16. Pinnipeds

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Background

Seals found in the EMAX study ecoregions include the harbor seal (*Phoca vitulina*), gray seal (*Halichoerus grypus*), harp seal (*Pagophilus groenlandicus*), and hooded seal (*Cystophora cristata*). Harbor seals are year-round inhabitants of the coastal waters of eastern Canada and Maine (Burns 2002) and occur seasonally along the southern New England and New York coasts from September through late May (Waring *et al.* 2004). Gray seals found in the U.S. Atlantic are part of the western North Atlantic population (Hall 2002) that inhabit waters from New England to Labrador and are centered in the Sable Island region of Nova Scotia. However, some pupping has been observed on several isolated islands along the Maine coast and in Nantucket-Vineyard Sound, Massachusetts (Waring *et al.* 2004). Harp seals are the most abundant pinniped in the northern Atlantic and Arctic Oceans (Lavigne 2002; Stenson *et al.* 2003); however, over the past decade during January to May, numbers of sightings and strandings have been increasing off the east coast of the U.S. from Maine to New Jersey (Waring *et al.* 2004). Hooded seals occur throughout much of the northern North Atlantic and Arctic Oceans, preferring deeper water and occurring farther offshore than harp seals (Kovacs 2002). Hooded seals tend to wander and have been seen in New England waters during January to May and as far south as Puerto Rico during summer and autumn (Mignucci-Giannoni and Odell 2001; Waring *et al.* 2004).

Data Sources and Quantitative Approach for Biomass Estimates

Biomass (in metric tons) of pinnipeds within an ecoregion was calculated as the sum of the seasonally averaged biomass of each species within that region. Biomass per area (in g m^{-2}) was calculated as biomass (in metric tons) per area of the ecoregion (in km^2; Table 1.1). The seasonally averaged biomass of species *k* within ecoregion *i* was calculated as the average of the seasonal biomass estimates for species *k* in ecoregion *i*:

(EQ. 16.1) $$Average\ Biomass_{ki} = \frac{\sum_{season}(seasonal\ \ biomass_{ki})}{4}.$$

The seasonal biomass estimate for species *k* within ecoregion *i* was the sum of the seasonal biomass of females and the seasonal biomass of males over all seasons *l*:

(EQ. 16.2) $$Seasonal\ \ biomass_{ki} = \sum_{season\ l}\ \sum_{sex\ j} \%sex_{kj} \bullet total\ \ seasonal\ \ abundance_{kli} \bullet avg\ weight\ of\ \ sex_{kji}$$

The seasons were defined as summer (June to August), fall (September to November), winter (December to February), and spring (March to May). The approaches used to estimate the seasonal abundance of each species and the animal weight for each sex of each species is described below.

Harbor seal abundance estimates were based on 2000-2001 aerial surveys (Barlas 1999; Hoover *et al.* 1999; Slocum *et al.* 1999; deHart 2002; Gilbert *et al.* 2005), and other ancillary data. Sexual parity was assumed based on literature review for other regions. The population

age structure was assumed to be 30% ages 1-3 and 70% ages 4+. Age 7 mean weights (kg) for males (80.791) and females (68.796) (M. Hammill, pers. comm., DFO, Mont-Joli, Quebec) were used to estimate Gulf of Maine biomass. Age 6 weights (76.450 males, 66.023 females) were used for the Southern New England and Mid-Atlantic Bight regions.

Gray seal abundance estimates were derived from 2000-2003 surveys (Barlas 1999; S. Wood pers. comm., UMass Boston) and other ancillary data. A 50:50 sex ratio was assumed. Age 9 weights (kg) for males (208.0) and females (153.0) (Mohn and Bowen 1996) were used to estimate biomass in all ecoregions.

Harp seal abundance estimates were based on strandings and bycatch data (Waring *et al.* 2004). A 50:50 sex ratio was assumed. Juvenile harp seals comprise the bycatch and strandings data; therefore, age 4 weights (kg) were used to estimate biomass. Female and male age 4 weights were derived from the following equations (Chabot *et al.* 1996):

(EQ. 16.3) Female: $\text{mass} = (98.6\ e^{(-1.325}e^{-0.383*\text{age})})$;

(EQ. 16.4) Male: $\text{mass} = (103.3\ e^{(-1.326}e^{-0.352*\text{age})})$.

Hooded seal abundance estimates were based on strandings and bycatch data (Waring *et al.* 2004). The stranding network saw primarily juvenile hooded seals (at ~ 120 cm / 27 kg with about 6-12 adults a year at ~215 cm / 136 kg; B. Rubinstein, pers. comm., New England Aquarium). Most were under 14 months because they were bluebacks, which have a distinct coloration until they molt at 14 months of age. Mean weight was calculated as (0.95 * 27 kg + 0.05 * 136kg) = 32.45 kg.

Quantitative Approach for Production Estimates

Net production biomass (in metric tons) within an ecoregion was calculated as the sum of the net production of species found in that ecoregion. Net production biomass per area (in g m^{-2}) was calculated as biomass (in metric tons) per area of the ecoregion (in km^2; Table 1.1). Net production biomass of species *k* within ecoregion *i* was calculated as the product of the seasonally-averaged biomass of species *k* within ecoregion *i* (eq. 16.1) and the net production rate for species *k*:

(EQ. 16.5) $$\textit{net production biomass}_{ki} = (\textit{seasonal avg biomass}_{ki} \bullet \textit{net production rate}_k)/1000\,.$$

The net production rate of harbor seals was assumed to be 6.5%, which is the percentage the harbor seal population in Maine increased between 1981 and 2001 (J. Gilbert, pers. comm.). In general, a net maximum production rate of 12% has been recognized as a default value for pinnipeds. This is based on theoretical modeling showing that pinniped populations may not grow at rates much greater than 12% given the constraints of their reproductive history (Barlow *et al.* 1995). Because the number of breeding gray seals in U.S. waters is expanding, a 12% net production rate was assumed. This is comparable to the rate of increase observed on Sable Island (Lesage and Hammill 2001). However, for both harp and hooded seals, a 6.5% value was assumed because these populations are not breeding in U.S. waters and the animals found in U.S. waters are essentially stragglers at the outskirts of their range.

Quantitative Approach for Consumption Estimates

Consumption biomass (in metric tons) within an ecoregion was calculated as the sum of the annual consumption biomass of species found in that region. Consumption biomass per area (in g m^{-2}) was calculated as consumption biomass (in metric tons) per area of the ecoregion (in km^2; Table 1.1). The annual consumption biomass (in metric ton) for species *k* within ecoregion *i* was estimated by:

$$\text{(EQ. 16.6)} \qquad Consumption\ biomass_{ik} = \frac{\sum_{season\ s} \sum_{days\ in\ s} daily\ feeding\ rate_{ks} \bullet (biomass/day)_{iks}}{1000},$$

where the (daily feeding rate)$_{ks}$ (in kg day^{-1}) is the daily feeding rate of species *k* for season *s* and the (biomass day^{-1})$_{iks}$ (in kg) is the biomass of species *k* within ecoregion *i* and within season *s*. The feeding rate per individual per day is defined as a percentage of its biomass. There is an inverse relation between feeding rate and body weight (Sargeant 1969). The daily feeding rate of pinnipeds was estimated using Innes *et al.* (1987):

$$\text{(EQ. 16.7)} \qquad Daily\ feeding\ rate_i = \frac{0.068 \bullet avg\ wt_i^{0.78}}{avg\ wt_i}.$$

The average body weights (avg wt) for each species are in the biomass section above.

Example Results

Biomass Estimates

The seasonal movements of pinnipeds between and outside the EMAX ecoregions are substantial, particularly for the southern two regions (Southern New England and Mid-Atlantic Bight) (Table 16.1), where there are only a few pinnipeds found in the summer. Pinnipeds primarily inhibit the Gulf of Maine region, and rarely use the Georges Bank region (Figure 16.1). Thus, it was assumed there were no seals in the Georges Bank area. Harbor seals contribute the most biomass to the pinniped mode in these U.S. waters.

Production Estimates

The patterns of production biomass (g m^{-2}) are similar to the patterns in biomass (Figure 16.1) because production biomass is simply the product of biomass and net production rate, which was assumed to be 6.5% for all species except gray seals (12%).

Consumption Estimates

Using equation 16.7, the daily feeding rate of pinnipeds ranged from 2.2% of the grey seal's body weight to 3.2% of the hooded seal's body weight, where the daily feeding rate of harbor and harp seals was 2.6% of its body weight.

The consumption biomass per area (g m^{-2}) is the highest in the Gulf of Maine and lowest in the Georges Bank and Mid-Atlantic Bight ecoregions (Figure 16.2). Harbor seals contribute most of the biomass in this node, so harbor seals contribute the most to the consumption biomass.

References

Barlas, ME. 1999. *The distribution and abundance of harbor seals (*Phoca vitulina concolor*) and gray seals (*Halichoerus grypus*) in southern New England, winter 1998 – summer 1999*. MA Thesis, Boston University, Graduate School of Arts and Sciences, Boston, MA; 52 p.

Barlow, J; Swartz, SL; Eagle, TC; Wade, PR. 1995. U.S. marine mammal stock assessment: guidelines for preparation, background, and a summary of the 1995 assessments. *NOAA Technical Memorandum* NMFS-OPR-6. 73 p. http://www.nmfs.noaa.gov/prot_res/readingrm/hqtechm.pdf

Burns, JJ. 2002. Harbor seal and spotted seal. *In*: Perrin, WE; Wursig, B; Thewissen, JGM, eds. *Encyclopedia of Marine Mammals*. New York, NY: Academic Press; p. 552-560.

Chabot, D; Stenson, GB; Cadigan, NB. 1996. Short-and long-term fluctuations in the size and condition of harp seal (*Phoca groenlandica*) in the Northwest Atlantic. *NAFO Sci. Coun. Stud*. 26:15-32.

DeHart, PAP. 2002. *The distribution and abundance of harbor seals* (Phoca vitulina color) *in the Woods Hole region*. MA Thesis, Boston University, Graduate School of Arts and Sciences, Boston, MA; 88 p.

Gilbert, JR; Waring, GT; Wynne, KM; Guldager, N. 2005. Changes in abundance of harbor seals in Maine, 1981-2001. *Mar. Mamm. Sci.* 21(3):519-535.

Hall, A. 2002. Gray seal. *In*: Perrin, WE; Wursig, B; Thewissen, JGM, eds. *Encyclopedia of Marine Mammals*. New York, NY: Academic Press; p. 522-524.

Hoover, KS; Sadove, S; Forestell, P. 1999. Trends of harbor seal, *Phoca vitulina*, abundance from aerial surveys in New York waters: 1985-1999. *In:* Proceedings of the 13th Biennial Conference on the Biology of Marine, Wailea, Hawaii, Nov. 28 – Dec 3, 1999. (Abstract).

Innes, S; Lavigne, DM; Earle, WM; Kovacs, KM. 1987. Feeding rates of seals and whales. *Journal of Animal Ecology* 56:115-130.

Lavigne, DM. 2002. Harp seal. *In*: Perrin, WE; Wursig, B; Thewissen, JGM, eds. *Encyclopedia of Marine Mammals*. New York, NY: Academic Press; p. 560-562.

Lesage, V; Hammill, MO. 2001. The status of the grey seal, *Halichoerus grypus*, in the Northwest Atlantic. *Can. Field-Naturalist* 115(4):653-662.

Mignucci-Giannoni, AA; Odell, DK. 2001. Tropical and subtropical records of hooded seals (Cystophora cristata) dispel the myth of extant Caribbean Monk Seals (*Monachus tropicalis*). *Bull. Mar. Sci.* 68(1):47-58.

Mohn, R; Bowen, WD. 1996. Grey seal predation on the eastern Scotian Shelf: Modeling the impact on Atlantic cod. *Can. J. Fish. Aquat. Sci.* 53:2722-2738.

Sergeant, DE. 1969. Feeding rates of Cetacea. *Fiskeridirektoratets Slorifter Serie Havundersokelser* 15:246-258.

Slocum, CJ; Schoelkopf, R; Tulevech, S; Stevens, M; Evert, S; Moyer, M. 1999. Seal populations wintering in New Jersey (USA) has increased in abundance and diversity. *In:* Proceedings of the 13th Biennial Conference on the Biology of Marine, Wailea, Hawaii, Nov. 28 – Dec 3, 1999. (Abstract).

Stenson, GB; Rivest, LP; Hammill, MO; Gosselin, JF; Sjare, B. 2003. Estimating pup production of harp seals, *Pagophilus groenlandicus*, in the Northwest Atlantic. *Mar. Mamm. Sci.*19(1):141-160.

Waring, G; Pace, RM; Quintal, JM; Fairfield, CP; Maze-Foley, K, eds. 2004. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments – 2003. *NOAA Technical Memorandum* NMFS-NE-182. www.nefsc.noaa.gov/nefsc/publications/tm/tm182

Table 16.1. Seasonal abundance estimates of each pinniped species within the EMAX ecoregions. It was assumed there were no pinnipeds in the Georges Bank ecoregion.

Species	Season	Ecoregion		
		GOM	SNE	MAB
Harbor seal	Spring	95,000	5,000	200
	Summer	100,000	0	0
	Fall	95,000	5,000	100
	Winter	90,000	10,000	300
Gray seal	Spring	1,000	4,500	5
	Summer	2,000	3,000	0
	Fall	2,000	4,500	5
	Winter	2,000	6,000	10
Harp seal	Spring	200	200	0
	Summer	0	0	0
	Fall	200	200	0
	Winter	200	200	0
Hooded seal	Spring	25	25	0
	Summer	0	0	0
	Fall	25	25	0
	Winter	50	50	0

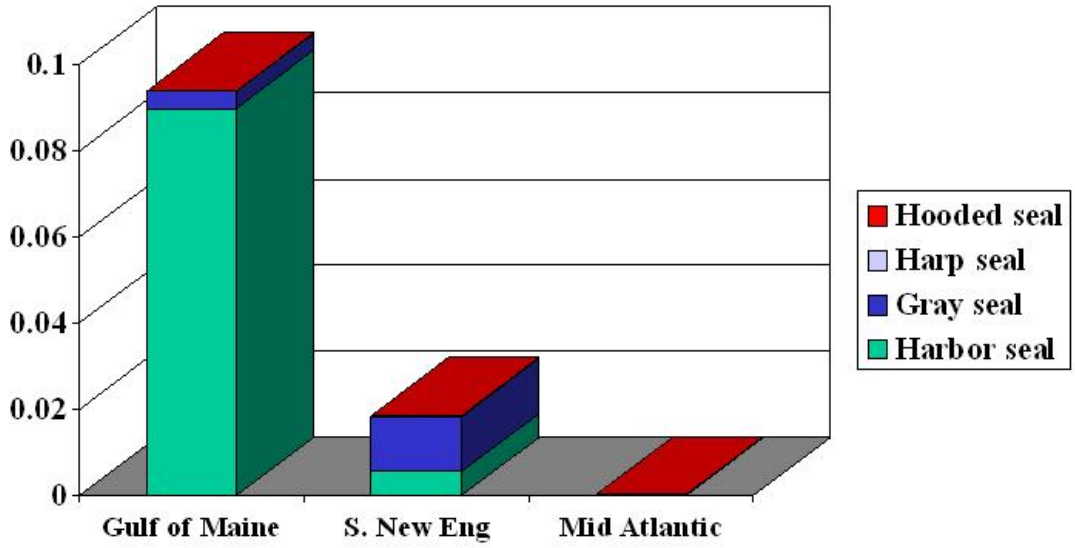

Figure 16.1. Biomass per area (in g m^{-2}) of species that make up the pinniped node for each ecoregion.

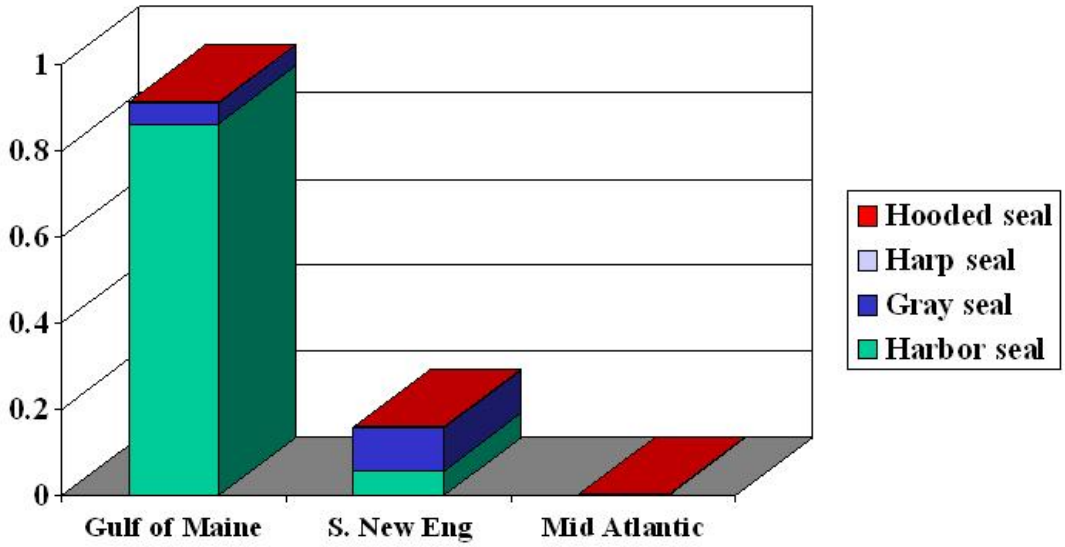

Figure 16.2. Consumption biomass per area (in g m-2) of species that make up the pinniped node for each ecoregion.