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Dr. Tudge

The Study of the Harp Seal

Classification and Systematics:

Pinnipeds are one of the most widely disturbed and diverse semiaquatic marine mammals in the world. There are 33 extant species of pinnipeds, and more than 50 species extinct already. They comprise the extant families Odobenidae (whose only living member is the walrus), Otariidae (the eared seals: fur seals and sea lions), and Phocidae (the earless/true seals). There are 18 living species among the family Phocidae, and the harp seal, *Pagophilus groenlandicus* is one of them. Taxonomy is the hierarchical classification system that can help people to classify organisms, in the order Kingdom, Phylum, Class, Order, Family, Genus, Species. The harp seal is classified as follows:

Table 1. Classification of the harp seal

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Carnivore
Family	Phocidae
Genus	*Pagophilus*
Species	*P. groenlandicus*

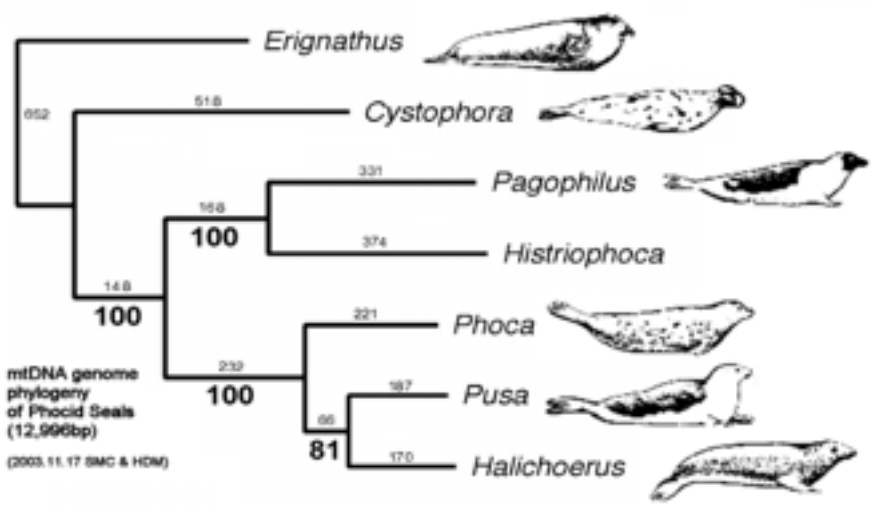
Table 1: Table 1 shows the taxonomy of the harp seal in the order kingdom, phylum, class, order, family, genus, and species it belongs to.

It is important to point out that the harp seal originally belongs to the genus *Phoca* with a number of other species, but it got reclassified into the monotypic genus *Pagpphilus* in 1944 (Perrin, 2010). According to the research, the scientific name for the harp seal has shifted frequently in the last two decades with generic names of *'Pagophoca*, *Pagophilis* and *Phoca*, and specific names of *groenlandicus* and

groenlandica' (Kovacs, 2015). Berta and Churchill (2011) started to use the name *Pagophilus groenlandicus*, and that is the name recognized by the Society of Marine Mammalogy (Committee on Taxonomy 2014). In 1998, Rice recognized two subspecies, *P. g. groenlandicus* and *P. g. oceanicus*, where the previous one breeding in the western North Atlantic off North America and also around Jan Mayen in the Greenland sea, and the later one breeding in the White sea (Kovacs, 2015). And biologist Lavigne found out there were three distinct populations centered on the breeding localities, with some associated morphological, genetic and behavioral differences, later Heptner and his co-workers provided more evidence for two distinct group, but included the Jan Mayen breeding group with the White Sea group based on 'no discernable morphological or protein polymorphism differences' (Kovacs, 2015). Research also addresses 'analysis of DNA sequence variation and also a comparison of fingerprint band-sharing coefficients, revealed that the breeding group in the Northwest Atlantic were one group and the animals that breed in the White sea and those in the Greenland sea off Jan Mayen were another group' (Perry et al. 2000). Given the lack of genetic differentiation between the two recognized subspecies and their actual affinities, they will be not differentiated in this assessment.

The scientific name of the harp seal is *Pagophilus groenlandicus* simply because most harp seal can be found in Greenland, and it means 'ice-lover from Greenland.' Meanwhile, the dark harp-shaped mark that displays on its back gives the name harp seal.

Figure 1. Phylogenetic Tree of Phocid Seals



(Image retrieved from http://bioweb.uwlax.edu/bio203/s2012/lind_vale/classification.htm)

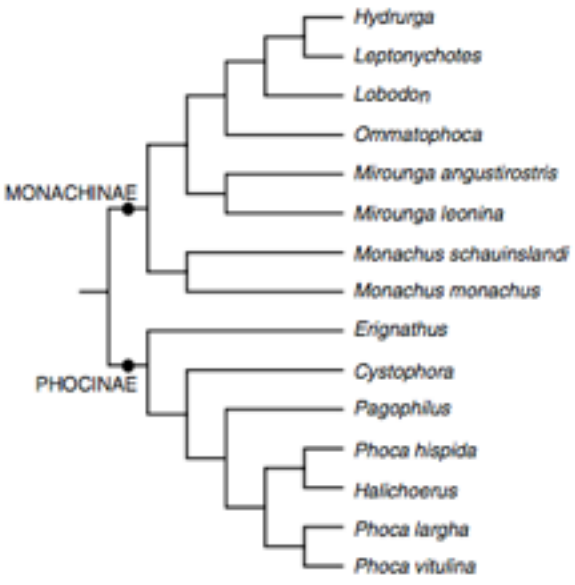
Figure 1 above shows the phylogenetic tree of Phocid Seals, it demonstrates that, according to the molecular data, harp seals are no longer belongs to *Phoca greolandica* as they are in fact not closely related to the hood seals anymore, or *Phoca vitulina* as morphological trees would suggest. According to the tree, one can tell that they are actually more related to the *Histriophoca* or spotted seals.

Evolution:

First of all, by looking at pinnipeds as a whole, there are two main theories of the evolution of pinnipeds. First, the biphyletic view, in which walruses and eared seals evolved from a bear-like ancestor and true seals evolved from an otter-like carnivore. In today, this aspect is no longer accepted as all the evidence is mostly morphological which can often be deceiving. The second view is that all of the pinnipeds belong to a monophyletic group and they all share a common ancestor, this point of view is the most accepted as it has been provided by extensive genetic evidence (Fyler,2005).

In general, Phocids have been divided into two to four significant subgroups including monachines (monk seals), lobodontines (Antarctic seals), cystophorines (hooded and elephant seals), and phocines (remaining Northern Hemisphere seals). Several molecular studies provide data on phocid interrelationship (Davis, 2014 & Fyler, 2005). According to these studies, strong support was found for monophyly of both the Monachinae and Phocinae (Flyer, 2005).

Figure 2: Phylogeny of the Phocidae based on molecular data (From Davis et al., 2004)



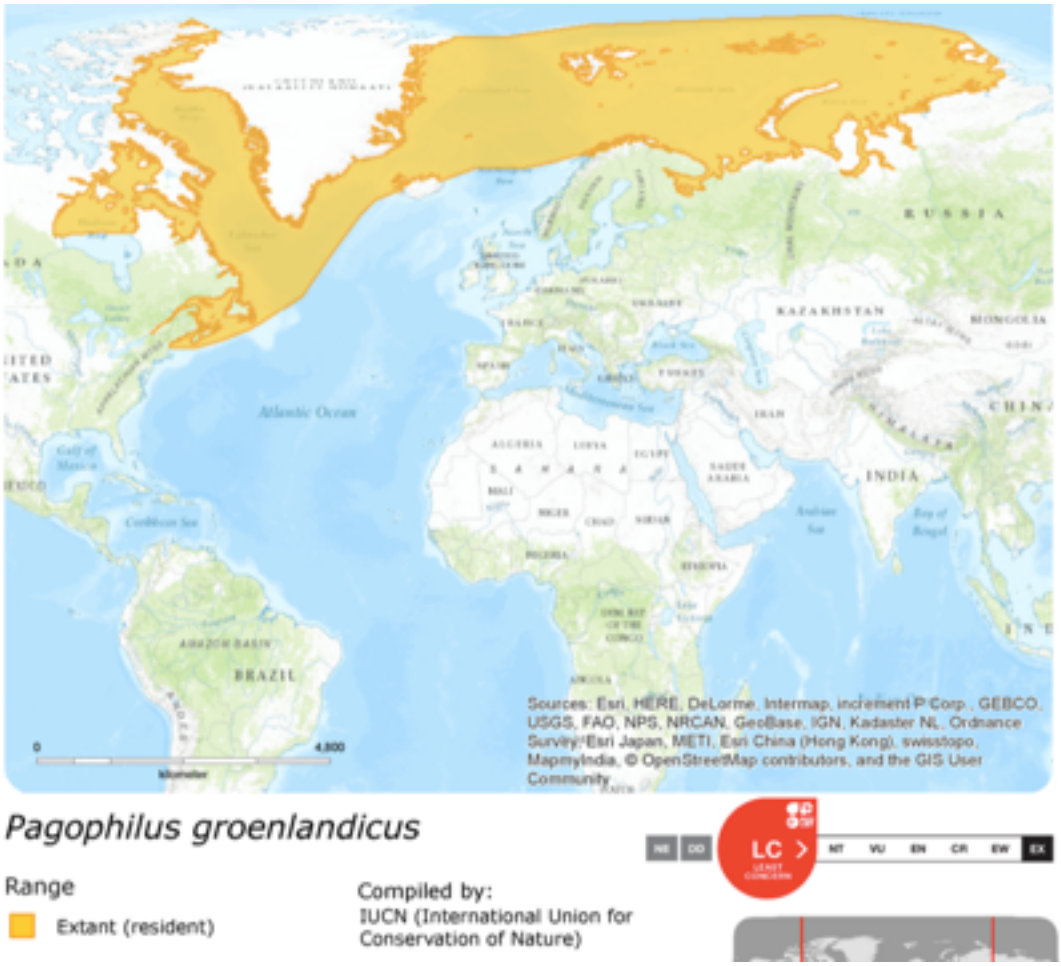
Distribution:

Research shows that harp seals are widespread in the North Atlantic and the adjacent Arctic Ocean and shelf seas (Lavigne, 2002). Their range extends from 'north Hudson Bay and the Foxe Basin, Baffin Island, and the Davis Strait, Gulf of St Lawrence and Newfoundland in the western North Atlantic, east to somewhat south of Greenland, continuing east to Iceland and from there to Northern Norway, the White Sea and the Barents and Kara Seas' (Rice 1998, Lavigne 2002).

In the northern side, their population limit in the eastern North Atlantic is at least to Franz Joseph Land and Svalbard and may continue to between 82-85 degrees oath depending on ice conditions (Lavigne 2002). At the same time, the southern limit of the distribution off North America shifts southeast occurred in the early 1990s (Lacoste and Stenson, 2000), which leads to 'increased occurrences of harp seals south of their usual limits, reaching the Gulf of Maine and Sable Island where large numbers have been recorded since the mid-1990s' (Lucas and Daoust, 2002). Studies also address that harp seals often occur transiently outside such range, south to Virginia in the United States, and similarly in Europe, they reach 'the United Kingdom, the Faroe Islands, Denmark, Germany, France, and even Spain' (Bloch et al. 2000).

As the most abundant pinniped species in the North Hemisphere, the population of the harp seal is close to 8 million globally (IUCN, 2008). According to Stenson (2013), pup production at all breeding sites combined is at least 1.4 million pups per year currently (Stenson, 2013). The breeding group in the West Ice near Jan Mayen was estimated at 296,000 in 1994, and this population increased to approximately 348,000 by 2003, and the White Sea breeding gourd was estimated to be 1.8 million in 2000 (Potelov et al. 2003).

Figure 3. Distribution map of the harp seal



(Image retrieved from The IUCN Red List of Threatened Species: Pagophilus groenlandicus – published in 2008. 4 http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T41671A10532935.en)

Anatomy/physical description:

Harp seals are sexually dimorphic in size and pelage. Usually, male harp seals weight an average of 135 kg and are 171~190 cm long while females weight an average of 120 kg and are 168~183 cm long. Size is not the only difference between the male and female harp seal; male harp seals tend to have a more obvious harp-like pattern on their back and black head then females (Jefferson et al., 1994). At the same time, adult harp seals have the relatively small hind flipper, and their fore flippers are pointed with short digit tips that boast large claw. They also appear with flat and wide heads, and they tend to have a relatively long, but tapered snout (Jefferson et al., 1994). The harp seals' eyes are large and contain a large spherical lens, which improves its focusing ability; and its whisker, called vibrissae, lie in horizontal rows on either side of its snout, which provide

a touch sense with labeled line coding, and underwater, it can help harp seals in response to low-frequency vibrations, such as movement (Perrin, 2009)

Figure 4: General anatomy of the harp seal

One thing unique about harp seals is they show a wide range of pelages (fur) through their development. Harp seal pups are born with a white coast of embryonic fur or lanugo. About 20 days later, pups begin to lose their white fur, creating a 'jagged coat' (Jefferson et al., 1994). At that point, the lanugo is replaced by a silver-white coat with irregular black spots on it, which the juvenile seal retains for about a year. After 12 to 14 months, the blacks spots grow larger and then the seal during this period is called a 'bedlamer' (Jefferson et al., 1994). Finally, when the harp seal reaches its sexual maturity (around 5.5 years old), the black spots change into a 'harp' shaped design, which is composed of two black lines that cover the dorsal side of the seal's flanks, starting at their pelvis and curving and converging between their shoulders (Jefferson, et al., 1994).

Figure 5. The female harp seal and her pup seal rest on an ice pack

(Picture retrieved from **https://www.naturepl.com/stock-photo-female-harp-seal-phoca-groenlandicus-touching-noses-with-her-pup-image01379272.html**)

Behavior:

Harp seals may travel up 5000 km in a year; their migratory patterns depend on where the population breeds and molts (Kovacs, 1987; Kovacs, 1995). Research also shows that birthing of the harp seal usually takes place in vast herds, which are quite highly synchronized. Birthing occurs during late February to April, with some variation across in the precise timing (Kovacs, 1995). Pups are born on the open free-floating pack ice and nursed for up to 12 days, in order to minimize energy cost, most pups are sedentary for the first month; some so immobile that they melt into the ice beneath them, forming ice 'cradles' (Kovacs, 1987). After molting, harp seals migrate to the northern end of their range and spend the summer there, and migrate back to the breeding territory in September. Even though harp seals joint together during the breeding season and molting stage, they prefer to spend the rest of time as 'solitary creatures,' research shows no evidence to social system or hierarchy within populations of harp seals (IUCN, 2008).

Harp seals spend a considerable amount of time in the open water, but as a semiaquatic marine mammal, they come out of the water on a regular basis (called 'haul out') to spend some time on land (Novak, 1999). They prefer to haul out at night, and the

two most extended haul outs occur during the breeding season and during molting stage, and during this period of time, harp seals make holes in the ice for easy access to water and to breath when swimming under the ice (Novak, 1999).

Harp seals are relatively shallow divers, and they have a varied diet of fish such as 'capelin, polar and Arctic cod, herring, sculpin, Greenland halibut, redfish, and plaice' (Novak, 1999). They also consume crustaceans such as amphipods and shrimps and prawns. There are several known predators including polar bears, killer whales, and sharks. Walruses also prey on harp seal females and pups in the White Sea area (Kleiman, 2004).

Adaptation:

Like mentioned previously, harp seals spend a significant amount of time in the water, and just like other pinnipeds, they have well-adapted lungs for such a lifestyle. The airways of harp seals are supported by smooth muscle, cartilage, and alveoli (which is a small sac under the surface of the membrane in cells), they are used as a site of diffusion for gases and nutrients (Denison, 1973). During the deep diving, the alveoli collapse entirely in the harp seal's lung; and different from terrestrial animals, harp seals have the ability to inflate their lungs even after they collapse due to an evolved pulmonary surfactant system (Denison, 1973).

In order to see both above and below the surface of the water, the eyes of harp seals are well adapted as well. Their eyes have evolved to be proportionally large, and contains a large spherical lens that helps them improve focusing ability for a navigation purpose (Perrin, 2009). Further, their pupil is mobile to assist in adapting the intense glare of the Arctic ice; and their cornea is lubricated by lacrimal glands, in order to protect the eye from sea water damage (Perrin, 2009). Its whiskers play a significant role in harp seals sensory system as well, they lie in horizontal rows on either side of the harp seal's snout, and they provide a touch sensor with labeled line coding, and underwater, they also help to respond to low-frequency vibrations, such as movement (Perrin, 2009).

Meanwhile, harp seals are very good at conserving their body heat, they combine anatomical and behavioral approaches to regulate their body temperature. They have a

thick layer of blubber under their skin which can help them maintain their body temperatures easily. However, blubber insulates the harp seals core but not the flippers as much, study suggests that the flippers rely on having circulatory adaptations to prevent heat loss (KVADSHEIM, 1997). Meanwhile, their flippers can be used as heat exchangers, warming or cooling themselves as needed. On the ice, they can press their fore-flippers to the body and their hind-flippers together to reduce heat loss (Perrin, 2009).

Threats:

Harp seals have been harvest for thousands of years by native peoples of the Atlantic Arctic, in including coast Northern Europeans for their oil (Kovacs, 1998). According to the research, 'The peak of sealing in the Northwest Atlantic occurred between 1818 and 1862 when 500,000 seals were harvested in many years, with maxima between 640 000-740 000 in individual years. During that time, it is estimated that 18.3 million harp seals, mostly whitecoats, were killed for oil' (IUCN, 2008). During the 20th century, harp seals became more valued for their pelts than their oil. During the 1960s, an average of 284,000 seals was taken per year in Northwest Atlantic stock (IUCN, 2008). In general, hunting has had a significant impact on the population size of harp seals, there was approximately 9 million harp seals existed 150 years ago, and now only about 3 million remain (ICUN, 2008).

At the same time, research has pointed out 'global climate warming is currently already causing major reductions in the extent and seasonal duration of sea ice cover in the Northern Hemisphere' (IUCN, 2008) which create a threat to many species of ice-associated marine mammals. Under such critical environment change, pinnipeds, such as harp seals that are dependant on sea ice for birthing, pupping, molting, and resting are very likely to be profoundly impacted.

Impacts:

Like other seal species, harp seals are blamed by the fishing industry for decreasing fish stocks, such as cod, especially in the Northwest Atlantic. However, evidence has shown that the decline in fish stocks is more likely caused by over-fishing

and discarding juvenile cod as bycatch (IUCN, 2008). In spite of such evidence, 'Canadian fishing interests and provincial government ministers in Newfoundland are calling for a massive cull of several million harp seals' (IUCN, 2008). Further, research has shown that the harp seal diet consists of over 120 species of fish and invertebrates, thus, somewhat ironically such a massive reduction in harp seal population would trigger a negative impact on the marine food web, further on commercially fished species (National Oceanic and Atmospheric Administration, 2018).

Conclusion:

Overall, as a species of true seal, the harp seal, *Pagophilus groenlandicus* is classified into the monotypic genus *Pagophilus*, and their closest relatives are bears. They are widespread in the North Atlantic and the adjacent Arctic Ocean and shelf seas. Harp seals are considered sexually dimorphic in size and pelage, and they also show a wide range of pelages through their development. Meanwhile, to adapt the extreme environment, harp seals are well evolved. They have thick blubber to maintain body temperatures, enlarged eyes to provide better navigation system, highly sensitive vibrissae to support the sensory system and an evolved pulmonary surfactant system to perform deep dive. International Union for Conservation of Nature (IUCN) states that due to the large population size, and increasing trends of the harp seal, it should continue to be classified as Least Concern (IUCN, 2015). However, people should aware that climate change and continuous hunting events create a severe threat to this species.

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