Status of the European Green Crab in Oregon Estuaries in 2004

by

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Executive Summary

The recent invasion of Pacific Northwest estuaries by the European green crab, *Carcinus maenas*, caused much initial alarm. Following the last El Niño of 1997-98, a strong cohort of young green crabs appeared in estuaries along the coasts of Oregon, Washington, and as far north as Port Eliza on the west coast of Vancouver Island, British Columbia. Unusually strong northward-moving coastal currents (up to 50 km/day from September 1997 to April 1998) must have transported green crab larvae from more established source populations in California to the Northwest. Coastal transport events and recruitment of young green crabs have been much weaker in recent years.

It was hoped that green crabs would go extinct in the Pacific Northwest estuaries once the original colonists reached the end of their life span of 4-6 years. This has not happened. Some recruitment has occurred every year since 1998. Recruitment strength appears to be linked to winter temperatures: cold winters (2002) result in poor recruitment while warm winters (2003), in good recruitment. Circumstantial evidence suggests that Coos, Yaquina, Netarts and Tillamook estuaries in Oregon and Willapa Bay, Washington harbor a small self-sustaining population of green crabs that is **not** dependent on a larval source from California.

There can be a substantial time lag between the discovery of an exotic species and its impact on the native community. For example, green crabs were documented to exist in New England in 1817, but it was not until the 1950's when this species expanded its range and increased in abundance sufficiently to impact the soft-shelled clam populations in Massachusetts, Maine and Nova Scotia. Even though green crab abundance in the Pacific Northwest is low when compared to Europe, eastern North America, Tasmania and California, it is imperative to continue monitoring efforts for two reasons:

1) to elucidate the process of range expansion of this model non-indigenous marine species with planktonic larvae and
2) to understand the role of ocean conditions on recruitment in order to predict the next strong recruitment event of green crabs.

Introduction

The invasive European green crab (*Carcinus maenas)* was discovered in Oregon, Washington and British Columbia coastal estuaries in the late 1990's (Behrens Yamada 2001). The simultaneous appearance of a strong new year class of green crabs in Oregon and Washington estuaries in the summer of 1998 was correlated with warm temperatures and strong northward moving coastal currents (>50 km/day) during the 1997/1998 El Niño (Behrens Yamada and Hunt 2000). This year class most likely arrived as larvae from well-established source populations in California. Since these original colonists have now approached the end of their lifespan, the next few years are critical for determining the fate of green crab populations in Pacific Northwest estuaries. While some recruitment of young green crabs has occurred in Oregon and Washington estuaries since 1998, none of the recent years have produced as strong a year class as that of 1998. With the loss of the large 98 females, it is not known whether the less abundant, smaller females can produce an adequate larval supply to "seed" our estuaries. On the other hand, the next strong El Niño could bring another influx of larvae from California, resulting in increased abundances and further range expansion. Scientists, managers and shellfish growers are concerned that increases in the abundance and distribution of this efficient predator and competitor could permanently alter native marine communities and threaten commercial species such as juvenile Dungeness crab, juvenile flatfish and bivalves (Lafferty and Kuris 1996, Jamieson et al. 1998). The goal of this study is to estimate the current densities and predict the future status of the European green crab in Oregon estuaries and the Pacific Northwest. This was accomplished by:

- Estimating the size/age structure and density of the Oregon green crab population.
- Estimating the year-class strength of young-of-the-year green crabs.
- Comparing patterns in recruitment strength over time and correlating them to ocean conditions.

Sampling Methods for Green Crabs in Oregon

Our sampling effort focused on four Oregon estuaries: Coos, Yaquina, Netarts and Tillamook. All estuaries were sampled at least twice during the 2004-trapping season (Appendix 2). In each estuary, we selected study sites within various habitat types and tidal levels. Since green crabs are rare and patchily distributed, we did not choose our sites randomly. Instead, we selected sites that were known to have harbored green crabs in the past. We learned that green crabs are most abundant in tidal marshes, gradually sloping mudflats and tidal channels where salinities remain above 15 ‰ and water temperatures range between 12- 18^{o} in the summer (Behrens Yamada and Davidson 2002). Green crabs were noticeably absent from the cooler, more saline mouths of estuaries, which are dominated by the larger and more aggressive red rock crab, *Cancer productus* (Hunt and Behrens Yamada 2003).

Since *C. maenas* larvae settle high on the shore (Zeng et al. 1999), and crabs move into deeper water as they age (Crothers 1968), we adapted our collecting methods and locations to effectively sample all age classes of *C. maenas.* Since traps differ in their sampling efficiency

for different sizes of crabs, we used two trap types (Table 1). Folding fish traps, with their wide slit-like openings, work well for adult crabs larger than 40 mm carapace width (CW); while minnow traps with their small mesh size (0.5 cm) retain young-of–the-year green crabs. Green crabs start entering these baited traps when they are around 20-30 mm CW. Typically, we would trap young-of–the-year green crabs in the high and mid intertidal with minnow traps and larger adult crabs in the low intertidal and subtidal zones with folding traps (Appendix 2).

Table 1. Types of traps used for sampling *C. maenas* in Oregon estuaries. Size selectivity is given in carapace width (CW).

Trap Type	Description	Dimensions	Tidal Height	Size Selectivity (CW)
Minnow/ Crayfish	Wire mesh (0.5 cm) cylinder with two openings expanded to 5 cm	21 cm diameter 37 cm long	Medium to high	Medium 30-70 mm
Folding Fish Trap	Plastic mesh (2 cm) with two slit openings (45 cm)	63 x 46 x 23 cm	Subtidal to lower intertidal	Large >40 mm

Rocks were added to the traps to weigh them down and to provide shelter for the crabs. We cut salmon backbones into sections and placed them into egg-shaped commercial bait containers (15 x 8 mm). Holes (0.5 cm) in the sides and lids of the containers allow bait odors to diffuse. One bait container with fresh bait was placed in a trap and left for one high tide (6-24 hours, depending on tidal height and tidal cycle). We retrieved the traps at low tide, identified all crabs to species and noted the sex, carapace widths (CW) and molt stage of all green crabs (Appendix 3). Green crabs were measured between the tips of their fifth anterio-lateral spines using vernier calipers. Native crabs and other by-catch were released while green crabs were removed from the ecosystem and destroyed.

Results

Densities of Green Crabs in Oregon Estuaries

The relative abundances of green crabs trapped in Oregon estuaries during 2004 are tabulated in Appendix 2 and summarized in Table 2. As can be seen from Appendix 2, Catch per Unit Effort (CPUE) is extremely variable, even within the same site. Thus, one must use caution in interpreting differences in CPUE between sites and over time. What can be concluded, however, is that catches have decreased an order of magnitude since 1999 (Table 2). While average CPUE in 1999 ranged from 0.4 to 0.7, that for 2002-2004 ranged from 0.03 to 0.3. While it appears that catches in Netarts and Coos Bays increased in abundance from 2003 to

2004, it should be noted that these higher values reflect our tendency to focus more on the "hot spots" rather than to consistently trap unproductive sites. We chose this strategy in order to obtain a sufficiently large sample size for assessing population structure.

Table 2. Relative Green Crab abundances for our study sites in Oregon estuaries from 1999 to 2004. Data for 1999 were complied from Hauck 2000 and Hunt and Behrens Yamada 2003.

Estuary	Number of crabs trapped (# trap-days)			
	1999	2002	2003	2004
Coos Bay	15 (39)	9 (180)	14 (203)	18 (137)
Yaquina	223 (323)	26 (168)	63 (1084)	12 (461)
Tillamook		2 (71)	6 (70)	4 (51)
Netarts		0 (44)	11 (44)	12 (39)
Total	238 (362)	37 (463)	94 (1431)	46 (688)

Estuaray	Catch per trap per day			
	1999	2002	2003	2004
Coos Bay	0.38	0.05	0.07	0.13
Yaquina	0.69	0.15	0.06	0.03
Tillamook		0.03	0.09	0.08
Netarts		0.00	0.25	0.31
Total	0.657	0.080	0.066	0.067

Age Structure of Green Crabs in Oregon Estuaries

From previous mark and recapture studies and from shifts in size frequency distribution over time (Behrens Yamada et al. 2005) we estimated the age of green crabs retrieved from Oregon estuaries in the summer of 2004 (Appendix 3). We assigned crabs to three age classes based on their size and coloration (Appendix 3, Table 3). Crabs under 55 mm at the end of the summer represent "recruits", or crabs that settled early in 2004. Crabs between 55 and 75 mm with green or yellow carapaces would represent the 2003-year class. All other crabs were categorized as

'older. Since we found only one recruit in Oregon in 2002 and none in Washington (Table 4), we deduce that "older" crabs settled in 2001, 2000, 1999 and 1998.

Table 3. Age structure of Carcinus maenas retrieved from Oregon estuaries in 2004. Note that a molt from Coos Bay and two sighting by Jessse Haye and one by John Faudskar for Tillamook Bay are included.

Estuaray	Year Class		
	2004	2003	"older"
Coos Bay	0	4	15
Yaquina	4	6	2
Tillamook	2	3	2
Netarts	0	10	2
Total	6	23	21

Early in the summer, we still retrieved 9 green crabs over 90 mm in carapace width in Coos and Netarts Bays, suggesting that some of the original colonists from the 1997/1998 El Niño cohort were still represented in Oregon estuaries (Appendix 3). When these larger crabs were taken into the lab, many became sluggish, stopped eating and died. None of these older crabs were trapped in our "hot spots" in Yaquina and Netarts Bays by the end of the summer and early fall (Appendices 2 and 3). Green crabs in Europe and Maine have a maximum longevity of around 4-6 years (Berrill 1982, Dries and Adelung 1982). We thus predict that very few, if any, of the 98-year class will survive the winter of 2004/2005.

Recruitment over time

Periodic sampling of young-of–the-year green crabs in Yaquina Bay and systematic sampling in Willapa Bay, by the Washington Department of Fish and Wildlife indicate that some recruitment occurred in these estuaries in most years from 1998 to 2004 (Table 4). In late summer and fall of 1998, we observed a well-defined cohort of young green crabs ranging in carapace width from 32-60 mm and averaging 47 mm in both estuaries. Catches of young-of-the-year green crabs in subsequent years, however, have decreased by at least one order of magnitude.

A correlation between mild winter temperatures followed by good green crab recruitment was observed for Maine and Europe (Berrill 1982, Beukema 1991) and appears to hold for the Pacific Northwest. The cold winter of 2002 was followed by very poor recruitment, while the mild winter of 2003, by good recruitment (Table 4). Catches of young crabs at the end of the

2003-growing season were especially high in Netarts, Tillamook and Willapa. This year class is presently the most dominant one in Oregon estuaries (Table 3). With the 98-year class dying of senescence, it is not know whether the 2003-year class is large enough to adequately "seed" Pacific Northwest estuaries with larval and keep the Oregon and Washington population from going extinct.

Table 4. Relative abundance (CPUE) and size of young-of-the-year *Carcinus maenas* at the end of their first growing season in the Coos, Yaquina, Netarts, and Tillamook estuaries, Oregon and in Willapa Bay, Washington. Crabs were typically caught in September and October. Catch per unit effort (CPUE) is reported as number of crabs per trap per day. N=number of young crabs sampled; SD=Standard Deviation; na=temperature data not available. Asterisk indicates that only 7 minnow traps were deployed that fall and that the one young crab entered a collapsible Fukui fish trap. Surface water temperatures for December-March for the Hatfield Marine Science Center Dock in Yaquina Bay were provided by David Specht of the Newport EPA; those for Willapa Bay, by Jan Newton of the DOE. Note that large mean size in 1998 and 2003 may be linked to warm water temperatures during the previous winter.

Year Class	Estuary	# Months <10°C	Mean Winter Temp. °C	N	CPUE Pitfall traps	CPUE Minnow traps	Mean Carapace Width (mm)	SD	Range
2002	Coos		na	0		0			
2003	Coos		na	1		0.01	59.4		
1998	Yaquina	0	10.9	201		5.0	46.9	5.0	32-60
1999	Yaquina	4	9.0	13	0.20		38.0	5.0	30-47
2000	Yaquina	3	9.5	14		0.31	37.5	5.0	30-45
2001	Yaquina	3	9.5	1		0.0*	55		
2002	Yaquina	4	9.2	1		0.01	38.9		
2003	Yaquina	0	10.5	9		0.07	44.9	5.5	41-59
2004	Yaquina	3	9.9	4		0.07	35.3	5.1	32-43
2002	Netarts		na	0		0.0			
2003	Netarts		na	6		0.15	49.4	3.7	45-55
2004	Netarts			0		0			
2002	Tillamook		na	0		0			
2003	Tillamook		na	5		0.17	50.0	3.1	46-55
2004	Tillamook		na	2		0.10	41.0		37-45
1998	Willapa	3	8.9	47	0.778	0.743	45.9	4.0	37-55
1999	Willapa	4	7.6	3	0.023	0	38.2	7.5	32-47
2000	Willapa	4	8.0	9	0.046	0.033	43.4	12.0	19-58
2001	Willapa	5	8.0	7	0.046	0.017	51.3	2.7	48-56
2002	Willapa	4	7.6	0	0.0	0.0	-		
2003	Willapa	3	9.0	10	0.133	0.0	48.3	5.1	43-59

2004	Willapa				Not sampled

Conclusions

Green crab recruitment strength and range expansions along the North Eastern Pacific coast appear to be linked to warm winter temperarures and strong El Niño events when pole-ward coastal currents are strong enough to transport larvae from established populations in California to the Northwest. The abundance of green crabs in Oregon estuaries has decreased by an order of magnitude since the last strong El Niño of 1997/1998 but catches over the last three years have remained stable at around 0.07 green crabs per trap per day. Even though coastal currents have not been favorable for larval transport from source populations in California, green crabs have persisted in Oregon estuaries. It appears that local reproduction and recruitment, especially following warm winters, have been high enough to keep these populations from going extinct. However, with the strong 98-year class dying of senescence, it is not know whether the 2003-year class is large enough to maintain adequate larval "seeding" of Pacific Northwest estuaries.

There can be a substantial time lag between the discovery of an exotic species and its impact on the native community. For example, green crabs were documented to exist in New England in 1817 (Say 1817), but it was not until the 1950's when this species expanded its range and increased in abundance sufficiently to impact the soft-shelled clam populations in Massachusetts, Maine and Nova Scotia (Glude 1955, MacPhail,et al. 1955). Even though green crab abundance in the Northwest is low when compared to Europe, eastern North America, Tasmania and California, it is imperative to continue monitoring efforts for two reasons:

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Appendix 1. Physical data for *Carcinus maenas* sampling sites in Oregon estuaries. Range of values observed includes sampling times in 2002 and 2003.

Coos Bay

Site	Date	Location Description	S ‰	Water Temp.	Air Temp.	Green Crabs Found?
Jordan Cove	***Range of values observed***		***29-34***	***14-18***	***14-22***	
	07/30/04	Marsh, *Scirpus americanus*				no
						no
Glasgow	***Range of values observed***		***28-30***	***15-19.5***	***15-16***	
		Quail road, mudflat				no
Russell Point	***Range of values observed***		***26-33***	***15-18***	***15-28***	
	07/01/04	Below bridge/oyster flats, pools by bridge pilings	26	15	17	**yes**
	07/16/04	Pools by pilings below McCullough Bridge	28	17.5	28	**yes**
		Pools by pilings below McCullogh Bridge				
Pony Point North Bend Airport	***Range of values observed***		***26-32***	***15-17***	***15-17***	
	07/03/04	Mudflat near rip rap, *Zostera marina*	25	17	17-18.5	**yes**
	07/31/04		23	16	17	**yes**

Yaquina Bay

Hatfield Marine Science Center Pump house		***Range of values observed***	***30-34***	***11-19***	***12-23***	
		Rip rap/ boulders/sandy mudflat/ *Zostera marina*				
	4/16/04	1 GR 57mm 1 GR 91mm male #4 orange	30	11	12	**yes**
	4/17/04		30	12	13	no
	4/22/04		31	11	13	no

	4/23/04		30	11	12	no
	4/29/04		31	12	13	no
	4/30/04		30	12	14	no
	5/7/04		31	11	12	no
	5/8/04		31	12	13	no
	5/13/04		30	11	13	no
	5/14/04		31	11	13	no
	5/20/04		31	12	14	no
	5/21/04		31	11	12	no
Johnson Slough	***Range of values observed***		***23-32***	***15-20***	***16-22***	
	10/12/04	Below bridge, dry mudflat around creek, *Salicornia* patches	25	16	16	no
Sally's Bend A	***Range of values observed***		***27-32***	***12-18***	***12-26***	
	9/28/04	At elbow near road entrance, mudflat, large *Scirpus* patches	30			yes
	9/28/04		30	15	15	yes
Sally's Bend B	***Range of values observed***		***29-32***	***12-18***	***12-24***	
	9/15/04	Across from George St., *Scirpus* patches	30			**yes**
	9/28/04		30	13.5	14	**yes**
	10/12/04		25	15	16	no
Sally's Bend C	***Range of values observed***		***28-32***	***10-19***	***10-22***	
	4/16/04	Fishing platform	30	11	12	no
	4/17/04	GR male 91#4 orange	31	11	12	**yes**
	4/22/04	GR male 57 yellow/orange	30	11	13	**yes**
	4/23/04		31	12	13	no
	4/29/04		31	11	12	no
	4/30/04		30	10	12	no
	5/7/04		31	11	13	no

	5/8/04		31	12	14	no
	5/13/04		30	11	12	no
	5/14/04		31	11	12	no
	5/20/04		31	11	13	no
	5/21/04		30	11	12	no
	0/15/04		30			**yes**
	9/28/04		30	13.5	14	no
	10/12/04		28	13	13	no
Oregon Coast Aquarium	***Range of values observed***		***23-34***	***9-21***	***8-22***	
	4/16/04	Tidal channel draining mudflat, along nature trail	30	11	12	no
	4/17/04	GR male 57mm yellow	31	11	13	**yes**
	4/22/04		31	11	13	no
	4/23/04		30	11	12	no
	4/29/04		31	12	13	no
	4/30/04		31	11	14	no
	5/7/04		31	11	12	no
	5/8/04		31	12	13	no
	5/13/04		30	12	13	no
	5/14/04		31	12	13	no
	5/20/04		31	11	14	no
	5/21/04		31	11	12	no
	9/15/04		30			no
	9/28/04		30	14	15	no
	10/12/04		29	13.5	17	no

Tillamook Bay

Tillamook Spit	***Range of values observed***		***0-30***	***14-18***	***13-27***	
	06/17/04	mudflat- vegetation ecotone/rip rap	0-22	14-18	13-27	**yes**

	09/24/04		0-16	18	17	**yes**

Netarts Bay

Whiskey Creek	***Range of values observed***		***10-34***	***20***	***17-20***	
	06/17/04	Tidal Creek, washed up *Z. marina* and algae	0	13	25	**yes**
	09/24/04		0-12	14	17-18.5	**yes**
RV Park	09/24/04	North, Inside bridge	15	15	18	no
Intersection Whiskey Creek & Netarts Bay Roads	***Range of values observed***		***27-34***	***18-19***	***17-20***	
	06/17/04	Pools by culvert	0-2	14-17	14-25	**yes**
	09/24/04		14-29	14-16	17	**yes**

Appendix 2. Relative abundance of crab species and sculpins (Numbers/trap/day) in Oregon estuaries during 2003. An asterisk beside trap number indicates that other traps were either opened or were stolen.

Coos Bay **Mean CPUE (Catch/trap/day)**

Site	Date	Trap Type	Zone	*Carcinus maenas*	*Hemigrapsus oregonensis*	*Hemigrapsus nudus*	*Cancer magister*	*Cancer magister* (Recruits)	*Cancer productus*	Sculpin	Number Traps
Russell Point	07/01/04	Fish	Pools by bridge	**0.4**	0	0	48.5	0	0.1	0.1	10
	07/16/04		*Zoster marina*	**0.5**	0	0	6.17	0	0	1.8	6
Pony Point/Airport	07/03/04	Fish	*Zostera marina*	**0.9**	0	0	10.9	0	5.4	1.8	10
	07/31/04			**0.3**	0	0	4.2	0.1	0.7	0.5	10
Charleston Boat Basin	08/03/04	Fish	*Low-mid*	0	0	0	11	0	0.5	7.5	5
	08/04	Fish		0	0	0	4.71	0	2.36	1.21	14
South Slough Valino Island	08/04	Fish	*Low-mid*	0	0	0	3.92	0	0	3.07	14
South Slough Hidden Creek	08/04	Fish	*Low-mid*	0	3.71	0	0	5	0	2.64	14
South Slough Dalton Creek	08/04	Fish	*Low-mid*	0	0	0	0	5.01	0	2.57	14
Jordan Cove	07/01/04	Minnow	*High*	0	0	0	0.14	0	0	0	7*
	07/16/04	minnow		0	0	0	0	0	0	0	13
	07/30/04	minnow		0	0	0	0	0	0	0.5	10
Glasgow	07/16/04	minnow	*High*	0	0	0	0	0.3	0	0.8	10

Yaquina Bay **Mean CPUE (Catch/trap/day)**

Site	Date	Trap Type	Zone	*Carcinus maenas*	*Hemigrapsus oregonensis*	*Hemigrapsus nudus*	*Cancer magister*	*Cancer magister* (Recruits)	*Cancer productus*	Sculpins	Number Traps
Johnson Slough	10/12/04	Fish	Below Bridge	0	0	0	1	0	0	0	2
HMSC Pump house	**4/16/04**	Fish	*Zostera marina*	0	0	0	0.1	0.1	0	0	6
	4/17/04	Fish		**0.1**	0	0	0	0	0	0	6
	4/22/04	Fish		0	0	0	0	0	0	0	6
	4/23/04	Fish		0	0	0	0	0	0	0	6
	4/29/04	Fish		0	0	0	0.1	0	0	0	6
	4/30/04	Fish		0	0	0	0	0	0	0	6
	5/7/04	Fish		0	0	0	0	0	0	0	6
	5/8/04	Fish		0	0	0	0.1	0.1	0	0	6
	5/13/04	Fish		0	0	0	0	0	0	0	6
	5/14/04	Fish		0	0	0	0	0	0	0	6
	5/20/04	Fish		0	0	0	0	0	0	0	6
	5/21/04	Fish		0	0.1	0	0	0	0	0	6
Sally's Bend C Fishing Platform	09/15/04	Fish	*Zostera marina*	**0.3**	0	0	0	0.67	0.67	1	3
	09/28/04	Fish		0	0	0	0	0	0	0	2
	10/12/04	Fish		0	0.5	0	1	0	0.5	0.5	2
Oregon Coast Aquarium	**4/16/04**	Fish	subtidal	0	0.1	0	0	0	0	0.1	6
	4/17/04	Fish		0	0	0	0	0	0.1	0	6
	4/22/04	Fish		0	0	0	0	0	0.1	0	6
	4/23/04	Fish		0	0	0	0	0	0	0	6
	4/29/04	Fish		0	0	0	0	0	0	0.1	6

	5/7/04	Fish		0	0	0	0	0	0	0	6
	5/8/04	Fish		0	0	0	0	0	0	0.3	6
	5/13/04	Fish		0	0	0	0	0	0	0	6
	5/14/04	Fish		0	0	0	0	0.1	0	0	6
	5/20/04	Fish		0	0	0	0	0	0	0.3	6
	5/21/04	Fish		0	0	0	0	0	0	0	6
	09/15/04	Fish		0	0.5	0	0.5	4.5	0	0.5	2
	09/28/04	Fish		0	0	0	0	0	0	0	4
	10/12/04	Fish		0	.5	.5	0	1	0	.5	2
Johnson Slough	10/12/04	Minnow	*Fucus/Scipus*	0	0	0	0	0	0	0	9
HMSC Pump house	**4/16/04**	**Minnow**	*Fucus*	0	0	0	0	0	0.1	0	6
	4/17/04	Minnow		0	0	0	0	0	0	0	6
	4/22/04	Minnow		**0.1**	0	0	0	0	0	0	6
	4/23/04	Minnow		0	0	0	0	0.1	0	0	6
	4/29/04	Minnow		0	0	0	0	0	0	0	6
	4/30/04	Minnow		0	0	0	0	0	0.1	0	6
	5/7/04	Minnow		0	0	0	0	0	0	0	6
	5/8/04	Minnow		0	0	0	0	0	0	0	6
	5/13/04	Minnow		0	0	0	0	0	0	0	6
	5/14/04	Minnow		0	0	0	0	0	0	0.1	6
	5/20/04	Minnow		0	0	0	0	0	0	0.1	6
	5/21/04	Minnow		0	0	0	0	0	0	0	6
Sally's Bend A	09/15/04	Minnow	*Zostera japonica*	**0.1**	1.0	0.5	0	0.9	0	0.1	10
	09.28/04	Minnow		**0.1**	0.1	0.1	0	0	0	0.2	10
	10/12/04	Minnow		0	0.1	0.1	0	0	0	0	10
Sally's Bend B George St.	09/15/04	Minnow	*Zostera japonica*	**0.1**	0.2	0.1	0	0	0	0.3	10

	09/28/04	Minnow	*Scirpus/ Zostera japonica*	**0.07**	0	0	0	0	0	0.27	15
	10/12/04	Minnow		0	0	0	0	0	0	0	4*
Sally's Bend Fishing Platform	**April /04**	**Minnow**		**0.02**	0	0	0	0	0.1	0.11	36
	May/ 04	Minnow		0	0.05	0	0	0	0	0.02	36
Oregon Coast Aqua.	April/ 04	Minnow		**0.02**	0	0	00	0	0	0.08	36
	May/ 04	Minnow		0	00	0	0	0	0.05	0	36
	09/15./04	Minnow		0	0	0	0	3	0	0.33	5
	10/12/04	Minnow		0	0	0	0	0	0	0	50

Tillamook Bay **Mean CPUE (Catch/trap/day)**

Tillamook Spit	06/17-18/04	Fish	*Zostera japonica*	**0.08**	1.5		0.75			8.08	12
Tillamook Spit	09/24/04	Fish	*Zostera japonica*	**0.17**	0.67	0.17	0.33	0.17	0	3	6
Tillamook Spit	06/17-18/04	Minnow	*Salicornia/ Scirpus/Fucus*	0	2	0.08	0	0	0	2.15	13
	09/24/04	Minnow	*Salicornia/ Scirpus/Fucus*	**0.1**	0.4	0.6	0.05	0	0	1.0	20

Netarts Bay **Mean CPUE (Catch/trap/day)**

Site	Date	Trap Type	Zone	*Carcinus maenas*	*Hemigrapsus oregonensis*	*Hemigrapsus nudus*	*Cancer magister*	*Cancer magister* (Recruits)	*Cancer productus*	Sculpin	Number Traps
Intersection	06/17-18/04	Fish	pools	**1.67**	0.83	0.83	7.17	0	0.83	1.5	6
	09/23-24/04	Fish	Pools	**0.17**	1.5	0.5	3.5	0	0.83	0.17	6
RV Park	09/24/04	Fish	Inside bridge	0	0	0	1	0	1	6	

Whiskey Creek	06/17-18/04	Fish	Channel and mudflat	0	3.4	0.8	1.6	0	0	1.6	5
	09/24/04	Fish		**0.5**	0	0.5	0	0	0.5	0	2
Whiskey Creek	06/17-18/04	Minnow	*Fucus*/mudflat	0	0.5	1.6	0	0	0	1.2	10
	09/24/04	Minnow	*Fucus*/mudflat	0	0.44	2	0	0	0	0	9

Table 3. *Carcinus maenas* catches and sightings in Oregon Estuaries in 2004. Year Classes are estimates based on crab size, carapace coloration, hardness and presence of large barnacles. Crabs that are green have molted recently, while red crabs have not molted for a long time, in some case well over a year. Missing limbs are numbered in sequence: 1= Right claw; 5= last leg on right side, 6= left claw, 10=last leg on left side.

Bay	Site	Date	Sex	CW	Color	Year Class	Condition/Comments
Coos Bay	Russell Point	7/01/04	F	59.5	Green	03	
	(below 101 Bridge)		F	59.7	Green	03	
			F	74.0	Orange		
			M	85.1	Red		
			?	46.4		03	Molt only
		7/17/04	M	66.5	Yellow	03	Missing limb 6
			M	75.3	Yellow		Missing limb 6
			M	84.5	orange		
	Pony Point	7/03/04	F	72.5	Red-orange		Missing limbs 6
			F	72.9	Red		Missing limbs 1, 6, 10
			M	93.4	Yellow		
			M	96.0	Yellow		
			M	92.7	Orange		
			M	92.9	Yellow-orange		Limb #1 regenerating
			M	84.9	Yellow-orange		
			M	91.2	Yellow		
		7/31/04	M	85.5	Yellow		Barnacles 5 mm in diameter
			M	91.3	Orange		
			M	84.0	Orange		Missing 2,3,4, tip of 10/ barnacle 9 mm
Yaquina Bay	Lab 31 drainage	3/26/04	M	52.3	Yellow	03	
	Sally's Bend Fishing Platform	4/16/04	M	93	Orange		
		4/16/04	M	64	Yellow	03	Missing limb #10

		4/17/04	M	63	Yellow	03	Missing limb #8
	Sally's Bend George Street	9/15/04	F	32.6	Green	**04**	
		9/28/04	M	34.2	Green	**04**	Missing limb # 7,8
	Sally's Bend Elbow	9/15/04	M	42.8	Green	**04**	Missing 2,3,4,5,7,8
		9/28/04	M	32.1	Green	**04**	
	Sally's Bend Fishing platform	9/15/04	M	68.9	Green	03	
	Science Center pump house	4/17/04	M	57	Yellow-orange	03	
		4/17/04	M	91	Orange		Missing limb # 4
	Oregon Coast Aqua.	4/22/04	M	57	Yellow	03	

Tillamook	Tillamook Spit	06/18/04	M	77.5	Yellow		
		09/24/04	M	75.2	Yellow-orange	03	
		09/24/04	F	45.0	Green	**04**	
		09/24/04	M	37.0	Yellow-green	**04**	
	Boulder Point	8/31/04	M	71.4	Yellow	03	Found by Jesse Hayes
	Boulder Point	10/13/04	M	~70	Yellow	03	Found by Jesse Hayes
	Sandstone Point	11/20/04	M	86.5	Green		Found by John Faudskar

Netarts	Intersection of Netarts and Whiskey Creek Roads	06/18/04	M	86	Orange		Missing limbs # 8, 9, 10
		06/18/04	M	93	Orange		Broken dactyls on both claws
		06/18/04	M	69.7	Yellow	03	Missing limb # 1
		06/18/04	M	63	Yellow-green	03	Missing limb #6

		06/18/04	M	66	Yellow-green	03	Missing limb # 1
		06/18/04	M	63	Yellow-green	03	
		06/18/04	M	72	Yellow	03	
		06/18/04	M	74.8	Yellow	03	
		06/18/04	M	70	Yellow	03	
		06/18/04	F	63	Yellow	03	
		09/24/04	F	67.0	Yellow-green	03	
	Whiskey Creek	09/24/04	F	58.0	Yellow-green	03	

Appendix 4

Number of green crabs in estuaries swells

By Eric Apalategui of the Longview, Washington Daily News
Nov 01, 2003 - 09:01:45 am PST

(Story was picked up by Associated Press and ran in Portland Oregonian and Seattle Post Intelligence.)

European green crabs made another push into Willapa Bay and other Pacific Northwest estuaries this year, renewing worries that the invading crustaceans might yet threaten coastal economies that rely on harvesting oysters, clams and crabs.

Researchers in Washington and Oregon say they caught 34 young green crabs in recent weeks, many of them with shells about the size of an Oreo cookie.

The catch shows that "the problem is not going away," said Bruce Kauffman, a state Department of Fish and Wildlife biologist based in Nahcotta.

Green crabs, which often hide in non-native Spartina grass, are voracious predators that can eat or out-compete young Dungeness crabs, native Olympia and farmed Pacific oysters and other shellfish. Oysters alone bring $32 million a year to Willapa Bay and Grays Harbor communities, and Dungeness crab are a mainstay in port town economies in both states.

This year's catches of young green crabs were higher than any year after 1998, when numerous green crabs were detected in bays from Oregon to Vancouver Island in British Columbia.

The latest age class of the feisty crustaceans could signal that green crabs have started to breed in Northwest waters, said Sylvia Behrens Yamada, a researcher and assistant zoology professor at Oregon State University. She also authored the 2001 book "Global Invader: The European Green Crab."

Yamada said the first wave of green crabs likely arrived as tiny larvae, riding powerful ocean currents north from San Francisco Bay, where green crabs have lived since at least the late 1980s, during the last powerful El Nino weather pattern. The last of those traveling crabs died of old age this year, judging from the lack of large crab in recent catches.

The generation of youngsters found this year -- when ocean currents weren't so strong -- may signal that breeding populations took hold somewhere in Oregon or Washington and sent larval crabs into northerly ocean currents to colonize new territory.

During three days earlier this month, Andrea Randall and another volunteer caught 10 young green crabs (plus one older crab) in traps they set in Willapa's tidal flats off the Long Beach Peninsula. Yamada's team caught another 24 young crabs in traps set in four Oregon bays, including Yaquina, Netarts and Tillamook.

It remains unclear whether green crabs can become a larger nuisance in the Pacific Northwest, where typical ocean currents make it more difficult for young crabs to reach bays and where some native species, such as the red rock crab, are even tougher customers than their European cousins.

Then again, Yamada said, it took green crabs more than a century to become firmly established on the East Coast, where they first appeared in the early 1800s. By the 1950s, the population exploded and was blamed for decimating the soft-shell crab fishery.

After a few years in which green crab numbers dwindled -- along with the state budget -- the Washington Department of Fish and Wildlife axed Randall's job as a green crab trapper this summer. The agency's Oregon counterpart also doesn't have staff to track the potentially harmful invaders, Yamada said.

"There's really not a lot of manpower out there looking for green crabs," she said. "We really don't learn, it seems. We have a very short-term memory."