Chapter 2

Outlook of Invasion of *Carcinus maenus*: Species distribution along salinity gradient of Yaquina Bay, Oregon

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Introduction

The introduction of the European green crab, *Carcinus maenas*, is causing great concern due to its potentially large effects on the native biota of the Oregon coast as well as the entire Pacific coast. Finding habitat in calm bays and estuaries, this voracious predator may have devastating effects on predator prey interactions that drive species diversity. In northern California, *Carcinus maena*s has already displaced the common red rock crabs, *Cancer productus* and *Cancer magister*, (reported by John Finger a clam raiser in Tomales Bay, California.) What effects might this predator have on other species?

This crab may consume members out of 104 biological families including, 18 genera, 5 plant and 14 animal phyla (Grosholz and Ruiz 1994). The marine invertebrates mostly affected by this invader species are the clams, mussels, oysters and other crabs. Although annelids, small crustaceans, and algae are not top on the green crab�s diet, they may also be selected as a food source (The Oregon Scientist 1997).

These invading predator crabs are highly adaptable and can tolerate a wide range of temperature and salinity variations making Oregon bays and estuaries possibly prime habitat. For example, Cohen et. al. (1995) have found that suitable habitat occurs where salinity levels range from 4 to 34ppt S. Successful breeding also requires salinity variation for this marine species, for instance, the reproduction of *Carcinus maenas* has been found to occur at salinity levels down to 12-13ppt S (Dries and Adelung 1982). Chapter 1 of this report examines distribution of *Carcinus maenas* and the salinity gradient of Yaquina Bay in more detail. Considering the salinity ranges of Yaquina Bay is not that high, other factors such as temperature, air exposure, sediment, and the larvae settling grounds may influence the fecundity and survivability of the green crab. Chapter 3 discusses effects of such landing sites like *Fucus gardneri* and *F. spiralis*.

In 1997, *Carcinus maenas* was discovered in Southern Oregon: 10 adults in Coos Bay, and a molt in the Coquille estuary. It is probably inevitable that these predators will migrate to other bays and estuaries since all bays and estuaries from Alaska to Baja California have suitable temperature and salinity conditions (Cohen et.al 1995). However, the methods of this migration are still under investigation.

Since no green crabs have been found in Yaquina Bay in Newport, Oregon, it is necessary to study the possible affects of this predator before the introduction. This present study involves the species distribution along the salinity gradient of Yaquina Bay. In order to assess which native species may be affected most by this introduction, an account must be made of those that are here already. But first, we must mention which habitats are more suitable than others.

Carcinus maenas is seldom found along the wave exposed areas of the intertidal because it prefers the sandy, muddy substratum of quiet bays and estuaries as suitable habitat (Crothers 1968). This crab species is not only a predator, but is prey as well, and must find safety and protection from exposure and other predators. A look at species distribution of the mid zone of the Yaquina Bay estuary along the salinity gradient will allow for a direct observation of native species present and those that could potentially be harmed by the predation and competition of the highly voracious invader, *Carcinus maenas*.

Materials and Methods

Five sites along the salinity gradient of Yaquina Bay were studied (see map). The first site, South Beach Jetty, was sampled near the mouth of the Yaquina River followed by the Hatfield Marine Science Center (HMSC). HMSC is located 1.9 miles from mile 0 at the South Beach Jetty site. The third site sampled was North West Natural Gas site, located 3.0 miles upstream. The Gas site was followed by Sawyer�s Landing at the 4.2 miles marker. The final site sampled, River Bend, is located at mile 5.2. These sites are noted on the report map located in the introduction and in Chapter 1. At each site, a distinct mid zone comprised of rocky substratum and muddy sediment was located and selected because it was a potentially suitable habitat for *Carcinus maenas* along the salinity gradient.

For each site sampled, we used a 15m belt transect. The transect line was laid haphazardly along the mid zone parallel to the water level. In addition, a meter stick was placed perpendicular to the transect line to limit observational boundaries. The entire transect was searched for the presence of species and the total area covered was 30 square meters.

In order to repeat these same methods at each site, a time limitation was used for observations ranging between 1.25 hours and 1.5 hours. Time searching for species was limited because of the heterogeneity differences at each site. For example, at the South Beach Jetty the mid zone was comprised of both rocky and sandy/muddy habitat where as the Hatfield site was composed of a dense rocky mid zone.

Macroscopic species were easily identified and noted. Some smaller species such as, small arthropods including the amphipods and isopods were only identified to family. This is probably adequate since it has been reported that *Carcinus maenas* has not had large affects on smaller crustacean populations (Ropes 1968, 1988; Reise 1977, 1978; Beukema 1991). Other species more common or slightly familiar were collected and identified to genus or species using Morris, Abbott, and Haderlie, Intertidal Invertebrates of California and/or Kozloff, Marine Invertebrates of the Pacific Northwest.

Results

We found that the species richness along the salinity gradient of Yaquina Bay decreased as we moved upstream into the estuary. South Beach Jetty had the highest richness comprised of 46 identified species of algae and invertebrates. Hatfield Marine Science Center was next with 33 species. The Northwest Narural Gas site, at mile 3 upstream from HMSC, had 24 identified species. Sawyer�s Landing had 21 species and River Bend had the lowest number, with 20 identified species.

An interesting observation took place at South Beach Jetty where we noticed that the cnidarian and echinoderm abundances dropped off the farther we moved into the estuary. We had difficulties sampling for bivalves due to the sedimentary conditions at the further sites causing relatively few identified at the four upper sites. Figure 1 shows in graphical form the species distribution along the salinity gradient of Yaquina Bay.

During the identification process, we were unable to identify some species beyond their phyla and some beyond their genera. Size distribution of some limpets, for instance, were too small to identify. However, our skills in field identification allowed us to determine that it was a different species than the others noted. On the species list (table 1) it is noted at *Lottia* spp.

The annelids observed were quite common and more easily identified to genera, especially those of the *Nereis* genera. These species were noted as *Nereis* sp A, sp B, and sp C. Each of these species were different species and were noted as such, however, as mentioned before, the field identification was limited. One species inparticular was noted for its massive size and its location inside a mucous lined tube of *Upogebia pugettensis*. This species was later termed *Nereis* sp C (large). Table 1 displays the entire species list for each site.

Table 1

Species	SB Jetty	HMSC	NW nat-gas	Saw Land	Riv Bend
ALGAE					
Fucus gardneri	X	X	X		
Fucus spirallis	X	X	X	X	X
Mastocarpus papillatus	X	X	X	X	X
Cladophora columbiana	X	X	X		
Ulva tineata	X	X	X	X	X
Entermorph intestinallis	X	X	X	X	X
	X	X	X	X	X
Cryptosiphonia woodii	X				
Laminaria sinclarii	X				
Polysiphonia spp.	X				
Dilsea spp.	X				
Ralfsia fungiformis	X	X			
Endocladia muricata		X			
Polysiphonia hendrii		X			
Ulva fenestrata		X			
CRABS					
Hemigraspus nudis	X	X	X	X	X
Hemigraspus oregonensis	X	X	X	X	X
Pagurus granosimanus		X			
Pagurus hirsutiusculus	X	X	X	X	X
Pachygrapsus crassipes	X				
Petrolisthes cinctipes	X				
Cancer productus	X	X			
Cancer magistar		X			
Cancer oregonensis		X			
Pagurus samuellis	X				
OTHER ARTHROPODS					
Balanus glandula	X	X	X	X	X
Cthamalus dalli	X	X	X		X
Semi-balanus cariosus	X				

Balanus balanus	X				
Idotea wosnesenskii	X	X	X	X	X
Idotea stenops	X				
Idotea spp.	X	X	X	X	X
Upogebia pugettensis		X	X	X	X
	X	X	X		X
	X			X	
Liparocephalus cordicollis	X				
Gnorimosphaeroma oregonense	X	X			
BIVALVES					
Mytillus califonianus	X				
Mytillus trossulus	X	X	X	X	X
Clinocardum nuttallii	X				
Tressus nuttalii	X			X	
GASTROPODS					
Littorina scutulata	X	X	X	X	X
Lottia digitalis	X	X	X	X	X
Nucella emarginata	X				
Tectura scutum	X				
Lottia pelta	X	X	X	X	X
Acmea spp.			X	X	
Lottia spp.	X	X			
ANNELIDS and WORMS					
Emplectomema gracile	X				
Notoplana spp.		X			
Nereis sp A	X		X	X	
Nereis sp B	X	X	X		
Nereis sp C					X
	X	X	X	X	X
ECHINODERMS					
Pisaster ochraceus	X				
CNIDARIANS					
Anthopleura elegantissima	X				
Anthopleura xanthogrammica	X				

Table 1- Species Richness list for Yaquina Bay, Oregon. This list shows the distribution of macroscopic species of the marine biota that was more commonly identifiable given the abilities and experience of researchers. In some cases, species were distinguished and identified to genera and then given a leter; A, B... Each represents a noticeable different species during the identification process. However, such species required more time for identification. This may be seen in the Arthropod, Bivalve, Gastropods, and Annelid sections. Future insight into time allotted for identification and/or the collection of species for identification should occur in order to enhance the possible effect of the introduction of Carcinus maenas.

Discussion

The results of this study illustrate a steady decline of species richness in the mid intertidal zone as one moves in the Yaquina Bay estuary. This trend is probably due to a number of factors such as decreasing and variable salinity levels, food availability, decreasing habitat complexity and the abundance and distribution of larvae.

Salinity is an important factor in limiting species richness in the estuary. Cnidarians and echinoderms may require higher salinity levels in their environments for survival and are the first organisms to disappear as one moves farther into the estuary. Varying salinity also affects the availability of food which may contribute to a decline of species richness.

Habitats become more uniform and begin losing their complexity as one moves upstream in the estuary, for instance, rocks become less abundant and the muddy sediment increases. The richness of niche space is greatly diminished which reduces the areas in which organisms can live and therefore species richness declines. Because of the reduced number of species, larvae distribution may be a factor in determining the number of species that settle in an area. Where and when the larvae settle is partially determined by the tides and current patterns of the incoming and out-going tides.

A probable source of error for this study is the time spent looking for and identifying species at each of the study sites. The time allotted for each belt transect was approximately 75 to 90 minutes. The majority of species identified were large and more readily found. Various microspecies such as some amphipods and smaller crustaceans may have been overlooked but *Carcinus maenas* has not been noted to have effects on these species. If more time was allotted for the searching method at each of the sites, the species list would most likely be larger and more complete. However, significant impact of the green crab is unknown for smaller species as noted previously. Because of the time of year that this study was conducted, the majority of searching time was spent at night where headlamps were used as a source of illumination. This probably led to oversights in certain species that either fled with the light or were more difficult to detect due to size, abundance, or location. Future sampling efforts should be made by company with a comparable ability for field identification of species and should increase the field identification time at each site if possible. This should be done in order to compare results of these studies along and enhance to knowledge of the possible inevitable effects of the European green crab.

As the European green crab begins to invade this area the species richness of the Yaquina Bay estuary could possibly be affected. This crab is known to live in a wide range of salinity (see Chapter 1) and therefore will probably colonize most of the estuary. It has been shown that *Carcinus maenas* consumes an immense variety of prey items including many of the species already existing in the bay. Because of this trait, this crab species is an excellent competitor and has the potential to displace a number of native crab and other species, such as *Cancer productus* and other predatory crabs (Cohen et.al. 1995). Therefore, the arrival and establishment of *Carcinus maenus* in Yaquina Bay estuary could affect not only the species richness of the area but could possibly cause other ecological changes as well.