13. Small Pelagics (commercial, other, squid, anadromous) and Mesopelagics

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Background and Estimation Approach

Five categories of small pelagic fish were assessed using a survey swept area biomass expansion approach. Categories included small pelagics – commercial; small pelagics – other; squid, anadromous, and mesopelagic fishes (Table 13.1). Time series of spring and autumn research bottom trawl survey swept area biomass were produced for the 1996-2000 period. Informative gamma priors for weighting coefficients were developed from sources in the literature for the various categories by using available values (Table 13.2; Edwards 1968; Harley *et al.* 2001). Specific priors were developed for herring, mackerel, butterfish, sand lance, and anadromous, while general priors were developed for the squid, mesopelagic, and pelagic - other categories (Table 13.2). In addition, species-specific weighting coefficients were developed from stock assessments for herring, mackerel, and butterfish to be used as maximum likelihood estimates for these species. Linear regressions of spring and autumn survey swept area biomass on stock biomass were used to estimate the coefficient for each of the three stocks.

Priors used in the analysis were based on a gamma distribution where:

(EQ. 13.1)
$$F(x) = u^{r} x^{r-1} e^{-ux} \Big/ \Gamma(r)\,; \qquad x>0$$

where u is the mean and r is a shape parameter.

Priors for herring and mackerel were developed from weighting coefficients provided in Edwards (1968) for herring and argentine. The value for butterfish was taken as the average for butterfish and redfish from the same source. The prior for sand lance was available from Harley *et al.* (2001) and for the anadromous category from Edwards (1968) for alewife. A general prior was developed for the rest of the categories, taken as the average for herring, argentine, butterfish, and alewife (Edwards 1968). A Bayesian model framework was developed for each pelagic category, a CV of 25% was assumed for the r and u parameters of the gamma distributions for each category, and informative priors were calculated (Figure 13.1 and Table 13.3). In the case of herring, mackerel, and butterfish, recent estimates of weighting coefficients from the linear regression analysis were additionally provided as specific maximum likelihoods used to modify priors. Biomass estimates for all other categories were calculated based only on priors.

A WinBUGS (Spiegelhalter *et al.* 2003) model was produced for each pelagic category or for each single stock of pelagic fish, and average values (1996-2000) of swept area biomass for spring and autumn for each ecoregion were input. Two MCMC chains (Monte Carlo Markov Chains) were initiated for each run with a 10,000 iteration burn in period and a 100,000 iteration output period. Total biomass for each ecoregion was produced (Table 13.4), along with summary statistics including mean, sd, median, quartiles, and 80% and 95% CI's. In addition, trajectories for each variable and posterior distributions were output as cross checks on model performance. Results for herring, mackerel, and butterfish were summed to produce total biomass estimates for the pelagic - commercial category, and sand lance and the pelagic - other category were summed to produce the total for the pelagic - other category.

Production

Production for herring and mackerel was estimated from age-based data. Instantaneous growth rates were estimated from mean weight at age data, multiplied by average biomass, and summed across ages to obtain estimates of total production for 1996-2000. These values were annualized and converted to g m^{-2} (Table 13.4). The values were divided by annual biomass to obtain P:B ratios for mackerel and herring. Butterfish production was estimated from surplus production methods. Production to biomass ratios were used to calculate production for the other small pelagic categories. The butterfish P:B ratio (0.95) was used to calculate production for the pelagic - other, mesopelagic, and squid groups. The herring P:B ratio (0.42) was used for the anadromous group (Table 13.4).

Consumption

Consumption to biomass ratios for small pelagic and demersal fish were investigated by exploring the approach used in Sissenwine *et al.* (1984). In this study C:B ratios for six Georges Bank species were calculated based on theoretical considerations, ranging between 3.2 and 4.9 (Sissenwine *et al.* 1984). New calculations for GOM fishes suggest that these estimates may be too high; Palomares and Pauly's (1998) estimates ranged between 1.2 and 3.9 (Table 13.5). Ratios for pelagic and demersal fish used to balance the GOM Ecopath and EcoNetwrk models were based on estimates from the NEFSC food habits database. These estimates utilized the Eggers (1977) equation for consumption, and all the ratios were less than those in the Sissenwine *et al.* (1984) and Palomares and Pauly (1998) approaches.

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Table 13.1. List of species in the pelagic category.

Pelagics				
Pelagic-Commercial	Squid	Anadromous	Pelagic-Other	
Clupea harengus	*Cephalopoda*	*Alosa pseudoharengus*	*Etrumeus teres*	*Scomberesox saurus*
Scomber scombrus	*Illex illecebrosus*	*Alosa aestivalis*	*Brevoortia tyrannus*	*Decapterus macarellus*
Peprilus triacanthus	*Loligo pealeii*	*Alosa sapidissima*	*Osmerus mordax*	*Selar crumenophthalmus*
		Alosa mediocris	*Argentina silus*	*Decapterus punctatus*
Meso-Pelagic			*Menidia menidia*	*Trachurus lathami*
Myctophidae			*Ammodytes dubius*	*Ariomma bondi*
Maurolicus sp.			*Anchoa mitchilli*	*Opisthonema oglinum*
			Anchoa hepsetus	*Sardinella aurita*
			Ablennes hians	*Hemiramphus brasiliensis*
			Scomber japonicus	*Mugil cephalus*
			Selene setapinnis	*Mugil curema*

Table 13.2. Values for weighting coefficients from Edwards (1968) and Harley *et al.* (2001) and average values used for developing priors for each category.

Category	Species	Coefficient	Average
Pelagic - commercial			
Herring and mackerel	Argentine	0.018	
	Herring	0.01	
			0.014
Butterfish	Butterfish	0.07	
	Redfish	0.27	
			0.17
Pelagic - other			
	Herring	0.01	
	Argentine	0.018	
	Butterfish	0.07	
	Alewife	0.22	
			0.08
	Sand lance	0.00087	0.00087
Squid			
	Herring	0.01	
	Argentine	0.018	
	Butterfish	0.07	
	Alewife	0.22	
			0.08
Anadromous			
	Alewife	0.22	0.22
Meso-pelagic			
	Herring	0.01	
	Argentine	0.018	
	Butterfish	0.07	
	Alewife	0.22	
			0.08

Table 13.3. Priors for gamma distributions for small pelagic fishes and squids

Pelagic - commercial	Herring	r ~ gamma(16,4)	u~ gamma(16,0.056)
	Mackerel	r ~ gamma(16,4)	u~ gamma(16,0.056)
	Butterfish	r ~ gamma(16,4)	u~ gamma(16,0.680)
Pelagic - other	Sand lance	r ~ gamma(16,4)	u~ gamma(16,0.0035)
	Other	r ~ gamma(16,4)	u~ gamma(16,0.320)
Squid	Squid	r ~ gamma(16,4)	u~ gamma(16,0.320)
Anadromous	Anadromous	r ~ gamma(16,4)	u~ gamma(16,0.880)
Mesopelagic	Mesopelagic	r ~ gamma(16,4)	u~ gamma(16,0.320)

Table 13.4. Estimates of average biomass and production by group and region during 1996-2000.

	Biomass (g m^{-2} yr^{-1})					
	Pel - comm	Pel - other	Squid	Meso	Anadromous	Total
MAB	5.998476	3.92701	1.424743	0.002302	0.112047	11.46457731
SNE	13.88781	1.151342	2.728052	0.001314	0.160336	17.92885055
GB	9.946622	1.054368	0.962301	3.66E-05	0.037755	12.00108276
GOM	4.545072	1.060215	0.134569	6.82E-05	0.077245	5.81716827
Total	8.280098	1.777949	1.267477	0.000928	0.100272	11.42672373

	Production (g m^{-2} yr^{-1})					
	Pel - comm	Pel - other	Squid	Meso	Anadromous	Total
MAB	2.217167	3.732137	1.354042	0.002188	0.047618	7.353151661
SNE	5.04278	1.094208	2.592676	0.001249	0.06814	8.799052399
GB	3.434282	1.002046	0.914548	3.48E-05	0.016045	5.366956876
GOM	1.892098	1.007603	0.127892	6.49E-05	0.032827	3.060484459

Table 13.5. Ratios for C:B for GOM-GB species from the Palomares and Pauly (1997) equation.

	W~	T'	A	log(C/B)	C/B
Atlantic mackerel	1000	3.55682	2.65	0.582798	3.82647
Herring	300	3.55682	1.5	0.594016	3.92659
Bluefish	11363	3.55682	2.12	0.323488	2.106142
BFT	545454	3.55682	7	0.38555	2.429683
Cod	90901	3.55682	1.5	0.0878	1.224053
Haddock	11363	3.55682	1.4	0.263728	1.835387
Spiny dogfish	5000	3.55682	1.6	0.353058	2.254542

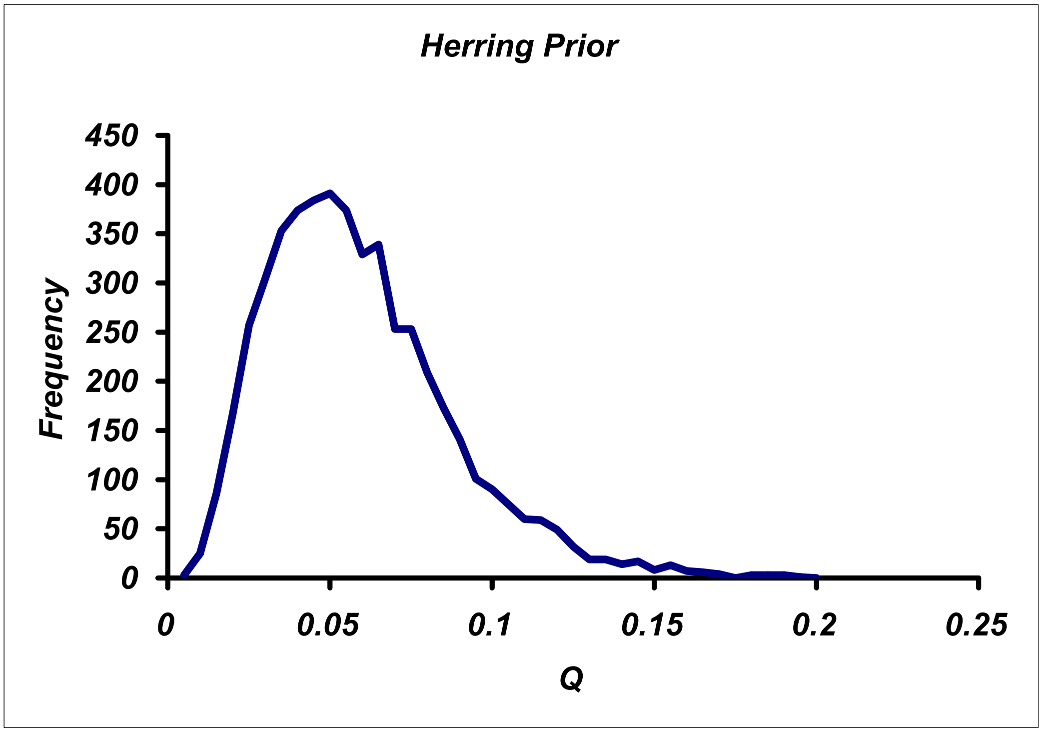

Figure 13.1. Example prior for Q on herring developed from values for herring and argentine from Edwards (1968) and stock abundance data.