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All's Whale that Ends Whale: How Correctly Identifying Antarctic-Feeding Grounds of Oceania Humpbacks Could Save an Endangered Population

Davey Holmes
Pomona College

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Davey Holmes

In partial fulfillment of a Bachelor of Arts Degree in Environmental Analysis, 2015-16 academic year, Pomona College, Claremont, California

Readers:
Char Miller, Pomona College
Travis Horton, University of Canterbury

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Pomona College, Claremont, CA, Environmental Analysis Program

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1. Abstract

Although major whaling practices have ceased, increasing human involvement and influence in the world's marine ecosystems continue to adversely effect global whale populations. It is a major concern throughout Antarctic waters, where endangered Oceania Humpback Whales (*Megaptera novarangliae*) annually feed. This study analyzes the extent to which a proposed marine protected area within the Ross Sea may indirectly harm the last remaining endangered population of Humpbacks. Using current satellite tracks of southern Humpback migrations, this model maps the effects of displaced Toothfish fisheries, and suggests further conservations efforts, based on New Zealand's Precautionary Approach, to protect these vulnerable whales.

2. The Last Ocean

The Ross Sea is a 3.6-million km^2 stretch of ocean off the west coast of Antarctica. Located approximately 4,000 km south of New Zealand, it has been nicknamed the "Last Ocean" and it is not just a ploy to get your attention. In 2008 a group of researchers at the National Center for Ecological Analysis and Synthesis mapped out human disturbance around the globe. The Ross Sea proved to be the most pristine area left on the planet.[1] Having escaped the devastation of pollution, invasive species, and human exploitation, this small stretch of water offers a uniquely unspoiled and dynamic ecosystem found nowhere else. As the Ross Sea is tucked into the Antarctic coastline (Figure 1), the waters remain between -1 and 4 degrees Celsius at the surface.[2] Due to extreme cold, Antarctica, the planet's southern most landmass, remains the only continent that has never been inhabited by humans.[3]

Yet even the region's brutal temperatures – air temperatures in Antarctica can fall as low as -89 degrees Celsius – have not managed to keep human curiosity at bay. Discovered in 1841 by James Clark Ross, the Ross Sea has since served as a crucial access point to the South Pole and increasingly important Antarctic research sites, such as those in McMurdo Sound.[4] As explorers and scientists have surveyed the area, they have documented the incredible geographic and biological features of

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[1] Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C., ... & Fujita, R. (2008).

[2] Murphy, E. J., Watkins, J. L., Trathan, P. N., Reid, K., Meredith, M. P., Thorpe, S. E., ... & Forcada, J. (2007). Spatial and temporal operation of the Scotia Sea ecosystem: a review of large-scale links in a krill centred food web. *Philosophical Transactions of the Royal Society B: Biological Sciences*,*362*(1477), 113-148.

[3] The Ross Sea. (2015). Retrieved December 9, 2015, from http://www.lastocean.org/Ross-Sea/Last-Ocean-New-Zealand-__I.103

[4] Cameron, et al., 2012, pp. 5.

the Ross Sea. The most readily noticeable and defining characteristic of the area is the massive Ross Ice Shelf, which covers nearly half the bay and is about the size of France (Figure 1). Stretching 700km long at its northern face, the ice shelf is over 400 meters thick, rising almost 40 meters above the surface of the water.[5] Early explorers knew this frozen wall as the Ross Barrier.[6]

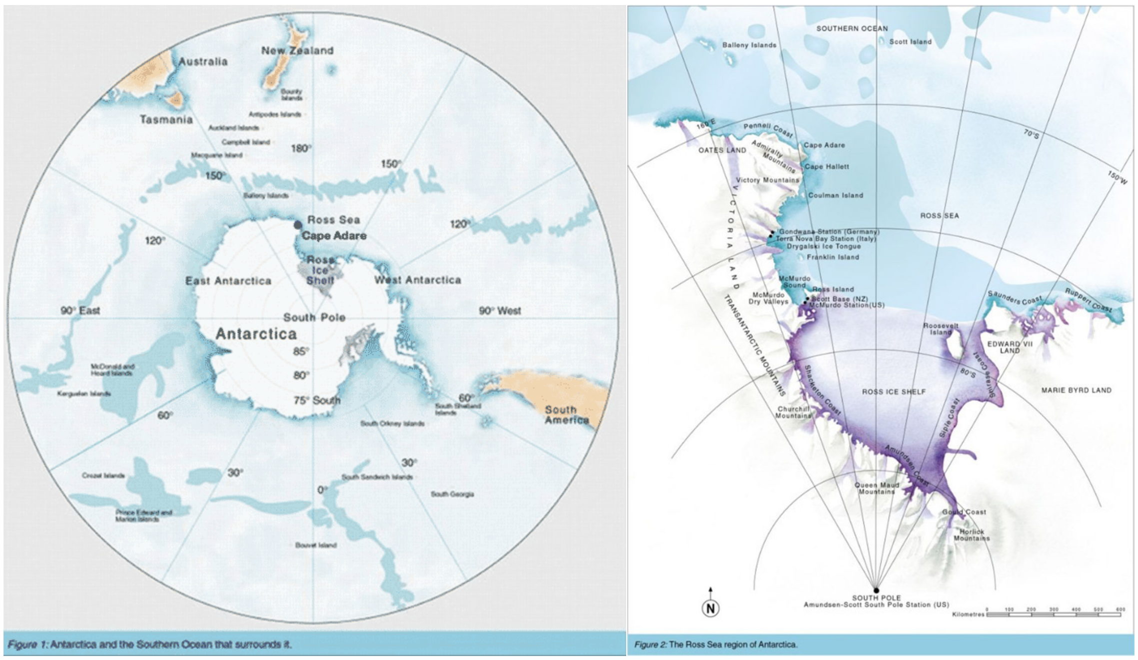

Figure 1. (Left) The Ross Sea sits directly along the International Date Line (180 degrees longitude). It is the nearest access to the South Pole.[7] (Right) Coving nearly half of the Ross Sea bay, the Ross Ice Shelf constitutes the single largest floating ice sheet in the world.[8,9]

500 meters below the ice, the continental shelf extends out to the northern edge of the Ross Sea. As the shelf angles down to the 3,000-meter deep sea floor of the South Pacific, the continental slope creates an optimal habitat for a rich

[5] Cameron, et al., 2012, pp. 7.
[6] The Ross Sea, 2015.
[7] Map of Antarctica. (2015). Retrieved December 9, 2015, from http://www.norwaysforgottenexplorer.org/english/MapofAntarctica/
[8] Cameron, A., Campbell, S., & Christian, C. (2012). Antarctic Ocean Legacy: A Marine Reserve for the Ross Sea. *Antarctic Ocean Alliance*. Retrieved December 9, 2015, from http://antarcticocean.org/wp-content/uploads/2013/03/AOA-Ross-Sea-Report-ENGLISH.pdf
[9] Map of Antarctica, 2015.

biodiversity of sea life. Along the slope upwelling currents brings nutrients, which alongside vast expanses of melting sea ice, help to spur on primary production in the area, drawing much of the Ross Sea's wild-life.[10]

While it was previously believed that sea ice served as little more than a resting spot for algae trapped during ice formation, today scientists understand the dynamic motions of sea ice to be vital in the lifecycle of krill and the entire southern ecosystem.[11] During periods of melt, live cells and detritus, which were stuck in the ice, are released. As summer temperatures heat the ice, the accelerated melt leads to increased nutrient dumps, which work to seed ice edge blooms where conditions are ripe for primary productivity of phytoplankton, in turn driving the regional production of krill.[12,13,14,15] Relative to other zooplankton, krill (*Euphausia surberba*) grow to a larger size (around 60mm) and live longer (5-10 years).[16] As a result, krill are a keystone of the Antarctic food web, supporting many large-bodied predators, as the dominant food chain path goes from phytoplankton to krill to predators.[17]

The unusually high production within the Ross Sea constitutes 28% of total phytoplankton production below 50 degrees South.[18] Although the Ross Sea comprises just 2% of the Southern Ocean, the high concentrations of phytoplankton

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[10] The Ross Sea, 2015.

[11] Ackley, S. F., & Sullivan, C. W. (1994). Physical controls on the development and characteristics of Antarctic sea ice biological communities—a review and synthesis. *Deep Sea Research Part I: Oceanographic Research Papers,41*(10), 1583.

[12] Ackley & Sullivan, 1994, pp. 1584

[13] Murphy, et. al., 2007, pp. 114.

[14] Murphy, et. al., 2007, pp. 137.

[15] Ackley & Sullivan, 1994, pp. 1584

[16] Murphy, et. al., 2007, pp. 137.

[17] Murphy, et. al., 2007, pp. 114.

[18] Cameron, et al., 2012, pp. 11.

make it the most productive stretch of all Antarctic waters. It also creates the potential for an incredibly robust food chain.[19] Consequently, the Ross Sea "is one of the healthiest functioning ecosystems left on the planet."[20]

As scientists continue to explore the area, high levels of biodiversity have quickly become a defining characteristic of the area. A third of the world's Adélie penguins make there home there, alongside almost a third of the world's Antarctic petrels and Emperor penguins.[21] Ross Sea waters also host nearly a dozen mammalian species, including Humpback and Minke whales, Weddell and Leopard seals, and Orcas.[22] In addition, 95 known species of fish inhabit the area, comprised of 61 notothenoids (a family of fish native to Antarctic waters that have a protein in their blood to prevent them from freezing), 34 non-notothenoids, and 7 species endemic to the Ross Sea.[23] Alongside the wide variety of vertebrates, over 1,000 known species of invertebrates also swim in the cold Antarctic waters.

Within this diverse ecosystem, there is clear evidence of top-down control of the food web, as grazing and predatory habits significantly affect the dynamics of krill and phytoplankton communities.[24] The removal of the large seal and whale predation over the last two centuries decreased the predation on krill populations, and has "undoubtedly generated long-term top-down cascade effects and modified the local plankton population" – effects that will continue to influence the future of

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[19] Ballard, G., Jongsomjit, D., Veloz, S. D., & Ainley, D. G. (2012). Coexistence of mesopredators in an intact polar ocean ecosystem: the basis for defining a Ross Sea marine protected area. *Biological Conservation*, *156*, 73.
[20] Sherirff, N. (2014). East-West hostility may stall Ross Sea conservation. Aljazeera America.
[21] The Ross Sea, 2015.
[22] Ballard, et al., 2012, pp. 73.
[23] Cameron, et al. 2012, pp. 12.
[24] Murphy, et. al., 2007, pp. 138.

the Southern Ocean food web.[25] By the early 21st century, as keystone predators have begun to recover, krill and other grazer stocks have begun to decrease in number.[26] Yet, aside from recent ecological shifts in predation, a decline in krill abundance has also been linked to changes in sea ice.[27] Recent studies have estimated that Krill populations have decreased by over 50% in parts of the Southern Ocean over the last 30 years. There are indications that as a result krill dependent predators maybe on the verge of decline.[28]

Today, the sheer breadth and abundance of top predators has become a characteristic of the Ross Sea.[29] As Ballard, et al. (2012) note: "owing to its relative isolation from human civilization and protection of its coastal habitat under the Antarctic Treaty, including several Antarctic Specially Protected Areas, it is the anthopogenically least affected stretch of ocean remaining on Earth."[30,31] Still, the area's current pristine state does not protect it from changes in planetary processes, however delayed the effects may be. Similarly, the wealth of marine resources available throughout the Ross Sea makes the area a prime target for the expansion of human development that could devastate this rare and endemic ecosystem.

[25] Murphy, et. al., 2007, pp. 138.
[26] Ballard, et al., 2012, pp. 71.
[27] Murphy, et. al., 2007, pp. 139.
[28] Murphy, et. al., 2007, pp. 115.
[29] Cameron, et al. 2012, pp. 13.
[30] Halpern, et al., 2008
[31] Ballard, et al., 2012, pp. 73.

3. Threats to the Ross Sea

Like many environments around the globe, climate change poses one of the greatest threats to the health of the Ross Sea ecosystem. Zhang (2007) suggests that it is possible for the Antarctic sea ice to actually increase despite significantly warming atmospheric conditions.[32] Although increasing sea ice may seem beneficial, given the importance of the ice edge for the nourishment of phytoplankton and subsequently the entirety of the food web, a significant extension of sea ice could severely decrease habitable ocean territory leading to increases in competition among the many species in the area. In addition to changing coastal-morphological conditions, climate change directly threatens the base of the Antarctic food web. Worldwide, oceans are already 30% more acidic than preindustrial levels. By 2100, the Southern Ocean is expected to become under-saturated in aragonite, a form of calcium carbonate used by key species to develop their shells, which will undermine the Antarctic food web. This is especially concerning as aragonite levels in the southern ocean are already low.[33]

Despite the extreme global impacts of climate change, it is not the only or necessarily even the most significant threat to the region. Working synergistically with climate change, the recently developed commercial fishing industry has begun to put intense pressure on the marine ecosystem in and around the Ross Sea.[34]

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[32] Zhang, J. (2007). Increasing Antarctic sea ice under warming atmospheric and oceanic conditions. *Journal of Climate*, *20*(11), 2527.

[33] Cameron, et al., 2012, pp. 9.
[34] Cameron, et al., 2012, pp. 15.

One of the most extensive and contentious fishing practices in the Southern Ocean is that of the Antarctic Toothfish Industry. A key predator in the southern ecosystem, the Antarctic Toothfish (*Dissostichus mawsonii*), also known as the Chilean Sea Bass (Figure 2), has become highly prized by chefs and seafood lovers in the US, Japan, and EU.[35] Living up to 50 years, the Antarctic Toothfish can reach up to 175cm and 80kg. However, they are not thought to spawn annually, which, in conjunction with their late maturity, makes them extremely vulnerable to overfishing.[36] While this species has long been studied for its ability to produce anti-freeze glycoproteins to prevent freezing in sub-zero waters, very little is known about their population numbers or structure.[37]

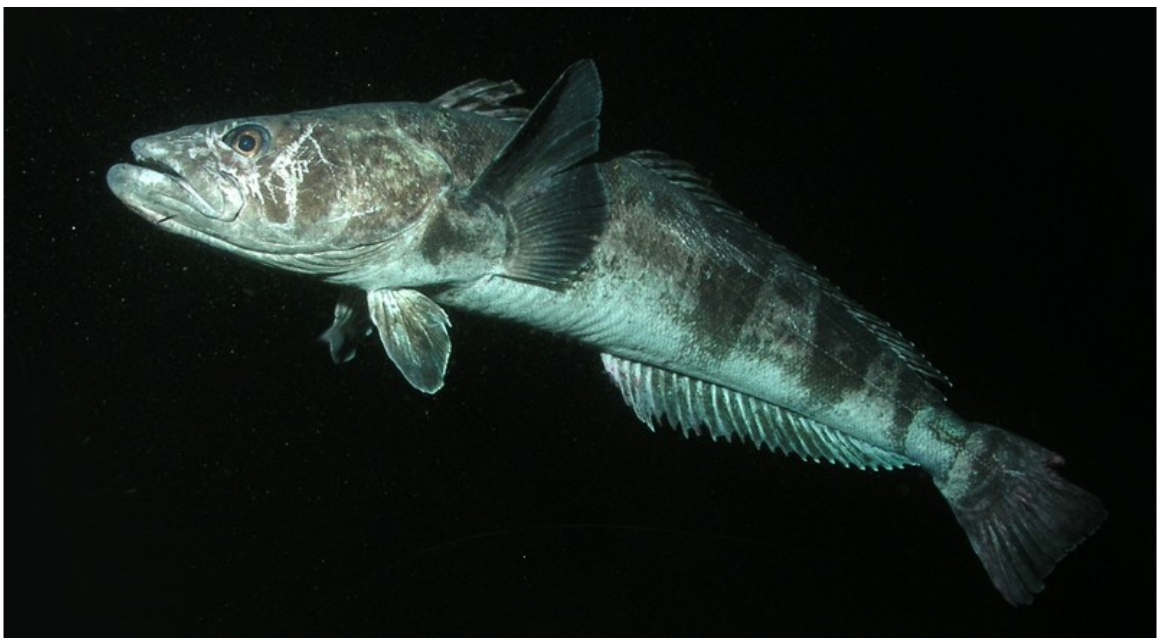

Figure 2. Antarctic Toothfish – also known as a Chilean Sea Bass[38]

[35] Agnew, D. J. (2000). The illegal and unregulated fishery for toothfish in the Southern Ocean, and the CCAMLR catch documentation scheme. *Marine Policy*, *24*(5), 367.

[36] Cameron, et al., 2012, pp. 13.

[37] Roberts, J.; Xavier, J.C.; and Agnew, D.L. (2011). The diet of toothfish species *Dissostichus eleginoides* and *Dissostichus mawsoni* with overlapping distributions. Journal of Fish Biology 79: 138–154.

[38] The Ross Sea, 2015.

In 1996, New Zealand began an experimental Toothfishery in the Ross Sea.[39] By 1998 only harvesting 41 tons were harvested.[40] However, within two years, the demand for the lucrative Chilean Sea Bass skyrocketed, leading to an annual take of 754 tons. By the new millennium, other nations, along with illegal fishers began exploiting the Antarctic Toothfish in the Ross Sea. As a result, in 2011, an estimated 20% reduction in the size of the adult population had already occurred.[41] Still, the total Antarctic Toothfish catch continues to rise, reaching 3,820 tons during the 2013/14 season – 3,320 tons of which were taken from the Ross Sea.[42]

The commercial fishing practices of the Toothfish industry within the Ross Sea undermine the ecological stability of the area and the pursuit of science in the world's last intact marine ecosystem. Compounding the biological factors however, fishermen search for and harvest the largest and oldest individuals, who are bound to be the best breeders, further crippling the population. Despite an American led "Take a Pass on the Chilean Sea Bass Campaign," boycotts from celebrity chefs, and legal catch quotas, Toothfish continue to sell rapidly in the US, Europe and Japan. In 2005, the market price for Toothfish approached $20 per pound, more than five times higher than when Toothfish were fist introduced to the Western markets in the 1980s. With an entire fish selling for upwards of $1,000 the Toothfish has quickly become one of the most valuable fish in the sea.[43]

[39] Sheriff, 2014.
[40] Agnew, 2000, pp. 365.
[41] Cameron, et al., 2012, pp. 9.
[42] Scientific Committee for the Conservation of Antarctic Marine Living Resources. (2014). Report of the Thirty-third Meeting of the Scientific Committee. *XXXIII*. Retrieved December 9, 2015, from https://www.ccamlr.org/en/system/files/e-sc-xxxiii_1.pdf
[43] Greenberg, P. (2005, October 23). The Catch. *The New York Times Magazine*.

Yet, the effects of overfishing far exceed the damage to one population or species. Around the world, the removal of high-level predators has led to spectacular and unexpected consequences that permeate every trophic level. The canonical example of a trophic cascade involves the extinction of wolves from Yellowstone National Park. At the opening of the park, wolves and other predators were not protected, and government sponsored control programs in the early 20th century effectively worked to exterminate the keystone species from Yellowstone. After the last wolf was killed in 1926, elk population exploded, as the wolves had previously preyed upon them.[44] As the elk multiplied, deciduous trees, such as aspen and cottonwood, suffered from over grazing. Without the dense groves of leafy trees, songbirds began to leave the park, leaving a once-vibrant and musical region still and silent. Without the vast expanse of roots working to stabilize the earth, rivers began to tear through their banks, leading to increased flooding.[45] It was only after more than half a century that the US government finally recognized the importance of this top predator in its native ecosystem and in 1995 reintroduced wolf populations. Almost immediately, elk populations began to decline as they were forced into less favorable areas, lowering their nutrition and reproductive success.[46] Consequently, deciduous groves have begun to rebound, bringing back songbirds, beavers, and other animals dependent on the unique habitat.[47,48,49,50]

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[44] Haines, Aubrey L. (1996). *The Yellowstone Story—A History of Our First National Park.* **II**. Niwot, CO: University Press of Colorado. pp. 80–82.
[45] Stolzenburg, William (2008). *Where the Wild Things Were*. Jeffers Literary Press.
[46] Ellig, Tracy (2009). Montana State University News Service.
[47] "Beyond the Headlines". *Living on Earth*. March 20, 2015. Retrieved October 30, 2015.

Just like that of the wolf, the danger in overfishing the Antarctic Toothfish lies in the species' important, yet vastly understudied role in the ecosystem. Having never found an egg or larval Toothfish, scientific analysis of the species and proposed management of its harvest is largely based on guesswork.[51] It is however likely that Toothfish occupy a keystone role in the environment, serving as a significant predator of smaller fish and squid as well as prey for larger species, including Sperm whales, Orcas, Weddell seals, and colossal squid.[52] Therefore the removal of Toothfish could lead to a boom in smaller fish and squid throughout the Ross Sea, in turn increasing predatory pressures on lower level organisms such as krill and phytoplankton, just as an increase in elk jeopardized the future of deciduous groves in Yellowstone. A decrease in krill population would then threaten the future of migratory baleen whale that come to the area to feed during summer months. Evidence of a trophic cascade effect has already been observed in the decline of Orcas, which heavily prey upon the Toothfish.[53] Additionally, since 1987, the fishing efficiency (number of Toothfish caught per hour fishing) of scientific expeditions has decreased from .0136 fish per hours to a mere .0005 fish per hour in 2007 (a decrease of 2,720%).[54] During this same period of time, the

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[48] Yellowstone National Park Wolf Reintroduction is Changing the Face of the Greater Yellowstone Ecosystem, YellowstonePark.com, June 21, 2011. Retrieved October 28, 2015

[49] Chadwick , D.H. (2011). "Keystone Species: How Predators Create Abundance and Stability". Mother Earth News.

[50] "Weaving A New Web: Wolves Change An Ecosystem", *Zoogoer* magazine, May/June 1998, Smithsonian National Zoo.

[51] The Ross Sea, 2015.

[52] The Ross Sea, 2015.

[53] Ainley et al (2010) An apparent decrease in the prevalence of "Ross Sea killer whales" in the southern Ross Sea. Aquatic Mammals 35: 335-47.

[54] DeVries, A. L., Ainley, D. G., & Ballard, G. (2008). Decline of the Antarctic toothfish and its predators in McMurdo Sound and the southern Ross Sea, and recommendations for restoration. *CCAMLR Document, WG-EMM-08/xx*.

commercial Toothfish catch has increase from negligible amounts as late as 1995 to 3,320 tons in the 2013-14 season, within the Ross Sea alone.[55]

In essence, this ecosystem is unique because it has, until this point, been able to remain essentially unaffected by climate change and threatening human development. It has been able to develop independently and largely naturally. Consequently the Ross Sea has become a pristine oasis of balanced biodiversity with a complex food web. Anthropogenic disruption of the established equilibrium of a pristine ecosystem, such as that of the Ross Sea, has already begun and will continue to seriously threaten its future.

[55] CCAMLR Statistical Bulletin, Volume 19, and CCAMLR Performance Review 2008.

4. Marine Conservation Efforts

Human effects on marine ecosystems remain somewhat hidden from the public eye because they are far off shore and/or beneath the water. In fact, many people only come to realize the threats of overfishing through increases in fish prices at the market. Technological innovations are a major catalyst of overfishing and have allowed fisheries to expand and exploit areas and populations that once were blocked by environmental or economic impasses. Those hurdles no longer exist and that is "why we have to declare marine reserves, because we can fish everywhere," said professor Daniel Pauly, marine biologist and fisheries expert at the University of British Columbia in Canada. "Whether it's the deep seas or stormy, icy waters, they're all accessible now. We can fish in Antarctica. We can break the ice. We can maintain ourselves in far away places".[56]

Humans' global reach can be modified through the use of new marine-conservation initiatives. Among these is one that the US and international organizations have been focusing on – Marine Spatial Planning. The United Nations Educational, Scientific, and Cultural Organization's guide to Marine Spatial Planning defines it as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process."[57] The United States expands this definition by asserting that MSP be based on sound-science to reduce environmental impacts and preserve critical ecosystem services,

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[56] Sheriff, 2014.
[57] Gopnik, M., Fieseler, C., Cantral, L., McClellan, K., Pendleton, L., & Crowder, L. (2012). Coming to the table: Early stakeholder engagement in marine spatial planning. *Marine Policy*, *36*(5), 1139

among other goals, to meet the aforementioned objectives.[58] Notably in 2005, 193 nations agreed to protect 20-30% of each marine habitat by 2012 and 10% of the oceans by 2010. However, as implementation of protection areas quickly fell behind schedule, in 2010, delegates of the 193 nations met at the 10th Conference of the Parties to the UN Convention on Biological Diversity (CBD) to extend the deadline to 2020.[59]

The primary tool in protecting the world's ocean has been the implementation of Marine Protected Areas (MPAs), which work to enclose and protect parts or all of a marine ecosystem. While the term "marine protected area" first appeared at the 1962 World Conference on Nation Parks in Seattle, it was not until 1976 that an international conference was held to address international progress in establishing these marine reserves.[60,61] As of the 2010 Conference of the Parties to the UN CBD, only 1.17% of the world's oceans were protected by MPA designations.[62] While twelve parties (Dominican Republic, Ecuador, Estonia, Germany, Guam, Heard and McDonald Islands, Jordan, Kiribati, New Zealand, Northern Mariana Islands, South Africa, and the U.S. minor outlying islands) are

[58] Gopnik, et al., 2014, pp. 1139

[59] Marinesque, S., Kaplan, D. M., & Rodwell, L. D. (2012). Global implementation of marine protected areas: Is the developing world being left behind?. *Marine Policy*, *36*(3), 727.

[60] de Morais, G. W., Schlüter, A., & Verweij, M. (2015). Can institutional change theories contribute to the understanding of marine protected areas?. *Global Environmental Change*, *31*, 155.

[61] Noël, J. F., & Weigel, J. Y. (2007). Marine protected areas: from conservation to sustainable development. *International Journal of Sustainable Development*, *10*(3), 233-250.

[62] Chuenpagdee, R., Pascual-Fernández, J. J., Szeliánszky, E., Alegret, J. L., Fraga, J., & Jentoft, S. (2013). Marine protected areas: Re-thinking their inception. *Marine Policy*, *39*, 234.

considered leaders, having already exceeded the CBD's 2020 goal of protecting 10% of their oceans, the majority of the world has not kept up with this promise.[63]

To rapidly address the deficiency in numbers of MPAs, international organizations and initiatives, such as the Global Ocean Legacy, have pushed for the creation of large scale, no-take MPAs – marine reserves off limits to fishing practices – to protect some of the world's last remaining pristine areas. These campaigns have been successful in increasing the MPA surface area of certain advanced economies, most notably around the Chagos archipelago in the Indian Ocean, Northern Mariana Islands in the Pacific Ocean, Australia's Coral Sea, and New Zealand's Kermadec Trench.[64] "Conceptually, [these large MPA's] correspond with the precautionary principle when faced with unknown consequences, which is largely the case with complex marine ecosystems," governments should embrace the social responsibility to protect an ecosystem from exposure to harm until sound evidence emerges that no harm will result.[65] In practicality, studies have continued to show positive conservation impacts on the marine ecosystems within MPAs.[66]

While MPAs can range from a network of small protection areas to a single large area, covering over 100,000km^2 and entire pelagic areas, the Chagos MPA, a proven success, set a record at the time of its implementation in 2010 as the largest

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[63] Fox, H. E., Soltanoff, C. S., Mascia, M. B., Haisfield, K. M., Lombana, A. V., Pyke, C. R., & Wood, L. (2012). Explaining global patterns and trends in marine protected area (MPA) development. *Marine Policy*, *36*(5), 1137.

[64] Marinesque, et al., 2012, pp. 736.

[65] Chuenpagdee, et al., 2013, pp. 234.

[66] Al-Abdulrazzak, D., & Trombulak, S. C. (2012). Classifying levels of protection in Marine Protected Areas. *Marine Policy*, *36*(3), 576.

MPA in the world.[67] Measuring over 640,000km^2, the Chagos MPA is more than two times the surface area of the United Kingdom, the area's controlling nation. While it has worked to safeguard and foster one of the healthiest reef ecosystems in the world, its extended reach has also shown to have a positive effect on the endangered migratory Green Sea Turtle.[68] Tracking data of the Green Sea Turtle shows that the Chagos MPA protects the turtles during their breeding season as they primarily stay near nesting beaches within the MPA.[69] By simply protecting breeding areas, the MPA has led to an increase in hatching success (proportion of successful hatchings per egg laid).[70] However, even though the Chagos MPA covered a vast expansion of ocean, a debate remains as to whether the MPA is actually large enough to offer maximized protection of the turtle species.[71] Studies have shown that while the Chagos MPA aids the recovery of Green Sea Turtles, "targeted protection of small coastal foraging areas could supplement this large MPA and increase the amount of time migratory species are in protected zones."[72] Since the implementation of the Chagos MPA, four more recent conservation areas have surpassed it in size, including the 2012 Australian Coral Sea Commonwealth Marine Reserve (989,842 km^2), the 2012 UK South Georgia Marine Protected Area (1,070,000 km^2), the 2014

[67] Hays, G. C., Mortimer, J. A., Ierodiaconou, D., & Esteban, N. (2014). Use of Long-Distance Migration Patterns of an Endangered Species to Inform Conservation Planning for the World's Largest Marine Protected Area.*Conservation Biology*, *28*(6), 1637.

[68] Sheppard, C. R., Ateweberhan, M., Bowen, B. W., Carr, P., Chen, C. A., Clubbe, C., ... & Gaither, M. R. (2012). Reefs and islands of the Chagos Archipelago, Indian Ocean: why it is the world's largest no-take marine protected area. *Aquatic conservation: marine and freshwater ecosystems*,*22*(2), 232-261.

[69] Hays, et al. 2014, pp. 1640.

[70] Hays, et al. 2014, pp. 1643.

[71] Hays, et al. 2014, pp. 1647.

[72] Hays, et al. 2014, pp. 1642.

US Pacific Remote Islands Marine National Monument (1,271,500 km^2), and the 2012 French Natural Park of the Coral Sea (1,292,967 km^2).[73]

[73] Pacific Remote Islands Marine National Monument. (2014). Retrieved December 9, 2015, from http://www.mpatlas.org/mpa/sites/8345/

5. Ross Sea Marine Protected Area (RSMPA)

Since in 2005, the United States and New Zealand worked to co-sponsor a proposal at the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to create a Marine Protected Area spanning 1.25 million km^2 in the Ross Sea (RSMPA). Of that, 1.14 million km^2 would be a no-take zone, off-limits to fisheries (Figure 3).[74] Although some of the MPA would be opened to limited commercial catches of Antarctic Toothfish and "special research zones" for limited scientific catches, it would protect a huge swath of the unique, yet vulnerable ecosystem. The RSMPA would continue the recent trend of protecting entire ecosystems with expansive conservation reserves.

Current U.S.–N.Z. Ross Sea Proposal and Historic Toothfish Catch 1998–2011

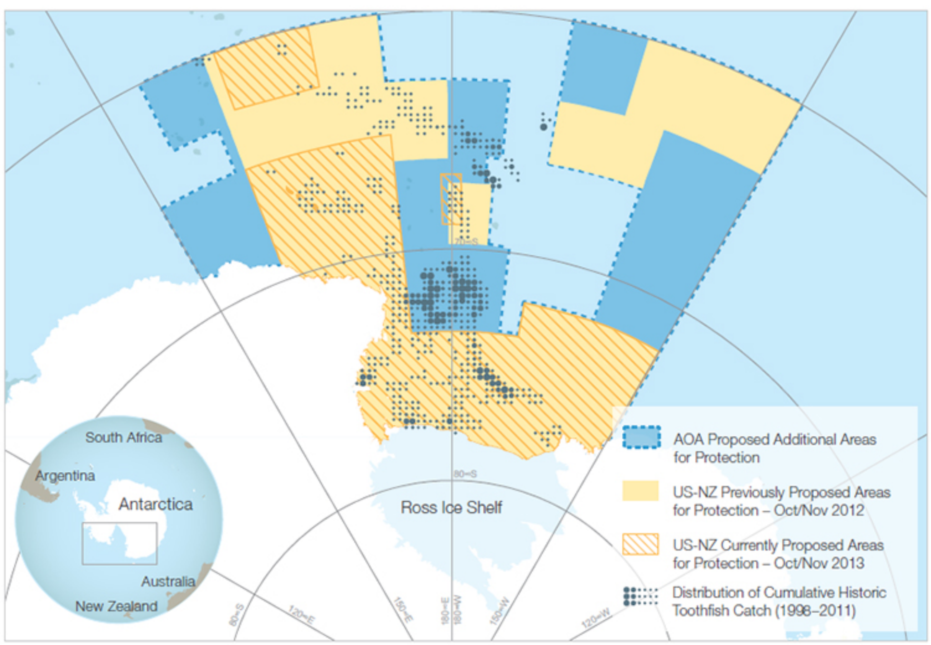

Figure 3. Although the current U.S.-NZ Ross Sea Proposal would create one of the largest MPAs in history, many NGOs argue for its expansion as political negotiations have already reduced its coverage.[75]

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[74] Ross Sea Marine Reserve Proposal. (2015, October 15). Retrieved December 9, 2015, from http://www.pewtrusts.org/en/multimedia/data-visualizations/2015/ross-sea-marine-reserve-proposal

[75] Ross Sea Marine Reserve Proposal, 2015.

The RSMPA would follow in the footsteps of the 2009 implementation of the South Orkney Islands Southern Shelf Marine Protected Area by CCAMLR. Comprising 94,000km^2, it became the first marine protected area in the southern ocean. However, the Southern Orkney MPA was not the first measure taken to protect and conserve the vulnerable Southern Ocean ecosystem.

In 1961, 12 nations who had scientists active in and around Antarctic, signed the Antarctic Treaty, putting a halt to the mad dash of the early 20th century to lay claim on Antarctic territories.[76] The treaty set aside the entire continent for scientific and peaceful purposes, halting ambitious nations from claiming the territories for their resources.[77] Today, 53 nations are party to the Treaty. CCAMLR was originally established as part of the Antarctic Treaty system to protect the species and ecosystems of the Southern Ocean, yet did not take force until 1982. The international commission is comprised of 25 member nations, including notably the US, China, EU, Japan, Russia, Australia, and New Zealand, among others. Eleven other states have acceded to the commission.[78] Stemming from the spirit of the Antarctic Treaty, CCAMLR's central objectives align with three conservation principles, based on the best available science:

1. To prevent any harvested population from falling below a naturally sustainable level.
2. To maintain and restore ecological relationships between harvested, dependent, and related populations within the Antarctic marine ecosystem.
3. To prevent or minimize change to the Antarctic ecosystem.[79]

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[76] The Antarctic Treaty. (2011). Retrieved December 9, 2015, from http://www.ats.aq/e/ats.htm
[77] Sheriff, 2014.
[78] Acceding States. (2014, December 9). Retrieved December 9, 2015, from https://www.ccamlr.org/en/organisation/acceding-states
[79] Cameron, et al., 2012.

The purpose of the proposed RSMPA reflects the intentions of both the Antarctic treaty and CCAMLR. The Delegations of New Zealand and the United States wrote in the RSMPA proposal: "Our delegations propose that CCAMLR establish this MPA to conserve marine living resources; maintain ecosystem structure and function; protect vital ecosystem processes and areas of ecological significance; and promote scientific research, including through the establishment of reference areas."[80] Throughout the proposal, the delegates emphasize the "exceptional ecological value" of the Ross Sea, citing its importance as the most productive stretch of the Sothern Ocean and its unique position as on of the last remaining ecosystems with its fully community of top-level predators. The importance of protecting this unique ecosystem will intensify as climate change continues to alter the world's oceans. According to IPCC predictions, the Ross Sea will be the last remaining area of the Southern Ocean with year-round ice as climate change proceeds. The same report continues by predicting that the Ross Sea will become a refuge for species as other waters warm and will serve as an area to study adaption and evolution as an environment changes.[81]

Along with the desire to preserve the Ross Sea ecosystem, New Zealand and the US see an opportunity to use this undisrupted ecosystem for future scientific research. Scientific data sets from the Ross Sea are among the largest and oldest of any in the Southern Ocean. Strong data sets include information on Adélie penguin,

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[80] Delegations of New Zealand and the United States. (2012). Proposal for the Establishment of a Ross Sea Region Marine Protected Area. Retrieved December 9, 2015, from http://www.nmfs.noaa.gov/ia/slider_stories/2013/07/ross_sea/ross_sea_mpa_proposal_for_web_story.pdf

[81] Cameron, et al., 2012, pp. 15.

Weddell seal, and Antarctic Toothfish populations, as well as hydrographic properties and benthic fauna within the Ross Sea.[82] Current data from the area will serve as control data, without the added noise of human interference, as scientists track the effects of climate change.[83] Such studies will be crucial in identifying the complete, global impacts of a changing planet.

Given the importance of the area, in 2010, more than 500 scientists signed a letter calling on CCAMLR to ban fishing and create a marine reserve around the entire Ross Sea.[84] However, MPAs are never introduced in a political or institutional vacuum. On an international scale, broader social and political issues often influence their creation.[85] Despite the Antarctic Treaty, early territorial claims continue to influence negotiations as non-claimant nations see the MPA as a way to exclude them from the claimant territories. Russia has been the most vociferous about this issue. It has continued to try to block the implementation of the RSPMPA, claiming that CCAMLR has no authority to establish the reserve – an argument the US State Department dismisses as "absolutely incorrect."[86] Recent political tensions between the US and Russia, however, have not helped remedy the mired negotiations. Talks took a downturn in 2013 when Russia granted asylum to NSA whistleblower Edward Snowden.[87] Consequently, President Obama cancelled a summit with Russian President Vladimir Putin. Snowden, Russia's annexation of Crimea, followed by international sanctions against Russia have led to a new-post

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[82] Cameron, et al., 2012, pp. 15.
[83] Delegations of New Zealand and the United States, 2012, pp. 1.
[84] Sheriff, 2014.
[85] Chuenpagdee, et al., 2013, pp. 238.
[86] Sheriff, 2014.
[87] Sheriff, 2014.

Cold War low in relations between the West and Russia. "It's taken a tremendous amount of time, money and negotiations to get this far," said Andrea Kavanagh, director of the Pew Charitable Trust Global Penguin Conservation Campaign, expressing his frustrations. "Talk of the Ross Sea marine reserve began over a decade ago, but Russia and Ukraine seem to be employing blocking tactics rather than engaging in earnest negotiations."[88] It is unclear whether the resistance by Russia is a political power play, an economically driven policy to prevent lucrative fishing grounds from being taken out of circulation, or both.

As with any political decision, compromises must be made. Specifically, when solving environmental problems the dilemma often becomes balancing economic growth with conservation. The US State Department has recognized the diverse needs and demands of many parties involved, altering RSMPA borders to bring countries on board while maintaining parameters set by the scientific community. However, as a result, the RSMPA has been reduced to almost a third the size of the original proposal. As countries such as Russia, Ukraine, and China come to the negotiation table with economic motives, conservation objectives may become suppressed. One US State Department Official voiced his unease, stating: "There are pressures on CCAMLR to focus more on fishing rather than conservation, and this is a continuing concern of the US."[89] A Ross Sea Marine Protected Area would have tremendous consequences for the ecosystem, scientific community, and economic players in the area.

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[88] Sheriff, 2014.
[89] Sheriff, 2014.

6. Oceania Humpback Whale Population

Although MPAs are often viewed as the apex of marine conservation efforts, establishing no-take zones within a confined area can have significantly negative effects for the surrounding ecosystems. CCAMLR itself has acknowledged that creating the RSMPA would require the Convention to reassess conservation measures concerning the Antarctic Toothfish fishery, such that fishing displaced by the MPA would be redistributed into the surrounding areas.[90] Increasing Toothfish catches outside of the RSMPA naturally alters the established equilibrium of the surrounding ecosystems, further endangering already vulnerable species and populations. One such population is the endangered Oceania Humpback Whale population, which uses areas around the Ross Sea as summer feeding grounds. Still recovering from the devastating effects of commercial whaling, the Oceania Humpbacks are uniquely vulnerable to alterations in the ecosystem. As human development and pursuit of economic gain has already driven these magnificent creatures near extinction, we must adequately assess the potential harm any further actions may have on the population.

6a. History of Whaling

Although unintentional offshoots of the RSMPA may adversely affect Oceania Humpbacks, the RSMPA aims to protect a unique and sensitive ecosystem. By contrast, throughout the history of human-whale interactions, humanity has pursued a much more malicious approach.

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[90] Delegations of New Zealand and the United States, 2012, pp. 6.

In the 11th century, the Basques of Northwest Spain began the first sustained commercial fishery targeting whales in the Bay of Biscay. For much of whaling history, humans have valued these large marine mammals as a resource for exploitation. Whale oil was burned for light, while whale meat became a source of food protein.[91] Although whale products had become commonplace throughout Europe and Eastern Asia, the commercial whaling industry remained limited. From the 11th century, through the time of Melville's Moby Dick, the technology available was rarely able to catch and overcome the faster great whales, such as the Finback and the Blue.

Whalers would give chase under sail before sending out smaller, wind or man-powered boats to pursue the whale. For nearly a thousand years the killing of a whale required hand-thrown harpoons to slow the whale before finishing it with a lance thrust deep into a vital organ. From there the whalers would either tow the body into port, or butcher the animal alongside the whaling vessel.[92] While whaling vessels could rarely catch the faster great whales, the brunt of the whaling industry fell onto slower species, such as the Humpback, Right, and Sperm whales.

By 1860, technological advancements were creating favorable conditions for the expansion of commercial whaling. In 1861, the Norwegian Svend Foyn patented a bow mounted exploding lance, which became known as the "bomb lance." This innovation revolutionized whaling, providing more effective means of killing whales, both quickly and from a distance. Around this same time, the sail began to

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[91] Herrera, G. E., & Hoagland, P. (2006). Commercial whaling, tourism, and boycotts: An economic perspective. *Marine Policy*, *30*(3), 261.

[92] Clapham, P. J., & Baker, C. S. (2002). Whaling, modern. *Encyclopedia of marine mammals. Academic Press, San Diego, CA*, 1328.

give way to the steam engine, radically changing the whaling industry, as they were now able to chase down any whale with their faster ships. By 1900, traditionally hunted populations of whales had become commercially exhausted.[93]

As new technology increased the number and diversity of whales available to whalers, so too did the discovery of the Southern Ocean whale stocks. After arriving at the South Atlantic island of South Georgia in 1904, Norwegian whaler, C.F. Larsen, reported having seen hundreds and thousands of whales. "Modern whaling had found its greatest playground," Clapham &Baker (2002) observed, "and a slaughter unparalleled in whaling history was about to begin."[94]

At the height of operations, hundreds of humpbacks were taken every month from the Southern Ocean. By 1915, the Southern Georgia population of humpbacks had been hunted to virtual extinction, with a total catch of some 18,557 whales.[95] Still, a dependence on land stations significantly limited whalers throughout the early 20th century. However, with the development of the factory ship, the industry was no longer tied to the land and could operate for extended periods of time in open water. The *Lansing* became the first factory ship in operation and set out for Antarctic waters in 1925. Whale carcasses could be dragged up the stern ramp and dismantled down to the bone within half an hour.[96] As a result, all Antarctic waters quickly became accessible to the whaling industry.

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[93] Clapham & Baker, 2002, 1329.
[94] Clapham & Baker, 2002, 1329.
[95] Clapham & Baker, 2002, 1330.
[96] Clapham & Baker, 2002, 1330.

Over the next six decades, more than two million whales were taken from the southern hemisphere.[97,98] The exploitation of whales nearly eliminated an entire trophic level from the marine ecosystem.[99] During the 20th Century, southern Humpback populations bore the brunt of devastating whaling practices. At a time when 208,359 Humpbacks were taken, including over 13,000 within the 1961-62 summer alone, south pacific Humpbacks were nearly hunted to extinction.[100-101-102]

Luckily, due to World War II, the whaling industry was forced to temporarily cease operations. In 1946, following the end of WWII, all major whaling nations (including Japan and Russia) signed onto the International Convention for the Regulation of Whaling, creating the new international governing body[103].

In 1949 the first species-specific quota for Humpbacks was put in place. Although committed to science, especially in its early years, the IWC was forced to concede to political and economic pressures allowing a 25,000 annual humpback quota despite scientists recommending a halt to all humpback whaling. Due to the lack of any level of enforcement, the first humpback quota was immediately exceeded in three subsequent seasons.[104] Reliant on a system of observers and inspectors to monitory whaling operations, IWC quotas were well intentioned, yet

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97 Garrigue, C., Dodemont, R., Steel, D., & Baker, C. S. (2004). Organismal and'gametic' capture-recapture using microsatellite genotyping confirm low abundance and reproductive autonomy of Humpback whales on the wintering grounds of New Caledonia. *Marine Ecology Progress Series*, *274*, 251-262.

98 Clapham & Baker, 2002, 1330.

99 Baker, C. S., & Clapham, P. J. (2004). Modelling the past and future of whales and whaling. *Trends in Ecology & Evolution*, *19*(7), 365.

100 Department of Conservation - Te Papa Atawhai. (2012). *The Conservation of Whales in the 21st Century*. New Zealand Department of Conservation.

101 Mikhalev, Y. A. (2000). Whaling in the Arabian Sea by the whaling fleets Slava and Sovetskaya Ukraina. *Soviet Whaling Data (1949-1979). Page (s)*, 141-181.

102 Garrigue, et al., 2004.

103 Clapham & Baker, 2002, 1330.

104 Clapham & Baker, 2002, 1330.

lacked the rigor needed. Inspectors were placed at shore stations and factory ships. However, "because the inspector is often from the same nation that he is policing, inspection is often lackadaisical," Harris (2003) noted, "The nationals are too sympathetic to their country's commercial and economic interests to make the voluntary program effective."[105] It was not until 1972 that the International Whaling Commission acted on its failures and instituted an Independent Observer Scheme, whereby two independent states would exchange observers.[106] By that time, the damage had been done.

As demand for whale oil dissipated in the early 20th century in favor of cheaper alternatives, such as kerosene, so too did the political power of the whaling industry.[107] Politicians were now free from the economic pressures of whaling, leading public sentiment to take on an even larger role in a nation's stance on the practice. As the 1960s US environmental movement gained momentum, politicians in western nations could gain popularity and be seen as environmentally conscious by simply opposing whaling.[108] The shifting public perception became epitomized during the 1972 United Nations Conference on the Human Environment in Stockholm with the famous phrase: "How can you save the earth if you cannot save the whale?"[109]

In 1986, the dawdling IWC responded, placing a moratorium on all whaling practices. At this time, however, Soviet whaling was already coming to an end; "with

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[105] Harris, A. W. (2003). Participatory Management of the Commons.*Policymaking and Peace: A Multinational Anthology*, 141.
[106] Harris, 2003.
[107] Morishita, J. (2006). Multiple analysis of the whaling issue: understanding the dispute by a matrix. *Marine Policy*, *30*(6), 806.
[108] Morishita, 2006, pp. 802.
[109] Morishita, 2006, pp. 806.

aging capital and the imminent dissolution of the USSR, the nation that had wreaked so much havoc on whale populations slowly removed itself from the business of commercial whaling." At the same time, however, Japan and Iceland began circumventing the moratorium through a concept they called "scientific" whaling, which allowed member nations to issue themselves permits for whaling on the basis of scientific research.[110-111]

In 1993, following the end of the Cold War, USSR scientist revealed the true impact of the Soviet whaling industry; its whaling fleet routinely killed every whale they came across, regardless of size, age, or protection status. The Soviet takes numbered over 200,000 in the southern hemisphere alone. By far the most significant disparity is in the number of humpbacks taken; while the Soviets only reported 2,710 catches, newly released accounts reveal the actual number to exceed 48,000.[112-113] Within the single season (1959/60) two Soviet factory ships accounted for over 13,000 humpbacks, mainly from Antarctic waters south of Australia and Oceania.[114]

To this day, while most migratory population of southern humpback whales have recovered to or near pre-whaling numbers, the Oceania sub-population remains the only group to be listed on the IUCN Red List as endangered.[115,116] Even

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[110] Herrera, 2006, pp. 261.
[111] Morishita, 2006, pp. 802.
[112] Clapham & Baker, 2002, pp. 1330.
[113] Clapham, P. J., Childerhouse, S., Gales, N. J., Rojas-Bracho, L., Tillman, M. F., & Brownell, R. L. (2007). The whaling issue: conservation, confusion, and casuistry. *Marine Policy*, *31*(3), 317.
[114] Clapham & Baker, 2002, pp. 1330.
[115] Horton, T. (Personal communication, February 24th, 2015).
[116] Childerhouse, S., Jackson, J., Baker, C.S., Gales, N., Clapham, P.J. & Brownell Jr., R.L. 2008. *Megaptera novaeangliae (Oceania subpopulation)*. The IUCN Red List of Threatened Species. Version 2014.3. www.iucnredlist.org.

without current pressures of whaling, Garrigue, Greaves, & Chambellant (2001) estimate the remaining population consists of only 314 individuals, less than 10% of pre-whaling numbers. With so few Oceania Humpbacks remaining, it is imperative that we know where these whales are at all times of the year to best protect them.

6b. Annual Migrations

From late May to September, Oceania Humpbacks congregate in the warm tropical waters of the South Pacific Islands to breed. During non-breeding months they embark on a massive, >5,000km migration south to feed in nutrient rich Antarctic waters. As the whales migrate south, native Maori, as well as biologists have long documented their appearance along the New Zealand coast.[117] While a multitude of studies dating back to Risting's 1912 publication have identified Oceania humpbacks in New Zealand waters, Melanesian people have recorded humpback migratory patterns far longer, as the appearance of these great whales have influenced many traditions and legends.[118]

The most famous legend refers to Paikea and the whale rider. There once was a chief Uenuku of a South Pacific island known as Hawaiki. Chief Uenuku had 71 sons – 70 of which were born to noble mothers, while one, named Ruatapu, was born to a slave. One day as Uenuku combed the hair of his 70 noble sons, Ruatapu

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[117] Dawbin, W. H. (1966). The seasonal migratory cycle of Humpback whales.*Whales, dolphins and porpoises. University of California Press, Berkeley*, 145-171.

[118] Garrigue, C., Greaves, J., Chambellant, M. 2001. *Characteristics of the New Caledonian Humpback* Clapham, P. J., Young, S. B., & Brownell, R. L. (1999). Baleen whales: conservation issues and the status of the most endangered populations. Mammal Review, 29(1), 37-62. *Whale Population*. Memoirs of the Queensland Museum, Brisbane. 47.2. ISSN 0079-8835.

asked why his father wouldn't comb his hair. Uenuku replied that combs were sacred and could only touch the head of royalty. As Ruatapu was not born of a noble mother, he was lesser than his brothers. Infuriated, Ruatapu vowed to seek revenge.[119]

One day, Uenuku decided to build a canoe for his many sons. After felling a tree and spending weeks carving out the canoe, Uenuku was ready to send off his sons in the morning. Ruatapu, however, saw this as an opportunity, cutting a hole in the bottom of the boat and filling it with wood chips.[120] As the boat took off in the morning, Ruatapu covered the hole with the heel of his foot until the canoe was out of sight of witnesses on the land. Ruatapu removed his foot from the hole and as the boat sank, drowned all his brothers but one, Kahutia-te-rangi. As Ruatapu swam after him, Kahutia-te-rangi called on Tangaroa, the god of the sea, for help. Tangaroa sent a Humpback whale (called "paikea" in Maori) to save him, and Kahutia-te-rangi rode the whale to safety.[121] In a last ditch effort, Ruatapu uttered a chant sending five giant waves after his half-brother, but Kahutia-te-rangi was already too far away. The waves instead bounced off the land and rushed over Ruatapu, drowning him. Meanwhile the Humpback whale had carried Kahutia-te-rangi to the east coast of the North Island of New Zealand. There, Kahutia-te-rangi

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[119] The Story of Paikea and Ruatapu. (1962, September 1). Retrieved December 10, 2015, from http://teaohou.natlib.govt.nz/journals/teaohou/issue/Mao40TeA/c5.html

[120] Whale Rider. Retrieved December 10, 2015, from http://whaleriderreligiousstudies.weebly.com/maori-mythology.html

[121] Maori Mythology and the Legend of Paikea. (2015, February 19). Retrieved December 10, 2015, from http://sites.psu.edu/tetirclblog/2015/02/19/maori-mythology-and-the-legend-of-paikea/

took the name Paikea to honor his savior, founding the Ngāati Porou, a Māori tribe, and becoming the first settler of New Zealand[122].

The legend of Paikea and the whale rider is consistent with seasonal Humpback appearances of Humpbacks along the eastern shore of the North Island of New Zealand every spring. Such tales have historically been used to track the movements of migratory animals long before the development of technology. However, as the whales continue south of New Zealand into uninhabited territory, historical narratives of Humpback movements fall off.

Using modern technology, scientists have begun to fill in this gap in traditional knowledge. As early as the 1950's, primitive whaling discovery-tracks and reports published by the New Zealand Department of Conservation suggested that Oceania Humpbacks feed on the western edge of the Ross Sea. Such theories were based on the notion that Humpbacks would follow the meridonal shortest-distance migration routes from their winter breeding grounds to summer feeding grounds. Yet, as whaling tracking data has continued to develop, the expected summer feeding grounds of Oceania Humpbacks expanded eastward. In 1966, Dawbin identified Oceania humpbacks as members of the Area V humpback population - those summering in Antarctic waters between 130 degrees E and 170 degrees W.[123] Garrigue, et al. have since corroborated this theory, using photo identification comparisons to place Oceania humpbacks in Area V. More recently, satellite tracking has been used to map humpback migrations from winter breeding

[122] Māori Whale Riders. (n.d.). Retrieved December 10, 2015, from http://whales.fieldmuseum.org/behind/people/maori-whale-riders
[123] Garrigue, et al., 2001.

grounds near New Caledonia. However, despite placing tracks on dozens of whales over the past decade, only two tracking devices have managed to record the location of Oceania Humpbacks as they make their way to Antarctic waters (Figure 4).[124]

Figure 4. Satellite tags have been able to track parts of the Oceania Humpback migratory route, showing these whales travel further east than once believed.

As we will later examine, these two tracks suggest that Oceania Humpback migrate to feeding grounds far east of the related East Australian Humpback population and

[124] Horton, T. 2015

the currently proposed Ross Sea Marine Protection Area. These two successful tracks are the catalyst of this study.

6c. Where are they going?

The migration of humpbacks is a crucial aspect of the species' life cycle. While they breed in the warm tropical waters off the Pacific islands, many of these areas are devoid of dense collections of food. Due to the lack of plankton swarms, it is thought that humpbacks do not feed in low latitudes or during their migrations.[125,126,127] Thus, during their long migrations and breeding season, humpbacks experience an extended period of nutritional stress and a detrition of body conditions.[128] Antarctic feeding grounds as a result become increasingly important, as "food quality and intake need to be optimized on feeding grounds in order to sustain migration and breeding behavior and, for females, lactation and pregnancy."[129] It is probable then that Oceania Humpbacks, as is likely with all populations of Humpbacks, are specifically migrating to areas of high food concentration. While it has been suggested that euphausiids (which include krill)

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[125] Stockin, K. A., & Burgess, E. A. (2005). Opportunistic feeding of an adult humpback whale (Megaptera novaeangliae) migrating along the coast of Southeastern Queensland, Australia. *Aquatic Mammals*, *31*(1), 120-123.

[126] Chittleborough, R. G. (1965). Dynamics of two populations of the humpback whale, Megaptera novaeangliae (Borowski). *Marine and Freshwater Research*, *16*(1), 33-128.

[127] Dawbin, 1966.

[128] Laerm, J., Wenzel, F., Craddock, J. E., Weinand, D., Mcgurk, J., Harris, M. J., ... & Barros, N. B. (1997). New prey species for northwestern Atlantic humpback whales. *Marine Mammal Science*, *13*(4), 705-711.

[129] Witteveen, B. H., Worthy, G. A., Foy, R. J., & Wynne, K. M. (2012). Modeling the diet of humpback whales: An approach using stable carbon and nitrogen isotopes in a Bayesian mixing model. *Marine Mammal Science*, *28*(3), E233-E250.

comprise only 5-30% of humpback diets[130], more recent studies have shown the mean Nitrogen-15 has decreased in whale diets over the years, indicating that mature whales are likely to be feeding more heavily at lower trophic levels, making krill an extremely important resource.[131]

The largest of any euphausiid species, krill constitute the largest biomass of the group and are a key species in the Southern Ocean, supporting a commercial fishing industry alongside the multitude of native predators. Although the Atlantic section of the Southern Ocean (0-90 degrees W) hold approximately 75% of the total stock, regional collections of krill occur around the Southern Ocean.[132] Despite the importance of krill, widespread uncertainty remains within the scientific community regarding their diets. While previously krill had been accepted as strictly herbivores, later studies have emphasized the presence of protozoans, marine snow, and smaller zooplankton in its diet.[133] These findings generated the hypothesis that the species switched prey depending on availability; during winter months, when phytoplankton populations decline, krill begin consuming a higher proportion of copepods.[134] However, subsequent quantitative volumetric gut studies of Sothern Ocean krill found that copepods constitute on average only 7% of

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130 Witteveen, B. H., Foy, R. J., Wynne, K. M., & Tremblay, Y. (2008). Investigation of foraging habits and prey selection by humpback whales (Megaptera novaeangliae) using acoustic tags and concurrent fish surveys.*Marine Mammal Science*, *24*(3), 516-534.

131 Witteveen, et al., 2012.

132 Atkinson, A., Ward, P., Hunt, B. P. V., Pakhomov, E. A., & Hosie, G. W. (2012). An overview of Southern Ocean zooplankton data: abundance, biomass, feeding and functional relationships. *CCAMLR Science*, *19*, 171-218.

133 Perissinotto, R., Gurney, L., & Pakhomov, E. A. (2000). Contribution of heterotrophic material to diet and energy budget of Antarctic krill, Euphausia superba. *Marine Biology*, *136*(1), 129-135.

134 Atkinson et al., 2012.

post-larvae krill diets, despite serving as an alternative food source.[135] Still further studies have shown the overwhelming dependence of post-larvae krill on seasonal blooms of phytoplankton, as the krill rely on large seasonal lipid stores.[136]

Relying on ocean currents to move about in the water, phytoplankton naturally accumulate within regions of the Southern Ocean. Similar to terrestrial plant-life, phytoplankton, also known as microalgae, rely on sunlight and key nutrients to survive[137]. Using chlorophyll, these single celled organisms produce energy through the process of photosynthesis. Growth in phytoplankton populations can be extremely rapid, depending on available nutrients, water temperatures, salinity, and what types of predators are grazing on the population, among other factors (Figure 5).[138]

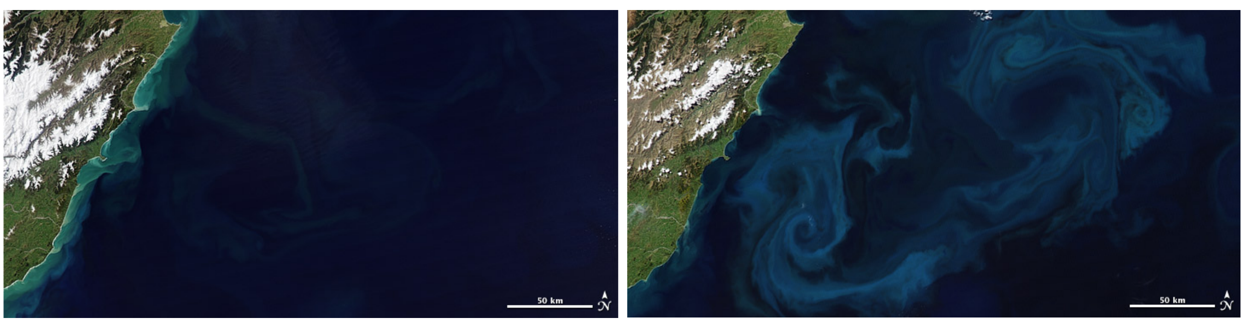

Figure 5. These two satellite images show a rapid bloom of phytoplankton off the coast of New Zealand between October 11th (Left) and October 25th, 2009 (Right).[139]

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[135] Schmidt, K., Atkinson, A., Steigenberger, S., Fielding, S., Lindsay, M., Pond, D. W., ... & Achterberg, E. P. (2011). Seabed foraging by Antarctic krill: Implications for stock assessment, bentho-pelagic coupling, and the vertical transfer of iron. *Limnology and Oceanography*, *56*(4), 1411-1428.

[136] Quetin, L. B., & Ross, R. M. (1989). Effects of oxygen, temperature and age on the metabolic rate of the embryos and early larval stages of the Antarctic krill Euphausia superba Dana. *Journal of Experimental Marine Biology and Ecology*, *125*(1), 43-62.

[137] What are phytoplankton? (2014, April 29). Retrieved December 10, 2015, from http://oceanservice.noaa.gov/facts/phyto.html

[138] Lindsey, R., & Scott, M. (2010). What are Phytoplankton? Retrieved December 10, 2015, from http://earthobservatory.nasa.gov/Features/Phytoplankton/

[139] NASA images by Robert Simmon and Jesse Allen, based on MODIS data

Scientists study phytoplankton populations by taking samples directly from the water. Population patterns may become evident through repeated sampling at permanent, fixed observation stations[140]. However, given the rough waters and brutal climate of the Southern Ocean, direct sampling can be extremely dangerous. Rather than risk their lives, scientists, especially those examining the broader phytoplankton distribution of a region or on a global scale, look towards satellite imagery to approximate population densities. Although individually tiny, when congregated in blooms of billions of phytoplankton, the chlorophyll within the organism actually alter the way in which light is reflected off the surface of the water, as exemplified in Figure 5.[141] The waters can take on a reddish, greenish, or brownish tint. Scientists use the differences in color to estimate density and biomass of phytoplankton populations throughout the world's oceans.

While phytoplankton populations are able to be located using satellite imagery, krill populations cannot. However, as the primary food for krill, we can use phytoplankton density and biomass as an indicator for krill population throughout the Southern Ocean; the higher the concentration and biomass of phytoplankton in an area, the higher the probability of krill populations nearby. With greater concentrations of krill, these areas would be most suitable to migrating Humpbacks in need of rich, dense pockets of food. Two well-established and documented populations of Southern migratory Humpbacks seem to follow this pattern.

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[140] Lindsey & Scott, 2010.
[141] Lindsey & Scott, 2010.

The Brazilian population of Humpback whales migrates annually down the coast of Brazil before crossing the South Atlantic to reach their summer feeding grounds just north of the Weddell Sea (Figure 6).

Figure 6. Satellite tracks of Brazilian Humpbacks show their migration from the east coast of Brazil to feeding grounds just north of the Weddell Sea.

This region, extending from the Antarctic Peninsula out into Southeast Atlantic, hosts one of the largest krill populations in the world, a fact collaborated by the presence of the majority of krill harvesting practices.[142] The area is also characterized by consistently dense swaths of phytoplankton (exemplified by chlorophyll levels consistently above .8mg/m^3; Figure 7).

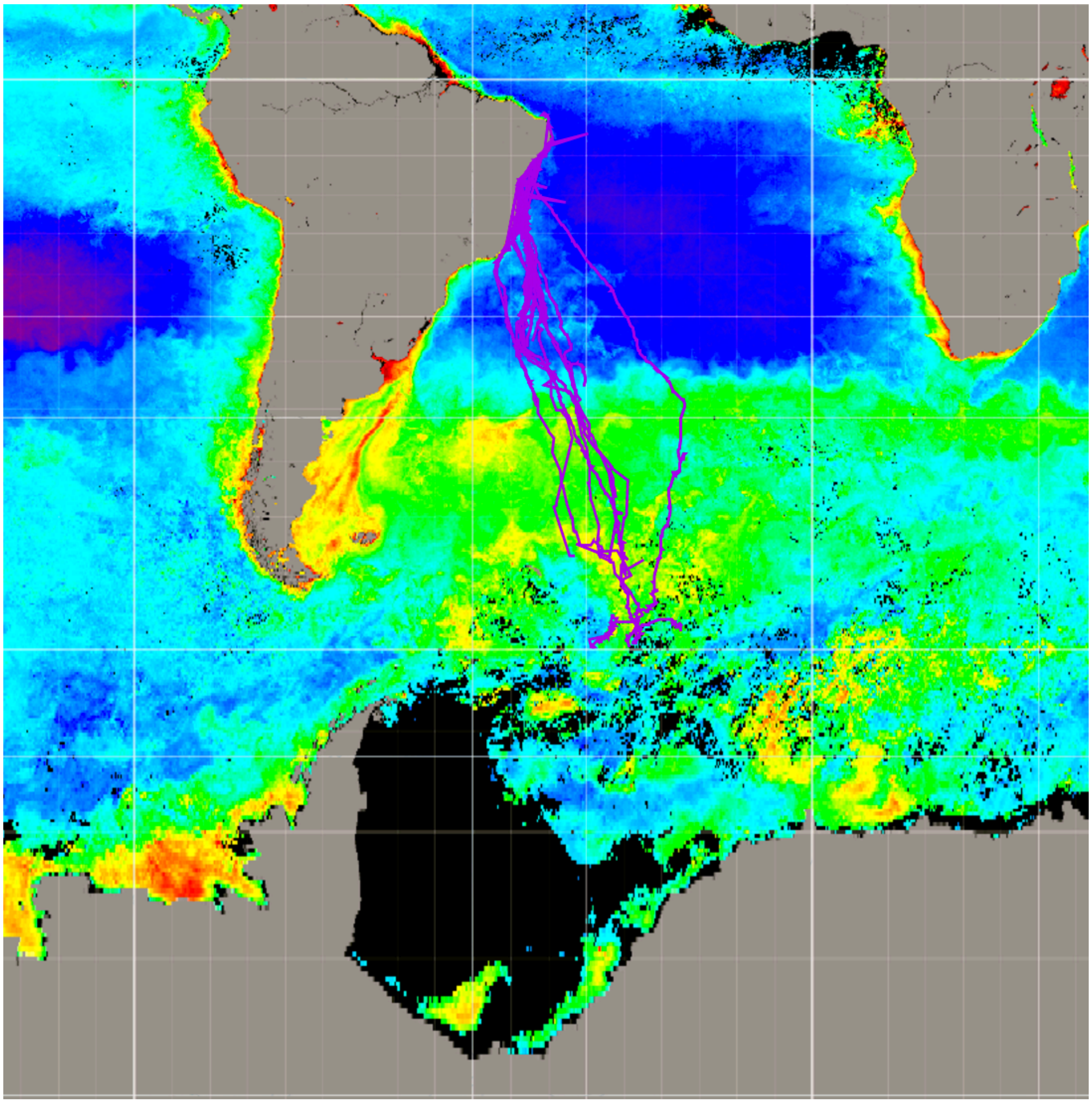

Figure 7. Brazilian Humpbacks migrate to an area of high chlorophyll concentration within the Southeast Atlantic.

142 Krill Fishing in the Antarctic Peninsula. (2015, April 1). Retrieved December 10, 2015, from http://www.pewtrusts.org/~/media/assets/2015/04/sos-interactives/krillfishingintheantarcticpeninsula.pdf?la=en

Similarly, the East Australian population of Humpbacks whales migrates annually down the coast of Australia to the western edge of the Ross Sea (Figure 8).

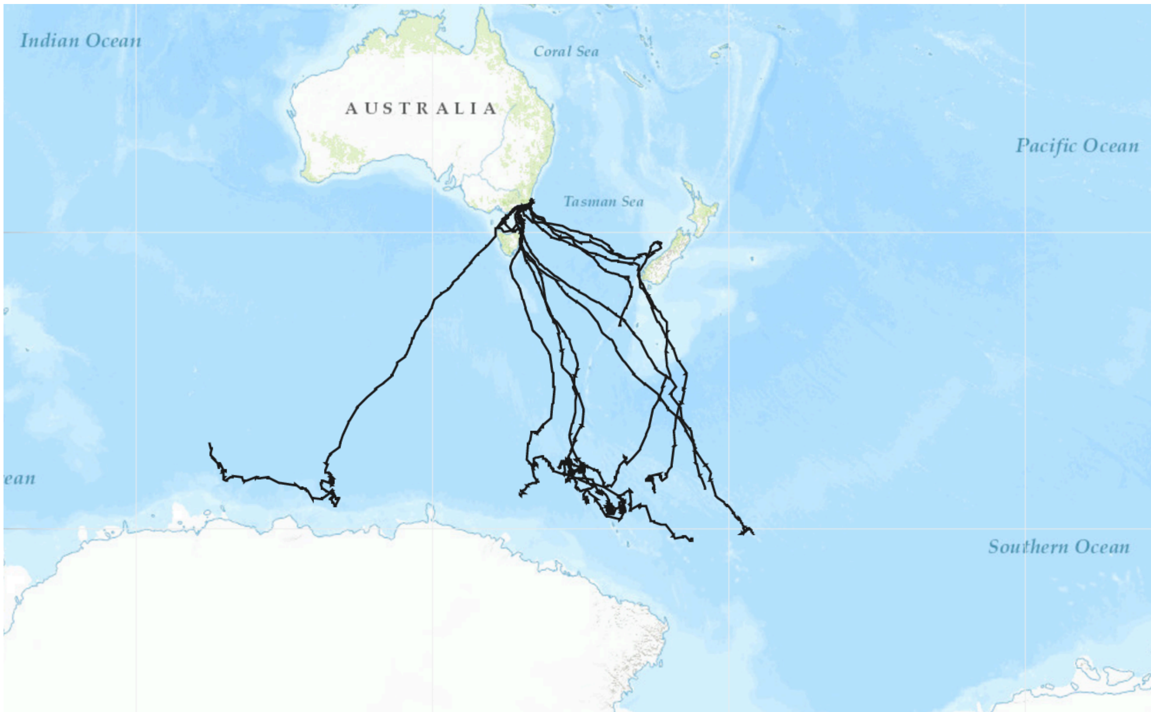

Figure 8. Satellite tracks of Australian Humpbacks show their migration from the east coast of Australia to feeding grounds off the West Bank of the Ross Sea.

Although the summer feeding grounds for individual whales within this population vary on a much larger scale than do those of the Brazilian population, the continued commitment to areas of high chlorophyll concentrations remains evident (Figure 9). Most of the Australian Humpbacks look to feed just north of the Balleny Isalands while others appear to head further west. Yet, there is no evidence of Australian Humpbacks migrating to feeding grounds between these two distinct locations. The reason for such an absence of whales could be due to the uniquely low concentration of phytoplankton and subsequently krill, throughout this middle ground (Figure 9). The seemingly conscious avoidance of such an area supports the notion that migratory Humpbacks are intentionally swimming towards areas dense quantities of available food.

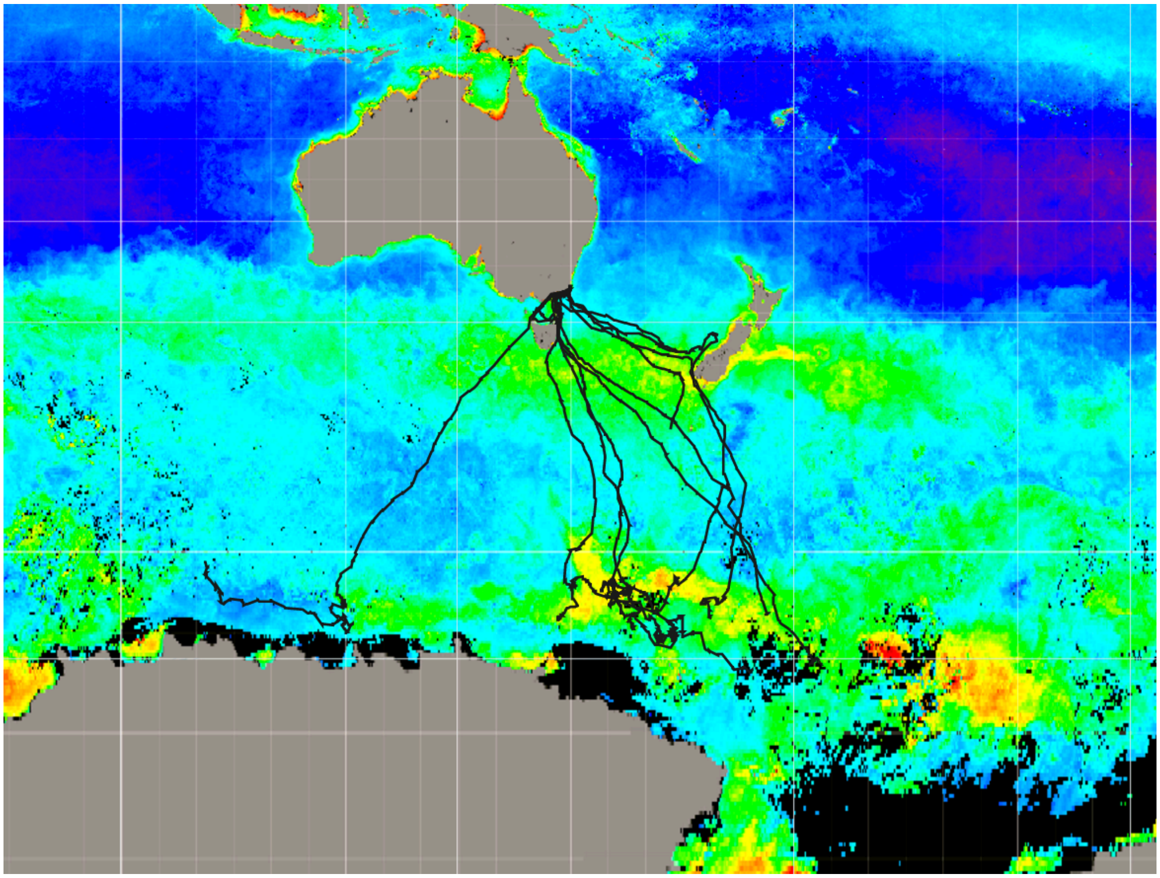

Figure 9. Australian Humpbacks migrate to areas of high chlorophyll concentrations in the Southern Ocean, while actively avoiding depleted areas.

Oceania Humpbacks, however, lack the amount of tracking data needed to be able to definitively pinpoint summer feeding grounds. Still, the two extended tracks of these whales suggest summer feeding grounds east of their Australian relatives (Figure 10). These two tracks illustrate routes, which would take the whales east even of the Ross Sea, a possibility rarely, if ever acknowledged in the scientific literature.

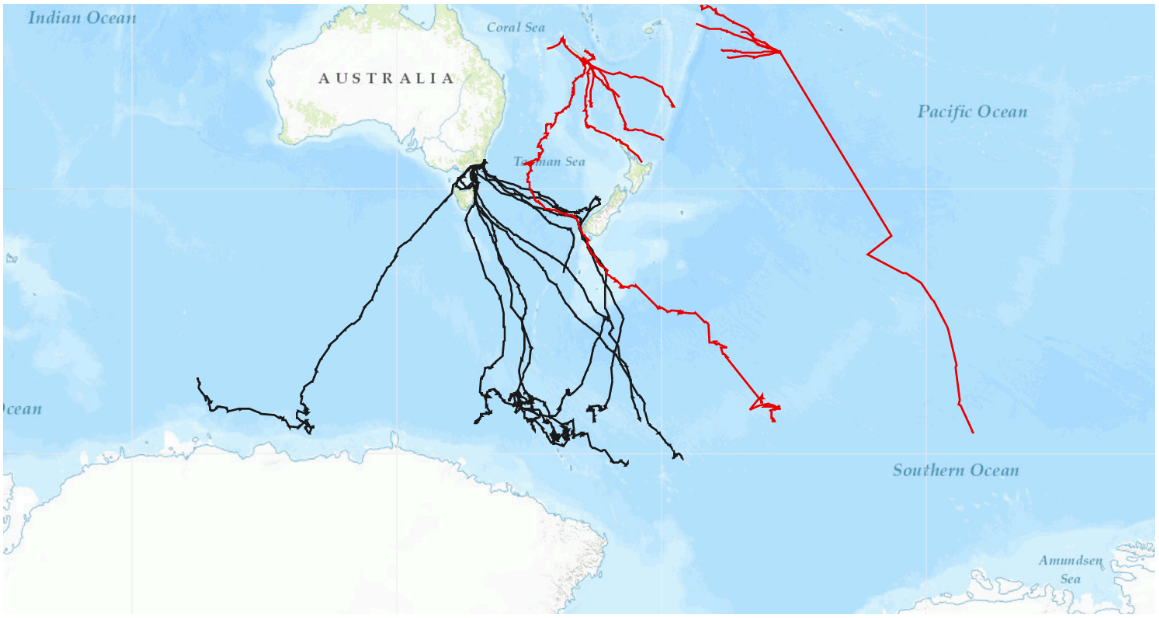

Figure 10. Oceania Humpbacks (red) seem to diverge from Australian Humpback (black), heading further east towards the Amundsen Sea.

Using the pattern established by Brazilian and Australian Humpbacks, extremely high chlorophyll concentrations within the Amundsen Sea present highly plausible feeding grounds for this endangered population (Figure 11).

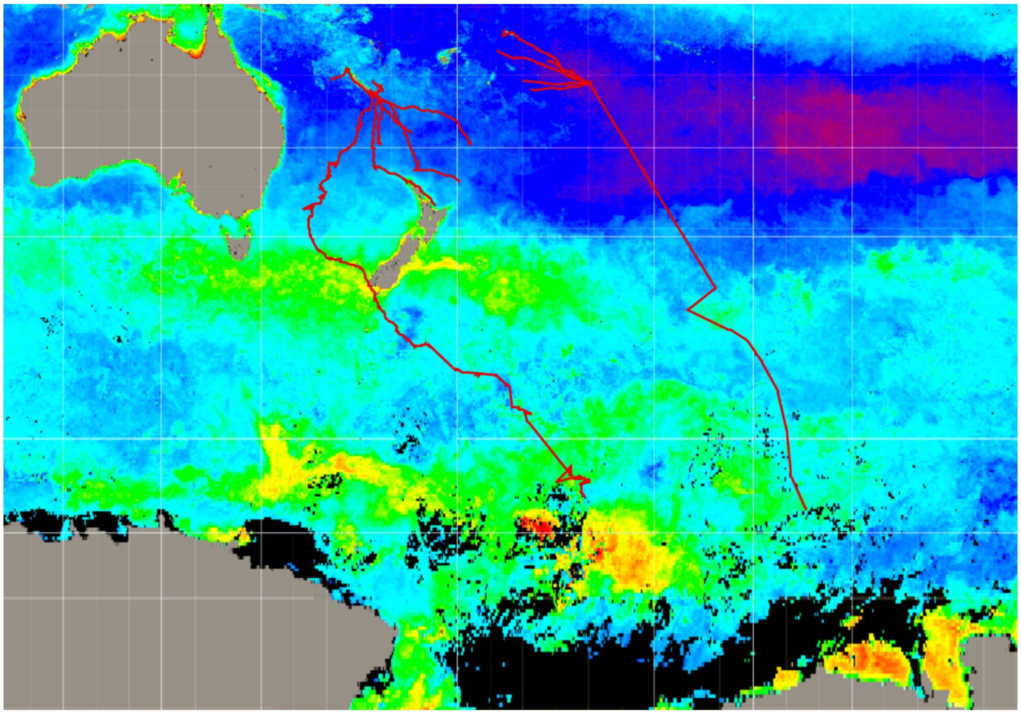
Figure 11. Oceania Humpback Tracks illustrate a path towards the high chlorophyll levels of the Amundsen Sea.

Perhaps the most significant realization of such a discovery (apart from differing from Australian feeding grounds and diverging from the currently established scientific record) is the fact that the proposed Ross Sea Marine Protected Area would not protect this endangered population whatsoever (Figure 12). However, the RSMPA does overlap the most densely populated feeding ground of the Australian Humpbacks, a population that has already recovered from less than 100 individuals in 1963 to over 15,000 today – roughly three fourths of pre-whaling population estimates (Figure 12).[143]

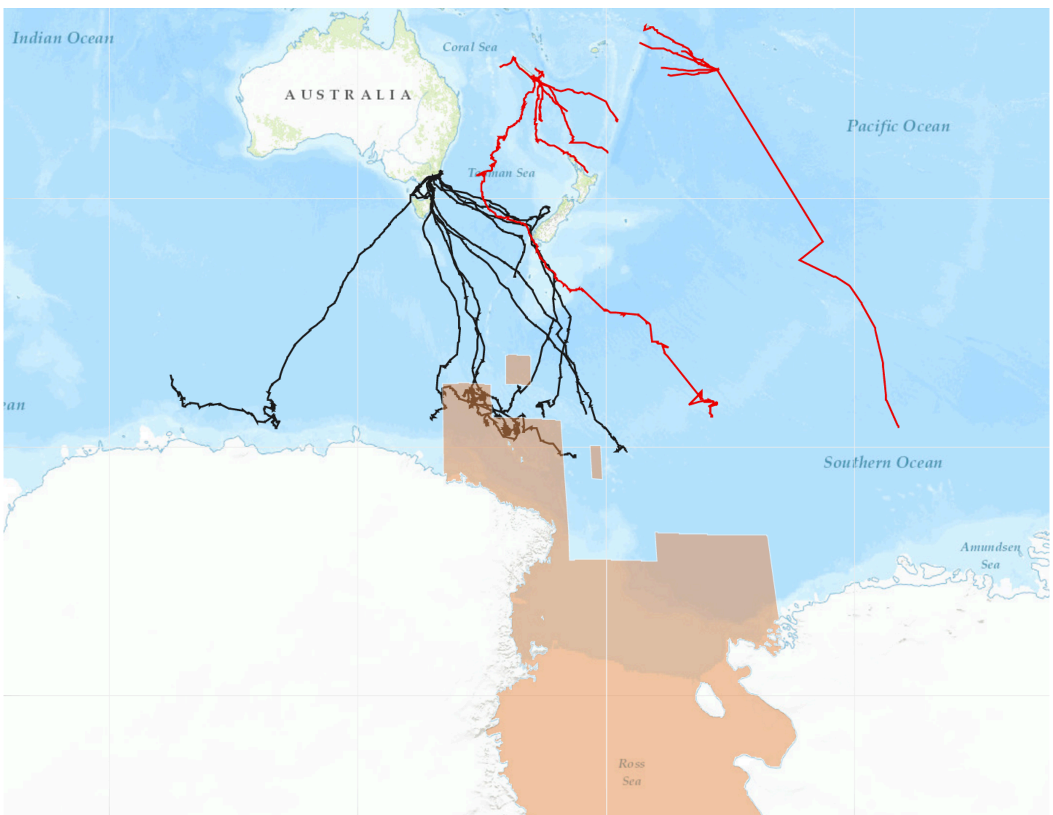

Figure 12. The RSMPA (light brown) overlaps with the feeding grounds of East Australian Humpbacks (black), while the Oceania Humpbacks (red), remain unprotected to the east.

[143] Horton, T. (2014). Oceania Humpbacks. Retrieved December 10, 2015, from http://megaptera14.blogspot.com/p/oceania-humpbacks.html

6d. Threats to Feeding Grounds

If Oceania Humpback feeding grounds are in fact east of the Ross Sea, the Ross Sea MPA could devastate the already vulnerable whale population. Noted throughout the 2010 US-NZ proposal, protection of the keystone Antarctic Toothfish population within the Ross Sea is a key objective of CCAMLR conservation efforts. As the Ross Sea hosts the largest population of Toothfish in the world, the RSMPA would quickly take large stocks of Toothfish out of circulation for fisheries. While effective in protecting the Ross Sea Toothfish population, the moratorium would displace thousands of annual tons of fishing. Not unique to the RSMPA, displacement of fishing practices is a major concern of many MPAs and no-take zones, concentrating practices into a smaller area, leading to conflict and ecological harm.[144] In the case of the RSMPA, it is unlikely any overall decrease in Toothfish takes will occur, as the fisheries argue that current restrictions limiting annual catch to around 3,000 tons already goes far enough to protect the ecology of the area.[145] It is plausible Toothfish fisheries won't look far to replace their lost stocks, turning eastward towards the Amundsen Sea. While lesser than that of the Ross Sea, the Amundsen Sea Toothfish population is the second largest in the Southern Ocean (Figure 13).

[144] Agardy, T., Di Sciara, G. N., & Christie, P. (2011). Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy*, *35*(2), 229.
[145] Sheriff, 2014.

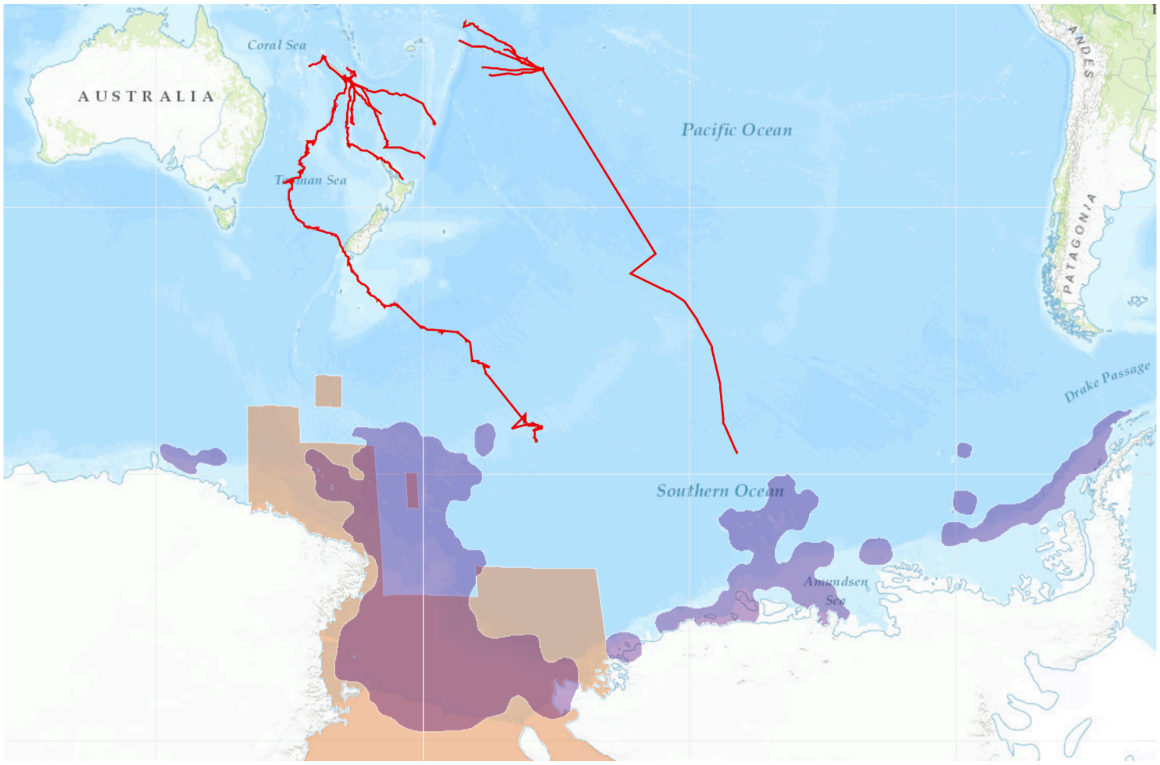

Figure 13. The RSMPA creates a no-take reserve of a significant portion of the world's largest population of Toothfish. As commercial fisheries look to new territory, they may settle on the second larges Toothfish population in the Amundsen Sea, an area where it appears the Oceania Humpbacks may be heading.

However, exploration of a new area comes with costs. As the Amundsen stock is smaller than that of the Ross Sea, the actual cost of fishing itself will also rise as it becomes more difficult to locate and catch Toothfish.[146] Short-term losses could in turn create incentives for excessive illegal fishing both within the RSMPA and through the overexploitation of newly discovered pockets of Toothfish.[147]

Illegal, Unregulated, and Unreported (IUU) fishing puts in jeopardy any conservation measures developed by CCAMLR to manage Toothfish stocks.[148] However, IUU fishing is not a new problem for Toothfish conservation efforts. The large amount of IUU fishing around South America was linked to the decreased

[146] Agardy, 2011, pp. 229.
[147] Brown, C. J., Abdullah, S., & Mumby, P. J. (2014). Minimizing the short-term impacts of marine reserves on fisheries while meeting long-term goals for recovery. *Conservation Letters*. 180.
[148] Agnew, 2000, pp. 361.

Patagonian Toothfish catches in 1995 and 1996. This forced many vessels to go in search of new territories, eventually discovering the Antarctic Toothfish, and the large Ross Sea population, now in need of protection itself.[149]

The largest threat for Oceania Humpbacks, should there be a collapse of the Amundsen Toothfish population, is that of a trophic cascade effect. Much like the wolves of Yellowstone, the extinction of Amundsen Toothfish could lead to unintended consequences for the rest of the ecosystem, including increased predatory pressures on the area's krill populations. Scientists currently estimate that there is 170-300 million tons of krill in the Southern Ocean – that is more than half the biomass of all of humanity. Of that, over half is consumed by natural predators.[150] Currently the krill industry only harvests around 200,000 tons of krill per year in the Southern Ocean, still far off the Southern Ocean annual catch limit of 4.6 million tons, which is based on an outdated 2000 population study. New technologies that also allow for quicker processing of krill harvests have stimulated new interests within the industry.[151] Human use of krill has also grown significantly in recent years as the zooplankton are now used to produce nutrient supplement like omega-3 fatty acid, as well as for bait in both commercial and recreational fishing. Still, the most important use contributing to the rise in demand for krill is their place in poultry production, pet foods, and aquaculture. With the global population expected to increase 30% by 2050 and billions rising out of poverty into

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[149] Agnew, 2000, pp. 362.

[150] License to Krill: A Story About Ecosystem-Based Management. (2015). Retrieved December 10, 2015, from http://www.nmfs.noaa.gov/stories/2013/03/3_25_13license_to_krillv2.html

[151] Krill Conservation. (2014). Retrieved December 10, 2015, from http://www.asoc.org/advocacy/krill-conservation

higher standards of living, the UN Food and Agriculture Organization expects the demand for animal protein to grow by 75%.[152] Krill will undoubtedly play a large role in helping to meet this challenge.

While some believe a reliance on krill to be possible, 2010 marked the first year that a majority of the krill fishery had to be shut down, as the industry exceeded its regional harvest limits.[153] In 2015, the industry harvested 291,370 tons – only 32,000 tons of which were caught by Chinese entities.[154] That may be about to change as Liu Shenli, chairman of the China National Agricultural Development group, has said he wants to increase investment in Antarctic krill fisheries. Reportedly, he has been advising China that it should increase its national catch to 1-2 million annual tons of Antarctic krill, 5-10 times the size of current global catch totals.[155] With the largest authorized Antarctic fleet, including eight 5,000-7,000 ton factory freeze trawlers, such ambitions could soon be possible to achieve. Dr. Rodolfo Werner, senior advisor to the Antarctic and Southern Ocean Coalition, worries that the significant increase in China's catch allowance could lead to a situation where CCAMLR would no longer be able to manage and monitor the krill fishery due to its sheer enormity. In addition he warns that, "Many things should happen before [the commission] could allow such a large catch."[156]

Yet demand for krill-based products will push increased catch totals. While not necessarily facing imminent collapse, by some estimates the Antarctic krill

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[152] License to Krill: A Story About Ecosystem-Based Management, 2015.
[153] Krill Conservation, 2014.
[154] Darby, A. (2015). China moves in for the krill. *The Sydney Morning Herald*.
[155] Darby, 2015.
[156] Darby, 2015.

population has decreased by as much as 80% since the 1970s.[157] The reasons behind such a decline have not been conclusively determined. It may be a result of decreases in sea ice, or potentially a reflection of rebounding whale populations following the IWC moratorium on whaling. 2015 krill population may still be even smaller than that of the most recent biomass estimate in 2000[158]. It is unknown whether current catch limits (based on the 2000 estimates) are still accurate today.

At a time when the krill industry may be increasing its catch totals, to what could prove to be unsustainable levels, climate change may work synergistically to apply increasing pressure on Antarctic krill populations. As Southern Ocean waters warm, they will be unable to hold the current abundance of nutrients which support robust primary production of phytoplankton, the major food source for krill. Additionally, “krill grow fastest in cold water and any warming can slow down or stop growth, reducing the food available for wildlife,” notes Dr. Simeon Hall, lead scientist at the British Antarctic Survey. “Our research suggests that expected warming this century could severely reduce the area in which krill can successfully grow."[159] Concurrently, changing climatic conditions are leading to extensions in both Ross Sea and Weddell Sea Ice shelves, thought to be major hotspots of Antarctic krill. Expansions in the sea ice shrink the territory of Antarctic krill while at the same time increasing competition by predators, including both animals and humans.

As their primary food sources, krill hold great significance for baleen whales,

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[157] License to Krill: A Story About Ecosystem-Based Management, 2015.
[158] Krill Conservation, 2014.
[159] Warming Antarctic seas likely to impact on krill habitats. (2013). Retrieved December 10, 2015, from http://phys.org/news/2013-08-antarctic-seas-impact-krill-habitats.html

such as Humpbacks, in the Southern Ocean. These whales rely on dense swarms of readily available food to build up fat deposits to maintain themselves the rest of the year. Jeopardizing the health and abundance of Antarctic krill directly jeopardizes the nutrition of southern baleen whales. Furthermore, the depleted Oceania population will require an excess of available food resources in order to rebuild populations to pre-whaling levels.[160]

In addition to a potential increase of competitive pressures for food, Oceania Humpbacks may also be subject to the increased probability of physical threats, such as entanglement in fishing gear and collisions with vessels. Studies estimate that 71% of all northern Humpbacks have been entangled in fishing gear at one point during their lifetime (Figure 14). A US study, which was reported to the

Figure 14. Humpback Whale entangled in a trawl net of the coast of South Africa.[161]

International Whaling Commission, found that between 60,000 and 300,000 marine

[160] Reilly, S., Hedley, S., Borberg, J., Hewitt, R., Thiele, D., Watkins, J., & Naganobu, M. (2004). Biomass and energy transfer to baleen whales in the South Atlantic sector of the Southern Ocean. *Deep Sea Research Part II: Topical Studies in Oceanography*, *51*(12), 1408.

[161] International Whaling Commission. (2015). Whale Entanglement - Building a Global Response. Retrieved December 10, 2015, from https://iwc.int/entanglement

mammals, including whales, dolphins, and porpoises, are incidentally caught by commercial fishing practices each year.[162] While not every instance of entanglement ends in a fatality, animals that break free can still suffer severe injuries. As fisheries shift their search of Toothfish away from the Ross Sea, the likelihood and entanglement of and subsequent injury to an Oceania Humpback will increase.

With more frequent traffic of fishing vessels in and around Oceania Humpback feeding grounds, the threat of accident collisions between vessel and the whales also heightens. Large whales are extremely susceptible to ship strikes, particularly as the rest on the surface or swim slowly.[163,164,165,166] Consequently, behind Finbacks, Humpback whales are the second most frequently hit species of whale (Figure 15). Large whale ship strikes have already been recorded around the world, including waters off the Coast of Antarctica, New Zealand, and the South Pacific Islands – all areas frequented by Oceania Humpbacks. As Jensen, et. al show, 84.4% of ship strikes cause some sort of bodily injury to the whale, and 68% result in death to the whale.[167] Due to such a small population, even one fatality to an Oceania Humpback is a huge blow to its population's chances of recovery.

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[162] Department of Conservation - Te Papa Atawhai, 2012.

[163] Behrens, S., & Constantine, R. (2008). Large whale and vessel collisions in northern New Zealand. *Rep. int. Whal*.

[164] Vanderlaan, A.S.M., and Taggart, C.T. (2007). Vessel collisions with whales: the probability of lethal injury based on vessel speed. *Marine Mammal Science*. 23(1): 144-156.

[165] Lammers, M.O., Pack, A.A., and Davis, L. (2003). *Historical evidence of whale/vessel collisions in Hawaiian waters (1975–present).* OSI Technical Report 2003-01. Prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary. Oceanwide Science Institute, Honolulu, HI, USA.

[166] Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S., and Podesta, M. (2001). Collisions between ships and whales. *Marine Mammal Science.* 17(1): 35-75.

[167] Jensen, A. S., Silber, G. K., & Calambokidis, J. (2004). *Large whale ship strike database*. US Department of Commerce, National Oceanic and Atmospheric Administration.

Figure 15. A Humpback Whale's injuries resulting from a ship strike.[168]

6e. Importance of Oceania Humpbacks

Protecting and promoting growth within the Oceania Humpback population are important within ecological, economic, cultural, and aesthetic value sets. Although little genetic mixing occurs between Oceania and East Australian Humpbacks, conserving a diverse genetic code will help to protect this vulnerable mega-fauna on a global scale from changing habit and disease.[169] More locally, the whales themselves generate significant economic benefits through ecotourism opportunities. By 2000, the international whale watching industry had grown to a billion dollar industry, more than doubling its size since 1996. Over 9 million annual visitors engage with the whales across 87 different countries today. A 1999 study by Dr. Mar Orams of Massy

[168] International Whaling Commission. (2015). Ship Strikes: Collisions between whales and vessels. Retrieved December 10, 2015, from https://iwc.int/ship-strikes

[169] Garrigue C, Aguayo A, Amante-Helweg VLU, Baker CS and 12 others (2002) Movements of Humpback whales in Ocea- nia, South Pacific. J Cetacean Res Manage 4:255–260

University estimated that a single whale generates over a million dollars in tourism revenues over its 50-year life span. New Zealand, a nation highly regarded as one of the best whale watching sites in the worlds, has experienced the transformative power of ecotourism first hand. Over the past 15 years, Kaikoura, a small town on the east coast of New Zealand's South Island, has been molded into the premier whale-watching site in all of Austral-Asia. In 2015, Whale Watch Kaikoura, run by the modern-day descendants of Maori whale-rider, Paikea, is the single largest employer in the area. Attracting more than one million tourists annually and embracing the ecofriendly economic potential of the whales has transformed Kaikoura into what Chris Cater, the New Zealand Minister of Conservation, described as "a hustle and bustle of activity; accommodation, restaurants, cafés and souvenir shops line the main street" (Figure 16).[170]

Figure 16. Annually more than a million tourists come to see the magnificent Humpback Whales as they migrate past the Kaikoura shoreline.

On a global scale, these charismatic mega-fauna also work to invigorate

[170] Department of Conservation - Te Papa Atawhai, 2012.

ecosystems around the world through their role as a keystone species. As the whales only feed while in the Southern Ocean, they disperse large amounts of Antarctic nutrients throughout their more northern breeding grounds. The whales also mix nutrients throughout the water column as the return from their deep dives. In addition to their feces, these nutrients fertilize surface photic zones for plankton and other microbial life. The presence of whales works as a trophic cascade, promoting phytoplankton growth, which in turn trickles up the food chain, boosting krill and fish populations. In addition, the growth of phytoplankton works to sequester carbon from the atmosphere – a benign form of geo-engineering.[171] The immense impact of whales on a global ecologic and regional economic scale promotes the importance of maintaining a healthy and growing stock of Oceania Humpback whales.

[171] *How Whales Change the Climate: Movie*. Sustainable Human. 2014. <http://sustainablehuman.me/how-whales-change-climate/>.

7. Recommendations from a Precautionary Approach

While the exact location of Oceania feeding grounds requires further research, CCAMLR must be cognizant of the potentially devastating, indirect effects the implementation of the current RSMPA proposal may cause. Alongside 194 other parties, both the United States and New Zealand signed the 1992 Rio Declaration on Environment and Development at the Earth Summit, later ratifying the document in 1994.[172] The Rio Declaration was comprised of 27 principles intended to guide nations on future sustainable development. It defined the right of people to be involved in the development of their economies and responsibility to safeguard a common environment. The 1992 Rio Declaration on Environment and Development, Principle 15 states:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.[173]

The Rio Declaration's Precautionary Principle built on the attitudes of individuals and nations towards the environment and development that sprouted from the 1960s environmental movement and were first identified at the 1972 United Nations Conference on the Human Environment.[174]

Since the Rio Declaration, New Zealand has actively worked to embrace the precautionary principle, incorporating this approach into many environmental laws

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[172] Status of Ratification of the Convention. (2014). Retrieved December 10, 2015, from http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php

[173] Annex, I. (1992, August). Report of the United Nations conference on environment and development. In *Rio de Janeiro (3–14 June 1992) A/CONF*(Vol. 151, No. 26, p. 12).

[174] Sustainable Development | Rio Declaration | Earth Summit. Retrieved December 10, 2015, from http://www.sustainable-environment.org.uk/Action/Rio_Declaration.php

and government regulatory strategies. For example, the New Zealand Fisheries Act of 1996, section 10 specifies four principles that must be taken into account to ensure sustainability of fisheries:

1. Decisions should be based on the best available information.
2. Decision-makers should consider any uncertainty in the information available in any case.
3. Decision-makers should be cautious when information is uncertain, unreliable or inadequate.
4. The absence of, or any uncertainty in, any information should not be used as a reason for postponing or failing to take any measure to achieve the purpose of this Act.[175]

Additionally, the 2003 Sustainable Development Program of Action lays out an overarching framework for future government strategies states in its principles that when making decisions, which could lead to serious or irreversible damage, the precautionary principle must be applied.[176]

The precautionary principle has become commonplace in New Zealand policymaking. While less apparent, it has also taken up an increasing role in US conservation and is actually rooted deep in US environmental history within the creation of the National Park system. The precautionary principle in fact is the backbone of the US-NZ joint RSMPA proposal. Calling on the world to preserve the unique and pristine Ross Sea ecosystem for its intrinsic and scientific values, the proposal encapsulates everything the principle and Rio Declaration stand for. Scientific evidence has yet to conclusively prove the negatives effects thought to be associated with the encroachment of human development specifically within the Ross Sea. Yet even without a concrete, scientific threat the 2010 proposal looks to

[175] Application of the precautionary principle in New Zealand. Retrieved December 10, 2015, from http://www.treasury.govt.nz/publications/research-policy/ppp/2006/06-06/06.htm
[176] Application of the precautionary principle in New Zealand.

prevent any potential future damage. As the most pristine area left on the planet, potential disruption to the Ross Sea ecosystem's equilibrium do constitutes "threats of serious or irreversible damage." Not only is protecting the Ross Sea morally reasonable, it is also politically in line with the Rio Declaration's Principle 15 on the Precautionary Principle.

However, I urge the New Zealand and United States delegates to additionally consider the secondary and tertiary effects of implementing a RSMPA and the unintended consequences within the broader Southern Ocean ecosystem. After studying the endangered green turtles of the Chagos Archipelago MPA, Hays, et al. (2014) concluded that, "even the largest MPAs should be supplemented by targeted smaller MPAs."[177] Although the overarching goal of CCAMLR is to eventually create a marine reserve spanning the entire Southern Ocean, facing political and economic pressures, they have resigned to beginning with smaller more directed reserves such as the RSMPA. This in no way undermines the legitimacy of the proposed Ross Sea MPA, as the Ross Sea ecosystem must be protected. However, the danger in such a relatively small scale, targeted MPA lies in the notion of path dependence. If the RSMPA is to be created nearby but not including the feeding grounds of endangered Oceania Humpbacks, it will become exponentially less likely that further actions will, or politically can be taken to also protect these necessary areas.[178] In essence, given the highly politicized and polarizing issue of marine protection in Antarctic waters, it is now or never for the protection of the Oceania Humpback Whales.

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[177] Hays, et al., 2014, pp. 1643.
[178] de Morais, et al., 2015.

Adhering to the Rio Declaration on Environment and Development, the RSMPA should be created, as a "lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[179] However with only 314 Oceania Humpbacks remaining, any actions, which could harm the population, are coinciding "threats of serious or irreversible damage."[180] While not an intended consequence, the implementation of the RSMPA could in fact jeopardize the future success of the entire Oceania Humpback population. By displacing a large portion of the commercial Toothfish fishery, the RSMPA may increase predation pressure on the Antarctic krill in and around the Amundsen Sea. As a staple of the Humpback diet, increased competition for krill could adversely affect the health and nutrition of these whales. As the summer months are the only time of year these migratory mega-fauna feed, having access to dense, nutrient rich collections of food are also imperative to the reproductive health of these whales. Scientists do not know where the tipping point may be for this already depleted population, yet with only 314 individuals left, losing even just one Oceania Humpback severely cripples the population's chances of recovery and pushes the whales towards extinction. Therefore it is imperative that the international community takes the following steps to ensure the ongoing protection of the Oceania Humpback population:

1. Further research be undertaken to soundly establish the location of Oceania Humpback feeding grounds in the Southern Ocean – How can we protect these whales if we do not know where they are going?

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[179] Annex, I., 1992.
[180] Annex, I., 1992.

2. Further research be undertaken to determine specific sustainable levels of krill harvests and the extent to which population fluctuations affect Oceania Humpbacks – We must fully and holistically understand the interactions of the Southern Ocean ecosystem and the effects of human activity in the region to be able to sustainably manage the environment.
3. Establish a supplementary MPA, *concurrently* with the RSMPA, to preserve the areas of and surrounding the Oceania Humpback feeding grounds, thereby avoiding the danger of path dependence.
4. Create a plan for the gradual growth of Southern Ocean protected areas, such that they will eventually incorporate the entire Southern Ocean, while gradually phasing out fisheries as to minimize economic shock.

Albert Einstein once said, "Our task must be to free ourselves by widening our circles of compassion to embrace all living creatures and the whole of nature and it's beauty."[181] The Earth itself is approximately 4.6 billion years old. Scaling that to a single day, humanity's place comes into perspective. Given a 24-hour history of the planet, humans have been around for only the last 17 seconds. However, within this time, the industrial revolution, which started more than 250 years ago, coverts to only about five microseconds (4.8 x 10^-6 seconds). That is fives orders of magnitude faster than the blink of an eye.[182] Yet, during this

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[181] Celebrate Biodiversity - Make Every Day Endangered Species Day. (2013). Retrieved December 10, 2015, from http://consciouscompanion2012.com/2013/05/17/celebrate-biodiversity-make-every-day-endangered-species-day/

[182] Ainscoe, E. (2014). Every Second Counts - Oxford University, Environmental Research Doctoral Training Partnership, DTP. Retrieved December 10, 2015, from http://www.environmental-research.ox.ac.uk/every-second-counts/

minuscule period of time, humanity – and the industrialization of its economy – has fundamentally altered the planet, leaving a noticeable imprint on the geologic record. We have changed the climate, as atmospheric CO2 surpasses 400ppm for the first time in 800,000 years.[183] We have altered isotope concentrations worldwide, through nuclear testing. And perhaps most importantly, we have facilitated what has been deemed the 6th mass extinction. Today, scientists estimate we are losing species 1,000 to 10,000 times faster than the planet's natural "background" rate of extinction.[184] "We are deciding," Elizabeth Kolbert writes in her book, The Sixth Extinction, "without quite meaning to, which evolutionary pathways will remain open and which will forever be closed. No other creature has ever managed this, and it will, unfortunately, be our most enduring legacy."[185] If we are unwilling to fight for the very species' we have left vulnerable, what then are we fighting for? It is only when the last Toothfish is sold, or the last Oceania Humpback dies that Mankind will realize that money can never buy back wildlife.

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[183] Global Climate Change: NASA scientists react to 400 ppm carbon milestone. (2015). Retrieved December 10, 2015, from http://climate.nasa.gov/400ppmquotes/

[184] The Extinction Crisis. Retrieved December 10, 2015, from http://www.biologicaldiversity.org/programs/biodiversity/elements_of_biodiversity/extinction_crisis/

[185] Kolbert, E. (2014). *The sixth extinction: an unnatural history*. A&C Black.

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Toothfish population data from the Pew Charitable Trust.

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