Research Note

Gastroliths in the harp seal *Phoca Groenlandica*

ERLING SVERRE NORDØY

Nordøy, E. S. 1995: Gastroliths in the harp seal *Phoca groenlandica*. *Polar Research 14(3)*, 335–338.

An adult harp seal, caught by accident in a gill net during the peak of the seal invasions along the northern coasts of Norway (1986/87), was found to have eaten 2.466 kg of stones with masses up to 265 g. Different theories to why harp seals on occasion deliberately eat stones, with particular emphasis on the hypothesis that these may aid in the physical breakdown of fish flesh and hard fish bones, are discussed.

Erling Sverre Nordøy, Department of Arctic Biology and Institute of Medical Biology, University of Tromsø, Breivika, N-9037 Tromsø, Norway.

Gastroliths (stones or pebbles in the stomach) have been found in many species of pinnipeds, such as the California sea lion *Zalophus californianus*, the harbor seal *Phoca vitulina* and the walrus *Odobenus rosmarus* (Emery 1941; Gjertz & Wiig 1992). Southern elephant seals *Mirounga leonina*, moreover, have been observed to contain as much as 35 kg of stones in their stomachs (Ling & Bryden 1981). Among the ice-breeding seals in the Northern Hemisphere, both the ringed seal *Phoca hispida* and the bearded seal *Erignatus barbatus* have been found on occasion to contain gastroliths in their stomachs (Kumlien 1879). A number of theories have been put forward to explain the function of gastroliths in pinnipeds (see King 1983; Riedman 1990). This note documents the first observation of gastroliths in harp seals *Phoca groenlandica*. It provides some support for the theory that gastroliths aid in the physical breakdown of large prey (Mathews 1929) and that they may also serve to grind up stomach parasites (Hamilton 1933).

During the winter of 1986–1987, there was a dramatic increase in the number of invading harp seals along the coast of northern Norway compared to previous years (Haug et al. 1991). Mark-recapture experiments suggest that the invading harp seals mainly belonged to the White Sea stock (Øien & Øritsland 1991), which during the winter is normally distributed within the Barents Sea and northwards to the pack ice between Spitsbergen and Novaja Zemlja. The harp seal reported in this study was caught by accident and drowned in a gill net, at the peak of the invasion, on 10 March 1987 in Troms county (69°39'N 18°41'E). The adult male had a curvilinear length from snout to tail-tip of 195 cm and a blubber thickness of between 30 and 45 mm along the ventral midline. Sternum blubber thickness was 40 mm, indicating that the condition of the animal was normal for the season (Sivertsen 1941). The body mass was estimated to about 150 kg, based on data on male body lengths and masses in March (Sivertsen 1941). The content of the seal stomach was analysed and found to contain large amounts of stones, together with some otoliths, fish bones and nematodes (Fig. 1). The total mass of the stomach content was 2.496 kg and consisted of 2.466 kg of stones (1.6% of body mass), 29 g of fish bones/otoliths and 1 g of parasitic nematodes. A total number of 139 stones, both flat and round, varying in mass (0.1–265.1 g) and diameter (0.5–7.7 cm), were found (Fig. 2). Based on the otoliths, which were minimally eroded, the prey was identified as cod *Gadus morhua*. Using a length–mass relationship for cod otoliths (Härkönen 1986), it was calculated that the total mass of the fresh undigested prey had been about 2.45 kg, while individual fish masses had varied between 0.3 kg and 0.7 kg.

The large amount of gastroliths present in the harp seal stomach suggests that these are swallowed intentionally and not by accident.

Laws (1956) reported that 84% out of 139 sou-

Fig. 1. The stomach content of an adult harp seal caught in a gill net during the seal invasion along the coast of northern Norway during the winter of 1986/1987. Shown are 2.466 kg of gastroliths and in the lower right corner some nematodes, otoliths (on darker paper) and fish bones. A bar with 1 cm divisions is shown at the bottom.

thern elephant seal stomachs contained sand and stones. Based on the observation that most of the solid material has been eaten just before the animals came ashore for a prolonged fasting period, he suggested that the stones served to relieve "hunger pangs" by providing the stomach muscles with bulk to relieve the contractions. The theory that pinnipeds may eat stones to relieve the sensation of hunger does not apply to the present incident since the animal had recently eaten and was in good condition. Moreover, stomachs of fasting harp seals collected in April at the outlet of the White Sea (n = 150) did not contain gastroliths (personal observation). The "ballast" theory, which implies that gastroliths help the seal to regulate buoyancy and balance while swimming and diving (Hamilton 1933), is also an unlikely explanation because in the spring harp seals are considerably leaner than in autumn (Nilssen et al. 1992a), and they would thus have no problem with a strong buoyant force due to a large blubber mass. A more relevant explanation for the current incident was proposed by Mathews (1929) who suggested that gastroliths aid in the physical breakdown of food. Spalding (1964) supported this theory when he reported that one-third of the Steller sea lions (*Eumetopias jubatus*) investigated had 1–10 gastroliths in their stomachs. He argued that since the sea lion's teeth are designed for grasping and tearing rather than grinding, the food is swallowed in larger pieces. Since much of the sea lion's food consists of large, heavily-boned species of fish, the grinding activity of stones in the stomach would be of assistance in the physical maceration of flesh and bones. Similarly, harp seal teeth are small and well-fitted for grasping but not for chewing prey.

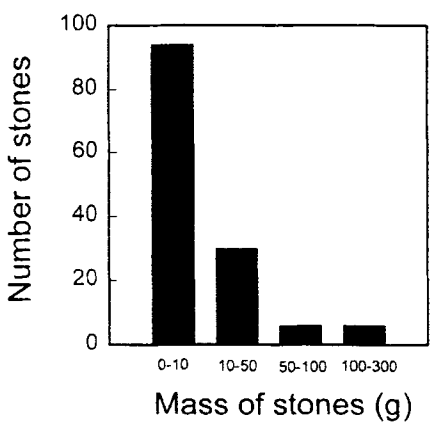

Fig. 2. Mass distribution of gastroliths in an adult harp seal.

From the observations of harp seal diet based on stomach content analysis during summer and autumn in northeastern Atlantic waters, it appears that the food normally consists of soft-bodied crustaceans and small fish, such as capelin *Mallotus villosus* and Arctic cod *Boreogadus saida* (Lydersen et al. 1991; Nilssen et al. 1992a). Such a diet is easily digested by harp seals (Mårtensson et al. 1994) and does not require gastroliths to aid digestion. During the seal invasions, however, there was a change in the diet, and heavily boned species of larger fish such as cod, haddock *Melanogrammus aeglefinus* and saithe *Pollachius virens* dominated (Haug et al. 1991; Nilssen et al. 1992b). The present individual had swallowed the fishes whole, as indicated by the presence of otoliths (from the head) and sharp bones (from the head and the rest of the fish) (Fig. 1). That harp seals may eat fish of this size (0.3–0.7 kg) in one piece is supported by the fact that captive harp seals have no problem swallowing herring *Clupea harengus* of masses of up to 0.8 kg in one piece (personal observation). A possible explanation for the presence of gastroliths in the present harp seal may be that the stones were deliberately eaten to aid digestion and the dissolution of the sharp bones when the diet changed to gadoid fishes, such as cod.

Haug et al. (1991) reported on the stomach content of 369 harp seals caught in gill nets along the coast of Norway in 1986–88. Despite the fact that gadoid fishes dominated in the diet of these seals, gastroliths, except for small pebbles accidentally eaten through the prey, were not observed in any of the stomachs (K. T. Nilssen, personal commun.). During the spring of 1995, however, 84 stomachs of yearling harp seals which were caught in gill nets along the coast of northern Norway were examined. Of these, one was found to contain 19 stones (total mass = 185 g), the largest being 40 g, in addition to otoliths from gadoid fishes (K. T. Nilssen, pers. commun.). This supports the observation that harp seals on occasion may deliberately eat stones. The reason for the low occurrence of gastroliths in gill net-caught harp seals may be that the stones are voided when the seals struggle in panic to escape from capture.

Emery (1941), in citing C. R. Schroeder, reported that both captive seals and sea lions have been observed to ingest pebbles from the floor of zoo tanks soon after feeding. These were apparently later regurgitated after the food had been digested. It is certainly possible that gastroliths also may function to remove difficult digestible hard fish bones from the stomach when the stones are regurgitated. In favour of the latter may be the fact that far fewer backbones and jawbones were found than would be expected from the number of otoliths still present in the harp seal stomach.

Another function of gastroliths in the stomach, as pointed out by Hamilton (1933), is the possible grinding effect on stomach parasites, such as nematodes. Harp seals are usually heavily infested with nematodes (personal observation). An alternative, or supplementary, explanation for gastroliths may be that the stones serve to destroy the parasites and reduce the irritation caused by them, thus lessening the degree of infestation.

In conclusion, I suggest that harp seals, on occasion may intentionally swallow gastroliths in order to ease the digestion of large prey, and that this phenomenon may represent the marine counterpart to the eating of small stones by many species of wild gallinaceous birds to support the grinding function of the gizzard (Schmidt-Nielsen 1984).

Acknowledgements. – Thanks to K. Lindgård for his comments to the manuscript. This study was supported in part by the Norwegian Fisheries Research Council.

References

Emery, K. O. 1941: Transportation of rock particles by sea mammals. *J. Sediment. Petrol. 11*, 92–93.

Gjertz, I. & Wiig, Ø. 1992: Feeding of walrus *Odobenus rosmarus* in Svalbard. *Polar Rec. 28*, 57–59.

Härkönen, T. 1989: *Guide to the otoliths of the bony fishes of the northeast Atlantic*. Danbiu, ApS, Hellerup, Denmark.

Hamilton, J. E. 1933: The southern sea lion, *Otaria byronia* (De Blainville). *Discovery Rep. 8*, 269–318.

Haug, T., Krøyer, A. B., Nilssen, K. T., Ugland, K. I. & Aspholm, P. E. 1991: Harp seal (*Phoca groenlandica*) invasions in Norwegian coastal waters: age composition and feeding habits. *ICES J. Mar. Sci. 48*, 363–371.

King, J. E. 1983: *Seals of the world*. Oxford: Oxford University Press.

Laws, R. M. 1956: The elephant seal (*Mirounga leonina*, Linn.) II. General, social and reproductive behaviour. *Falkl. Isl. Depend. Surv., Lond. Scient. Rep. 13*, 1–88.

Ling, J. K. & Bryden, M. M. 1981: Southern elephant seal *Mirounga leonina* Linnaeus, 1758. Pp. 297–327 in: Ridgway, S. H. & Harrison, R. J. (eds): *Handbook of Marine Mammals. Vol. 2: Seals*. Academic Press, London.

Lydersen, C., Angantyr, L. A., Wiig, Ø & Øritsland, T. 1991: Feeding habits of northeast Atlantic harp seals (*Phoca groenlandica*) along the summer ice edge of the Barents Sea. *Can. J. Zool. 48*, 2180–2183.

Kumlien, L. 1879. Contributions to the natural history of Arctic America made in connection with the Howgate Polar Expedition, 1877–78. *Bull. United States National Museum, No. 15*. Government Printing Office, Washington.

Mathews, L. H. 1929: The natural history of the elephant seal, with notes on other seals found at South Georgia. *Discovery Rep. 1*, 233–256.

Mårtensson, P.-E., Nordøy, E. S. & Blix, A. S. 1994: Digestibility of crustaceans and capelin in harp seals (*Phoca groenlandica*). *Mar. Mamm. Sci. 10*, 325–331.

Nilssen, K. T., Haug, T., Potelov, V. & Timoshenko, Y. 1992a: Preliminary data on feeding and condition of Barents Sea harp seals (*Phoca groenlandica*) throughout the year. ICES, CM 1992/N:5. 23 pp.

Nilssen, K. T., Grotnes, P. E. & Haug, T. 1992b: The effect of invading harp seals (*Phoca groenlandica*) on local fish stocks of North Norway. *Fish. Res. 13*, 25–37.

Øien, N. & Øritsland, T. 1991: Recaptures of harp seals (*Phoca groenlandica*) tagged as pups in the Greenland Sea, pup production and dispersion patterns. Unpublished paper no. WP SEA-33 presented to the Joint ICES/NAFO Working Group on harp and hooded seals, Copenhagen, 14–18 October 1991. 21 pp.

Riedman, M. 1990: *The Pinnipeds. Seals, sea lions, and walruses*. University of California Press, Los Angeles.

Schmidt-Nielsen, K. 1984: *Animal physiology: adaptation and environment*. Cambridge University Press, Cambridge, UK.

Sivertsen, E. 1941: On the biology of the harp seal *Phoca groenlandica* Erxl. Investigations carried out in the White Sea 1925–1937. *Hvalrådets. Skr. 26*, 1–164.

Spalding, D. J. 1964: Comparative feeding habits of the fur seal, sea lion, and harbour seal on the British Colombia coast. *Bull. Fish. Res. Board Can. 146*, 1–52.