THE IMPACT OF STAGHORN SCULPIN PREDATION ON NEWLY SETTLED DUNGENESS CRAB

During late spring/early summer, vast numbers of Dungeness crab (*Cancer magister*) megalopae reach estuaries and settle on intertidal flats, and during the next two months the crab population is rapidly culled by predation and cannibalism. Crab without appropriate refuge habitat are highly vulnerable to predation by fish and birds and accordingly survival of young crab is highest in shell and eelgrass beds. Staghorn sculpin (*Leptocottus armatus*) known to be generalist, opportunistic predators with large gapes, have high estuarine abundance, and are distributed throughout estuaries as crabs settle and moult to 1st instar. The objective of this study was to assess the potential impact due to staghorn sculpin predation on newly settling Dungeness crab in the Washington coastal estuary of Grays Harbor.

Staghorn sculpin and Dungeness crab population dynamics have been followed by monthly trawl surveys from April to September in 1983 through 1989. Young sculpin are found in the upper reaches of the subtidal channels and creeks, and migrate to deeper channels of the bay as they grow. Sculpins sampled by our gear ranged in size from 60 to 230 mm TL, and all sculpin greater than or equal to 80 mm TL were found to be capable of consuming newly settled crabs which comprised similar proportions of the diet of two size groups of sculpin in our samples.

The summer diet of staghorn sculpin composition was assessed by a series of 6 trawling trips in April through August, 1989. Stomach contents of sculpin from these monthly collections were analysed by a modified Index of Relative Importance (Stevens *et al.*, 1982). The sculpin's diet consisted of amphipods (46%), crangonid shrimp (24%), and small fish (12%) in April and *Callianassa* sp. (45%) and nereid polychaetes (37%) in May before crab settlement. In early June as crab became available, sculpin switched to nereid polychaetes (60%) and Dungeness crab (23%) as their primary food. In July and August, *Callianassa* and *Upogebia* sp., two species of mud shrimp, and *C. magister* were the three major items of diet. By pooling the results of all stomach content analyses from April to August, it was determined that *C. magister* formed 9% of the total summer diet of staghorn sculpin in Grays Harbor. It should be noted that the IRI index is a composite of frequency of occurrence, numerical and gravimetric percentages and thus a conservative measure of dietary importance in this case.

Staghorn sculpin are opportunistic feeders. This is shown by shifts in monthly diet that reflect prey availability. These fish have relatively high food requirements for rapid estuarine growth during warm summer months when water temperatures reach 14–16°C. Percent gut fullness (by visual assessment) was routinely high (>50% to distended) and mean gut contents were calculated at 7% of dry fish body weight. Interannual variability in sculpin populations was examined from 1983 to 1988 and peak summer populations ranged from 1 to over 3 million sculpin, with a six year mean estimated to be 2 million fish.

To assess the potential impact of sculpin predation on crabs, energetic requirements were used to derive an estimate and then field data were used to substantiate the parameters. An average size sculpin of 120 mm TL (20.4 g wet wt, 4.1 g dry wt) would consume 7% of its body weight per day (0.3 g dry wt) as a daily ration. If 10% of the total summer diet is Dungeness crab, then sculpin would consume 0.03 g crab dry weight per day. Gutermuth and Armstrong (1989) calculated the dry weights of Dungeness crab instars. Thus the daily ration of crab is equivalent to either 2 first instars, 1 second instar or 0.5 third instars. This pattern and frequency were substantiated by examining the number and stage of crab consumed by sculpin from early June to late July. As the instar size increased the number of instars eaten per fish decreased. Two scenarios of sculpin impact took into account variation in crab settlement period, crab moult frequency, proportion of daily ration composed of specific crab instars, and numbers of resident sculpin. Extremes in the different scenarios predicted staghorn sculpins could consume between 158 and 180 million newly settled Dungeness crab during June and July. Armstrong *et al.* (1987) have estimated that the average estuarine population of newly settled Dungeness crab is about 400 million which is reduced to between 20 and 40 million juvenile crab by the end of the summer. Thus, of the 360 million crab lost during summer, staghorn sculpin predation accounts for approximately 44 to 50% of the loss.

Literature Cited

Armstrong, D., Wainwright, T., Orensanz, J., Dinnel, P. and Dumbauld, B. 1987. Model of dredging impact on Dungeness crab in Grays Harbor, Washington. University of Washington, School of Fisheries Report No. FRI-UW-8702. 167p.

Gutermuth, F. and Armstrong, D. 1989. Temperature-dependent metabolic response of juvenile Dungeness crab *Cancer magister* Dana: Ecological implications for estuarine and coastal populations. Journal of Experimental Marine Biology and Ecology **126**: 135–144.

Stevens, B., Armstrong, D. and Cusimano, R. 1982. Feeding habits of the Dungeness crab *Cancer magister* as determined by the index of relative importance. Marine Biology **72**: 135–145.

Janet L. Armstrong, David A. Armstrong, and Paul A. Dinnel, School of Fisheries, WH-10, University of Washington, Seattle, WA 98195, USA.