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Aquatic Nuisance Species
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Providing current information on monitoring and controlling the spread of harmful nonindigenous species.

Nonindigenous Species and Upcoming Guidelines for Prevention

by William (Jay) Rendall

The topic of regulations and guidelines to prevent the introduction and spread of nonindigenous aquatic nuisance species (ANS) is large and complicated. Therefore, this article will not cover the topic in detail, but rather will provide a broad overview of past, current, and upcoming ANS regulations and guidelines, and will try to answer the question of whether regulations, alone or together with other activities, are an essential part of ANS management. By way of definition, "guidelines" means activities that someone is recommended to follow; "regulations" means what someone is required by law to follow.

Lessons from the Past and Visions for the Future

Several lessons from the past provide the context for discussing the importance of guidelines and regulations:

- There are many pathways of introduction and spread for ANS, most of which are related to human activities, both accidental and intentional. New species continue to be introduced and spread within North America through these pathways.
- Introductions have many costs associated with them: control and management costs; long-term ecosystem changes; and loss of recreational opportunities.
- Often there are no acceptable controls available for use in natural waterbodies once ANS become established.
- Once species are successfully introduced, any control efforts will be very expensive and eradication very unlikely.

Guidelines & Regulations *continued on page 18*

Have Claw, Will Travel

by Andrew N. Cohen

The common green crab *Carcinus maenas*, a marine species native to Europe, has spread to many parts of the world, where its appetite for commercially valuable clams and crabs has distressed some important fisheries. Originally restricted to Europe and possibly northwest Africa, it invaded eastern North America by 1817, southern Australia by 1900, and California by 1989 or 1990. Recent genetic studies have also revealed the presence of the Mediterranean green crab *Carcinus aestuarii* alongside common green crabs in South Africa and Japan (where green crabs have been reported since 1983 and 1984, respectively)(Geller et al. in press). Additional records of the European green crab from Hawaii, Panama, Brazil, and at several sites in the Indian Ocean represent introductions that never "took," probably because the crab cannot reproduce successfully in these warmer waters (Carlton and Cohen in press).

Have Claw *continued on page 16*

In This Issue:

Have Claw, Will Travel

Continued from page 13

Transport Mechanisms

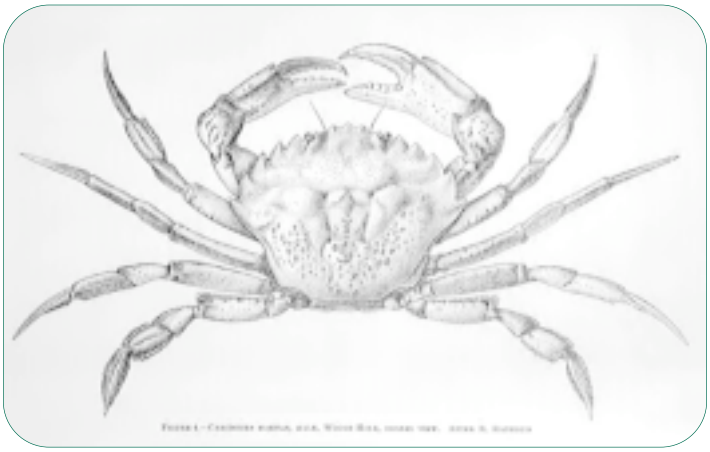
These otherwise hardy crabs are remarkably **polyvectic***, having had access to many modes of transoceanic and interoceanic transportation. In the early days they could be carried among rocks loaded for solid ballast or on the hulls of ships—nestled among dense growths of attached organisms such as barnacles, mussels, sponges, seaweeds, sea squirts, and mussels, or in cavities cut into wooden hulls by wood-boring clams and crustaceans. In recent years they could be transported as larvae or small crabs in ballast water tanks or in other parts of ships' sea-water systems; in accidental association with the burgeoning global shipments of living marine organisms for aquaculture facilities and food markets; or they escaped or were released from aquaria at educational or research institutions (Cohen et al. 1995; Carlton and Cohen in press). Le Roux et al. (1990) suggested that green crabs arrived in South Africa on semi-submersible exploratory drilling vessels, a mechanism that has transported whole communities of organisms across oceans (Benech 1978). However, green crabs most likely reached California in seaweed-packed shipments of marine bait worms from Maine (Cohen, Carlton, and Lau, unpublished data).

Green Crabs in North America

In eastern North America green crabs gradually spread from the New York-New Jersey region north to Canada, where they are now one of the most commonly encountered intertidal and nearshore crabs. In the 1950s they became very abundant in bays and estuaries in northern New England, where they caused massive destruction in the soft-shell clam fishery (Glude 1955; MacPhail et al. 1955), and inspired a variety of control efforts including the use of fences and of bait soaked in pesticide (Smith and Chin 1951; Hanks 1961). Predation by green crabs has also induced evolutionary changes in shell shape in snails in this region (Vermeij 1982).

Green crabs were first collected in California in 1989 or 1990, with a population discovered in an artificial lagoon in southern San Francisco Bay where bait trappers sometimes found their traps packed with hundreds of green crabs. A single adult crab was also caught near Bodega Bay, about 50 miles north of San Francisco, in 1989. By 1995 green crabs had been collected in seven bays from Elkhorn Slough north of Monterey to Humboldt Bay near Eureka, a distance of 320 miles (Cohen et al. 1995; Grosholz and Ruiz 1995; Miller 1996); and in April 1997 green crabs were discovered in Coos Bay, Oregon, another 200 miles farther north (N. Richmond pers. comm.). The crab's physiology and **biogeography** suggest that its expansion will ultimately be limited in the north by winter water-surface temperatures averaging about -1° to 0°C, and in the south by average summer water-surface temperatures of about 22°C, which are warm enough to inhibit reproduction; this corresponds to a potential range from north of the Aleutians in Alaska south to central Baja, California (Cohen et al. 1995; Carlton and Cohen in press).

words in **bold type are defined in the glossary on page 23.*



The common green crab *Carcinus maenas*

In California, green crabs are found in bays in intertidal and shallow subtidal waters and in nontidal lagoons, mainly on sand and mud but also on riprap and under rocks in the intertidal zone at low tide. In Europe and eastern North America green crabs are common in sheltered marine and estuarine waters, and present in all but the highest-energy, outer coast environments. Its habitat in these parts of the world includes mud, sand, and rock bottoms, eelgrass beds, and salt marshes. Although green crabs typically live in water less than 20 feet deep, they have been collected down to at least 180 feet (Cohen et al. 1995). With time green crabs may occupy a similar range of habitats on the Pacific coast.

Adult green crabs can tolerate salinities from 4 parts per thousand (ppt) (nearly fresh) to 54 ppt (saltier than the ocean), and have successfully reproduced in salinities as low as 13 ppt. In winter the crabs, especially the females that are carrying eggs, often move into deeper and typically saltier water, perhaps because at colder temperatures the eggs are less tolerant of low salinities. A mature females can produce up to 200,000 eggs a year, so a population of green crabs can increase rapidly if conditions are right (Cohen et al. 1995).

Effects of Green Crabs

Green crabs have the potential to damage the commercially important Dungeness crab, oyster, and clam fisheries, and to seriously affect many other species. The greatest concerns stem mainly from the green crab's feeding activities—this is a crab that will eat nearly anything. Scientists have recorded an enormous variety of organisms consumed by green crabs, including species from at least 104 families and 158 **genera** in 14 animal and five plant and protozoan **phyla**, although the crab doesn't seem to like echinoderms (the phylum that includes starfish and sea urchins).

Analyses of stomach contents have revealed wide variations in the green crab's main prey: mussels, clams, snails, worms, barnacles, seaweeds (algae), or isopods and other crustaceans. This variety is partly because different organisms are common in different areas, but also seems partly due to crabs selecting different prey. There is also evidence that crabs change their diet with the season, and that large and small crabs, male and female crabs, and crabs in different molt stages may also prefer different foods (Cohen et al. 1995).

***Have Claw** continued on next page*

Have Claw *continued from previous page*

Green crabs locate their food mainly by smell and touch. They readily dig up clams and other prey buried a few inches deep, and occasionally dig as deep as six inches to extract large clams. In the laboratory they have been observed eating mussels and soft-shell clams that are as long or even longer than their **carapace** width, and hard shelled clams and snails that are over half their carapace width. On the Pacific coast, green crabs might reduce production in oyster farms and clam fisheries by preying on young oysters and clams as well as on adult clams (Cohen et al. 1995).

The potential predation on and competition with the commercially and recreationally harvested Dungeness crabs are of particular concern. While green crabs often spend their entire lives in bays and estuaries, Dungeness crabs use these sheltered waters primarily as nursery areas; typically entering when very young and returning to the ocean a year or so later as subadults. Since adult green crabs will mainly encounter smaller juvenile Dungeness crabs, and since green crabs in the laboratory have eaten Dungeness crabs up to their own size (Grosholz and Ruiz 1995), the situation does not bode well for the Pacific coast crab fishery. Green crabs only grow to about three inches in width and despite their abundance in Europe and eastern North America are rarely harvested for food, so losses in the Dungeness crab fishery are unlikely to be offset by the development of a fishery for green crabs.

Photograph by Caroline Kopp
The common green crab *Carcinus maenas*

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Upcoming Meetings

American Fisheries Society Meeting
24-28 August
Web Page: www.esd.ornl.gov/societies/AFS

Zebra Mussels: Lessons Learned in the Great Lakes
10 September, A Nationwide Videoconference, sponsored by Illinois-Indiana Sea Grant Program, in cooperation with the Great Lakes Sea Grant Network and Purdue University Cooperative Extension Service.
POC: Patrice Charlebois, 847-872-0140/
Tom Luba, 765-494-8414. Read details on the Web
http://www.aes.purdue.edu/acs/zm/regis.html

The Midwest Fish & Wildlife Conference
7-10 December, Milwaukee, WI
Session: Invasive Species:
Impacts on Terrestrial Communities
Contact: Bill Swenson, University of Wisconsin
(712) 394-8410 email: wswenson@staff.uwsuper.edu

Eighth International Zebra Mussel and other Aquatic Nuisance Species Conference
16-19 March 1998, Sacramento, CA
Contact: Elizabeth Muckle-Jeffs
(800) 868-8776 email: profedge@renc.igs.net

63rd North American Wildlife and Natural Resources Conference
20-24 March 1998, Orlando, FL
Session: Nonindigenous Species: Methods of Introduction and Impacts
Contact: Richard E. McCabe,
Wildlife Management Institute (202) 371-1808

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