

From San Juan island I travelled to Sidney, Vancouver Island. A fantastic whale-watching trip from Victoria included sightings of sea lions (left), killer whales (right), Dall's porpoise and humpback whales.

Washington - *continued*

Having taken a ferry from Victoria to Port Angeles, back on mainland Washington, my route first took me along the Olympic Peninsula to Neah Bay, then south to La Push. The autumnal scenery of Washington (left) and frequent sightings of bald eagles (right) kept me entertained during the long days of cycling.

I was slightly less enamoured with the weather, with torrential rain (left), low temperatures and multiple punctures (right) making for tough days.

Oregon

After riding 346 miles along the forest-cloaked coast of Washington, the rain and punctures continued into Oregon. Days with punctures were frustrating and my progress felt slow. Four punctures over four consecutive days was a definite low point; a change of strategy was required.

Depoe Bay was an exciting stop on my route, made better by a break in the rain and more gray whale sightings. One whale was seen from the gray whale fountain on the main street (left), while another three gray whales were seen close to shore from nearby Rocky Creek State Park (right).

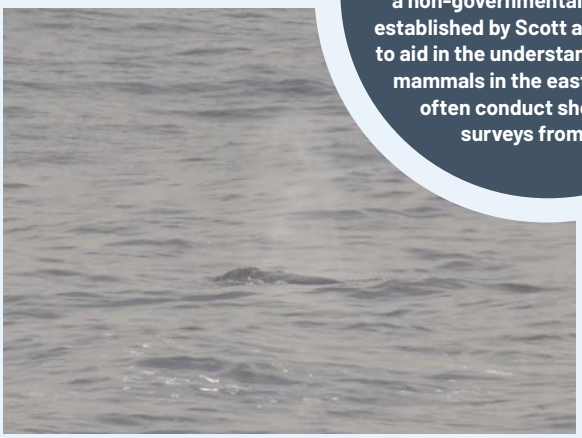
Drastic times called for drastic measures and, having reached Newport (left), I promptly ordered some solid tyres for my bike. The week-long wait for the tyres gave me an opportunity to meet scientists at Oregon State University's Marine Mammal Institute, explore the Hatfield Marine Science Visitors Centre and see some of the local sights. By the time of my departure (right), wildfires were raging in northern California.

7. Appendix – more from the road

California

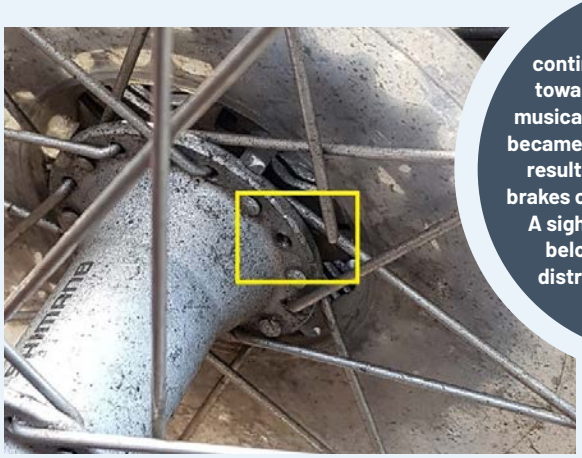
Six weeks and more than 900 miles into my trip, I cycled into California (left). Recent rain and lower temperatures had diminished the risk of wildfires in northern California, although fires continued burning further south. My route took me through miles and miles of magnificent Redwood forest (right) where the bear sightings continued.

In Fort Bragg I was able to visit the excellent Noyo Center for Marine Science, with its incredible killer whale skeleton. Sarah Grimes, the center's marine mammal stranding coordinator, kindly showed me the sights, including a gray whale skeleton at nearby MacKerricher State Park.



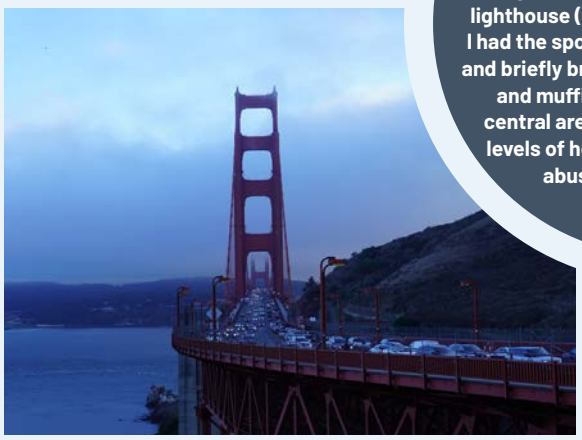
Stranded near Manchester Beach following a broken spoke, I visited Point Arena Lighthouse (left) where a brief gray whale sighting (right) made my day. The Mendonoma Whale and Seal Study – a non-governmental organisation established by Scott and Tree Mercer to aid in the understanding of marine mammals in the eastern Pacific – often conduct shore-based surveys from here.

California - *continued*



My bike troubles continued as I headed south towards San Francisco. The musical ping of snapping spokes became all too familiar, as did the resultant wobble and rubbing brakes of the newly wonky wheel. A sighting of a gray whale far below me was a welcome distraction as I cycled hilly, cliffside miles.

Reaching San Francisco and cycling over the Golden Gate bridge (left) was a happy milestone and I celebrated with a whale watching trip during which the fog lifted only long enough for a quick glimpse of Point Bonita lighthouse (right). Whilst in San Francisco I had the spokes of my rear wheel replaced and briefly broadened my diet from noodles and muffins. Staying in Tenderloin, a central area of San Francisco with high levels of homelessness and substance abuse, was an unexpected eye opener.



Wildlife sightings continued as I continued south, including a coyote in Golden Gate Park, San Francisco, a gang of raccoons at Half Moon Bay (left) and otters aplenty in Moss Landing (right). Unfortunately, my new spokes didn't last long and my time in Santa Cruz was spent getting a new rear wheel fitted to my bike.

7. Appendix – more from the road

California – *continued*

Monterey Bay is a world-renowned for it's incredible marine life. My time there was a highlight of my trip and featured otters, seals (left), sea lions, humpback whales (right), Pacific white-sided dolphins and – a new species for me – northern right whale dolphins!

Monterey Bay Aquarium was incredible. A second visit – this time with local sea otter citizen scientist Robert Scoles – was required after I accidentally missed a sizeable portion of the aquarium on my first visit.

California – *continued*

Point Lobos Whaling Cabin lies to the south of Monterey, nearer Carmel. The Whalers Cabin was built by Chinese fishermen in the 1850s and was the site of whaling station from 1862 to 1879. Vast pots for melting blubber stood outside whilst an array of flensing tools lined the museum's walls.

South of Monterey, Big Sur is a rugged but beautiful stretch of coastline. Thanksgiving traffic on the twisting Highway 1 made for some close calls but regular stops to appreciate the bluffs and beaches helped calm my nerves.

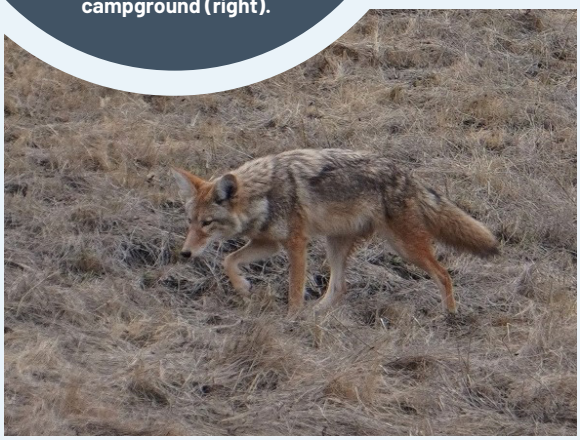
Storm-force winds and torrential rainfall arrived, triggering numerous rockfalls that closed Highway 1 to cars. After waiting a day in the hope the weather would abate, I decided to push on and had the toughest day of my trip cycling less than 30 miles from Gorda to San Simeon.

7. Appendix – more from the road

California – *continued*

My arrival in San Simeon, drenched, cold and exhausted, was rewarded with excellent elephant seal sightings on the beach.

Continuing south, the end of my trip was fast approaching. Having been on the road for ten weeks, I was only permitted to remain in the US for two more weeks. Short of time and eager to avoid a section where the road de viated inland, I cycled to San Luis Obispo, seeing coyotes (left) and another bear along the way, and took a train to Santa Barbara. Back on the road, camping opportunities became less frequent and my last night of camping was a memorable one at Sycamore Canyon campground (right).



California – *continued*

After more stormy weather, I finally reached Santa Monica having cycled almost 1,750 miles and travelled a total of 4,000 miles from Alaska on my journey to follow the southward migration of the gray whales. My final visit was to Point Vicente Interpretive Centre to meet Alisa Schulman-Janiger, director of the Gray Whale Census and Behaviour Project, a shore-based gray whale census that has been running since 1984. When I visited on 8th December, it was a year to the day since the team had seen their first southbound gray whale of the previous year's migration. In 2019, however, the first southbound gray whale was seen on the 12th December, two days later than the first pair of gray whales was seen in Ojo de Liebre, the most northerly of the Baja lagoons having completed their migrations.

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