Status of the European Green Crab in Oregon Estuaries

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by

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Executive Summary

The invasion of Pacific Northwest estuaries by the European green crab, *Carcinus maenas*, caused much initial alarm. Following the strong El Niño of 1997-98, 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 have been much weaker in recent years.

Crabs from the 1997/98 colonizing year class were still in the population during the early summer of 2003. Males from that year class ranged from 86-98 mm in carapace width. By the fall we did not trap any crabs over 80 mm, suggesting that these older crabs were dying. Estimates for green crab longevity range from 4 years in Europe to 6 years in Maine. We thus predict that most of the colonizing year class will die of senescence over the 2003/2004 winter.

The loss of the 97/98-year class of green crabs, however, does not mean that green crabs are becoming extinct in Northwest estuaries. Recruitment in 2003 in Yaquina, Netarts, Tillamook and Willapa Bay have has been much stronger than in previous years. Circumstantial evidence indicates that these estuaries harbor a small self-sustaining population that is not dependent on a larval source from California.

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: 1) to elucidate the process of range expansion of a model non-indigenous marine species with planktonic larvae and 2) to serve as an early warning system for the next strong recruitment event of green crabs.

Professional and Outreach Activities in 2002 and 2003

Dec. 12, 03	Review of "Exotic Species Detection Plans for the Puget Sound, Lower Columbia, and Tillamook Bay National Estuary Programs" by Andy Cohen.	Lower Columbia Estuary Partnership's office in Portland
Dec. 6. 03	***Oregon Sea Celebration*** Sylvia Yamada was one of three invited panelist for Invasive Species Session	One-day Symposium sponsored by the Portland Audubon Society and Portland State University
Nov. 6, 03	***Non-indigenous Species Forum*** Sylvia Yamada was one of two invited speakers	FW426/526, Coastal Ecology and Resource Management Class, Hatfield Marine Science Center
Nov. 5, 03	***European green crabs resurge in Northwest.*** Eric Apalategui's article was picked up by Associated Press	Story was featured in Portland Oregonian, Salem Statesman Journal, Seattle Post Intelligence and by KLCC Radio in Eugene.
Oct. 30, 03	***Green crabs in estuaries swell.*** Phone interview by reporter, Eric Apalategui	Article in Daily News, Longview, Washington See Appendix 4 for transcript.
Oct. 22, 03	***Invasive Species: European Green Crab, Why do we Care?*** Talk presented by Marsha Becklund	Biology 101 class, Oregon Coast Community College, Newport, Oregon
Oct. 11, 03	***The status of the European Green: Are these crabs establishing themselves in the Northwest?*** Talk by Sylvia Yamada	Pacific Coast Shellfish Growers Association, Meeting, Portland, Oregon
Oct. 11, 03	***Prey consumptions in two estuarine crabs: the introduced European green crab and native Dungeness.*** Talk by Tim Davidson and S.B.Yamada	Pacific Coast Shellfish Growers Association Meeting, Portland, Oregon
Oct. 3, 03	**Green crab trapping**–Sylvia Yamada Sally's Bend and Johnson Slough in Yaquina Bay	Sampling exercise with students from the FW426/526 class, Coastal Ecology and Resource Management
July 28, 03	Phone interview by reporter, Quentin Dodd of Campbell River, B. C.	Article for Northern Aquaculture Magazine
July 21, 03	Evaluation of potential study sites for a non-indigenous species survey of Tillamook Bay.	Meeting with Derek Sowers of the Tillamook Estuaries Partnership and Andy Cohen of the San Francisco Bay Estuarine Institute

July 19/03	***Are European Green crabs establishing themselves in Oregon?*** Guest lecture by Sylvia Yamada	Oregon Institute of Marine Biology Biological Invasions In Marine Environments (Bi 408/508)
June 20/03	***Invading green crab repelled by native red crabs.*** Associated Press	Article picked up by The World (Coos Bay Oregon), Corvallis Gazette Times etc.,
June 19/03	***Invading green crab repelled by native red crabs.*** Radio story and phone interview by Jeff Brady	Oregon Public Broadcasting
Nov. 21/02	***The status of the European Green Crab in Pacific Northwest Estuaries.*** Talk given by Sylvia Yamada	University of Oregon, Community Ecology class (Bi 472/572), Eugene, Oregon
Sept. 29/02	***The status of the European green crab invasion in the Pacific Northwest and what to do about it!*** Talk given by Sylvia Yamada and Brett Dumbauld (WDFW)	Meeting of the Pacific Coast Shellfish Growers Association and the National Shellfish Association, Newport, Oregon
June 26/02	***The status of the European Green Crab in Pacific Northwest Estuaries***. Talk given by Sylvia Yamada	Invited seminar speaker: Oregon Institute of Marine Biology, Charleston, Oregon

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 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 will be critical in 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, the virtual absence of recruits in 2002 could foreshadow a decline of the population (Behrens Yamada and Davidson 2002). 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 green crab population.
- Estimating the year-class strength of young-of-the-year green crabs.
- Comparing patterns in recruitment strength over time and place and correlating them to ocean conditions.

Sampling Methods for Green Crabs in Oregon

Our sampling effort focused on five Oregon estuaries: Coos, Alsea, Yaquina, Netarts and Tillamook . All estuaries were sampled at least twice during the 2003-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 as well as new sites with suitable habitat. We learned that green crabs are most abundant in tidal marshes, gradually sloping mudflats and tidal channels where salinities remain above 15 ‰ and summer 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 (1cm) 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 8-24 hours, depending on tidal level. At low tide, we retrieved the traps, identified all crabs to species and noted the sex and carapace widths(CW) and molt stage of all green crabs. 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 2003 are tabulated in Appendix 2 and summarized in Table 2. While we caught over twice as many crabs in 2003 than in 2002, catch per unit effort for all the estuaries was the same (0.08 vs. 0.07). In contrast, catches were an order of magnitude higher in the summer of 1999 with averages ranging from 0.3 to 0.8 crabs per trap per day in Yaquina Bay (Hunt and Behrens Yamada 2003).

Table 2. Relative Green Crab abundances in Oregon estuaries in 2002 and 2003.

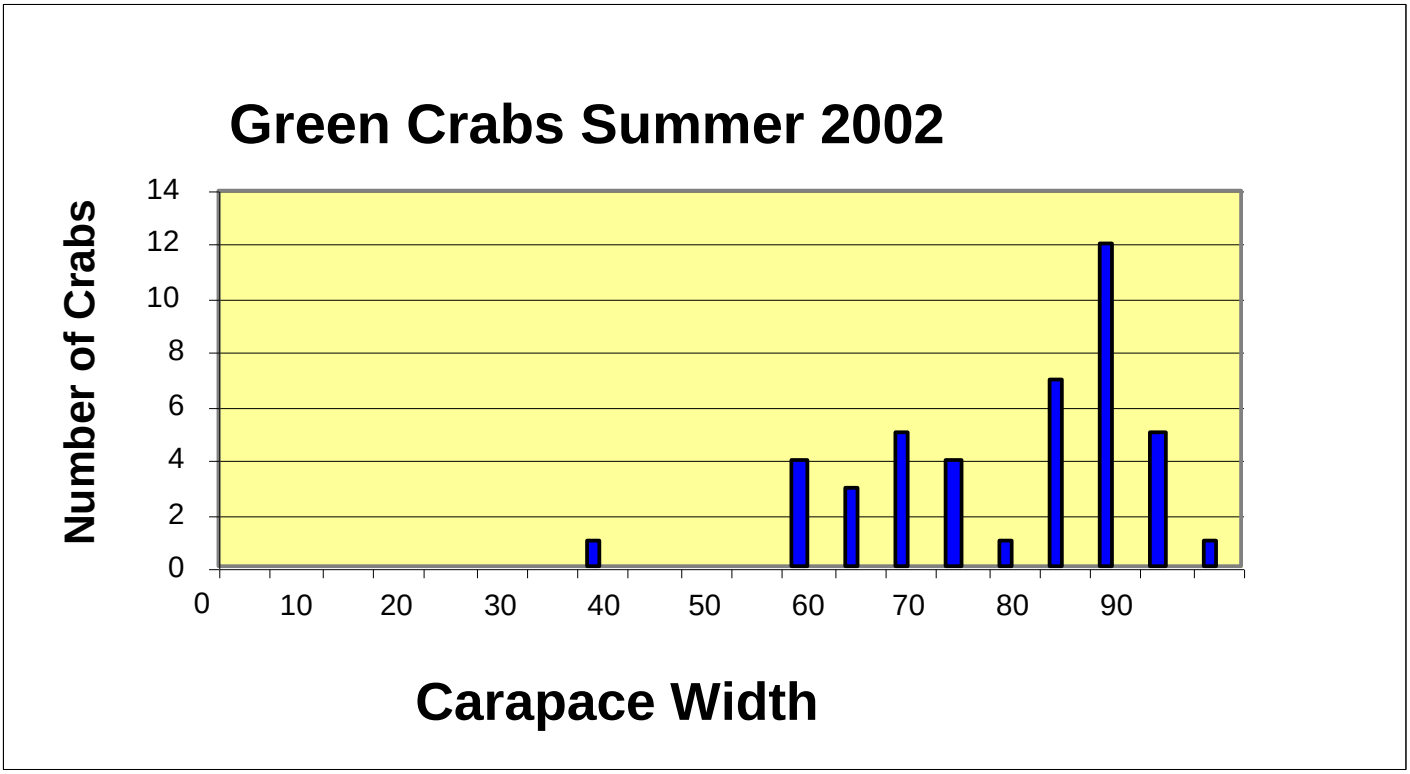
Estuary	Number of crabs trapped (# traps)			
	2002		2003	
Coos Bay	9	(180)	14	(203)
Alsea			0	(30)
Yaquina	26	(168)	63	(1084)
Tillamook	2	(71)	6	(70)
Netarts	0	(44)	11	(44)
Total	37	(463)	94	(1431)

Estuary	Catch per trap per day	
	2002	2003
Coos Bay	0.05	0.07
Alsea		0.00
Yaquina	0.15	0.06
Tillamook	0.03	0.09
Netarts	0.00	0.25
Total	0.080	0.066

Age Structure of Green Crabs in Oregon Estuaries

From previous mark and recapture studies and from shifts in size frequency distributions over time we estimated the age of some of the green crabs retrieved from Oregon estuaries in the summer of 2003 (Appendix 3). Large crabs over 85 mm in carapace width with hard, worn carapaces and red bellies had not molted in well over a year. They were assigned to the 98 year-class. Crabs between 70 and 85 are difficult to age and may comprise the 98, 99, 00 and 01-year classes. Crabs that had attained a carapace width of 60-70 mm by the end of the summer most likely belonged to the 02 year-class while newly molted crabs under 60 mm were classified as new recruit (2003 year-class).

In 2002 we retrieved at least 17 green crabs from the 98-year-class, suggesting that the original colonists from the 1997/1998 El Niño were still well represented in Oregon estuaries, especially in Coos Bay (Figure 1, Appendix 3). These older crabs (86-97 mm) were still present in the population in the spring and early summer (April to July) of 2003 (Figure 1, Appendix 3). Between August and October of 2003, however, we trapped very few large crabs suggesting that these original colonists were approaching the end of their natural life span. 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 not many of the 98-year class will survive the winter of 2003/2004.



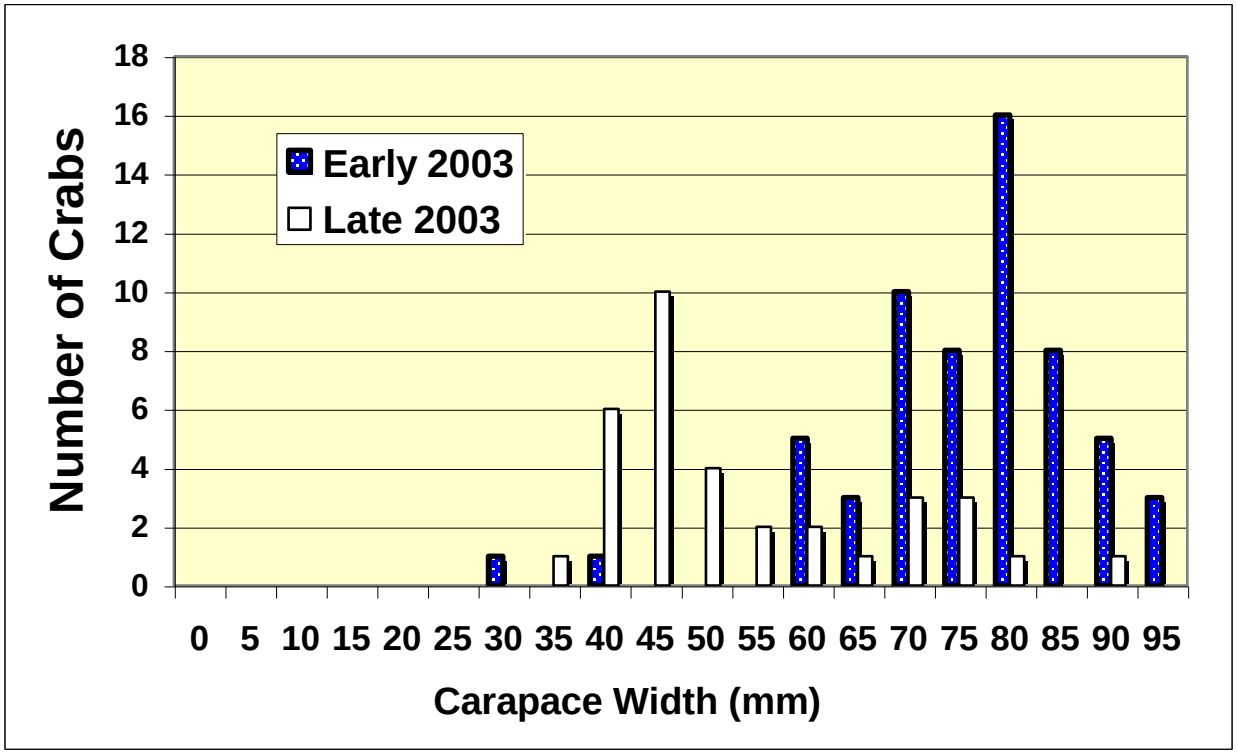


Figure 1. Size Distribution of *Carcinus maenas* trapped in Oregon estuaries in 2002 and 2003. Note that crabs ≥ 85 mm were still present in early 2003 (April-July) but dropped out of the population in August-October as a new year class appeared.

Recruitment over time and place

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 from 1998 to 2003. 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 (Table 3). Catches of young crabs in subsequent years, however, have decreased by at least one order of magnitude. Recruitment in 2002 was the lowest, with only one young-of-the-year crab recovered in each estuary (Table 3). Catches of young crabs increased at the end of the 2003 growing season, especially in Netarts, Tillamook and Willapa (Table 3). While we observed no evidence of recent recruitment in Coos Bay in 2002, we did trap one recruit in September of 2003. (Appendix 3).

Table 3. Relative abundance (CPUE) and mean carapace (CW) width of young-of-the-year *C. maenas* at the end of their first growing season in Yaquina Bay, Netarts, and Tillamook, Oregon and Willapa Bay, Washington. Crabs were typically caught between September and October. Catch per unit effort (CPUE), reported as number of crabs per minnow and/or pitfall trap per day, is only a rough measure of relative abundance since total effort and sampling locations varied between years. N=number of young crab sampled, SD=Standard Deviation. Asterisk indicates that only 7 minnow traps were deployed and that the crab was trapped in a folding fish trap. Data for Willapa Bay were kindly provided by the Washington Department of Fish and Wildlife.

Year Class	Estuary	N	CPUE Pitfall traps	CPUE Minnow traps	Mean *Carapace* Width (mm)	SD	Range
2002	Coos	0		0			
2003	Coos	1		0.01	59.4		
1998	Yaquina	201		5.0	46.9	5.0	32-60
1999	Yaquina	9		0.04	36.0	4.4	30-44
2000	Yaquina	14		0.31	37.5	5.0	30-45
2001	Yaquina	1		0.0*	55		
2002	Yaquina	1		0.01	38.9		
2003	Yaquina	9		0.07	44.9	5.5	41-59
2002	Netarts	0		0			
2003	Netarts	6		0.15	49.4	3.7	45-55
2002	Tillamook	0		0			
2003	Tillamook	5		0.17	50.0	3.1	46-55
1998	Willapa	47	0.778	0.743	45.9	4.0	37-52
1999	Willapa	30	0.150	0.200	53.9	8.7	32- 60
2000	Willapa	9	0.054	0.033	43.4	12.0	19. -58
2001	Willapa	8	0.050	0.017	52.4	3.8	49-60
2002	Willapa	1	0.013	0.0	59.9	-	
2003	Willapa	10	0.133	0.0	48.3	5.1	42- 59

What factors contribute to strong green crab recruitment and range expansion? Behrens Yamada and Hunt (2000) combined size data from green crab sightings and growth measurements of tagged crabs and inferred that there have been three northern range expansion on the West Coast on North America: 1993, 1995/6 and 1997/8. Each of these events is correlated with unusually strong northward-moving coastal currents during the winter and early spring . For example, northward coastal currents off the Oregon coast during the winter of 1997/98 reached 50 km/hour (Huyer et al. 1998; Barth and Smith 1998). We believe that these unusually strong pole-ward currents during El Niño conditions can act as transport mechanism for moving green crab larvae from established source population in California to the Pacific Northwest. Northward coastal currents have been much weaker since 1998 (Table 4) suggesting that the green recruitment in those years is due to local reproduction.

Table 4. Green crab recruitment strength and relative strength of pole-ward coastal currents from January to April. Since the strength of pole-ward coastal currents is correlated with sea level, we used the mean monthly sea level anomalies for the San Francisco tidal station (ftp://ilikai.soest.hawaii.edu/islp/slpp.anomalies)as a proxy for pole-ward coastal current velocity. Note that in 1998 coastal currents were unusually strong. Actual measurements off Newport, Oregon were as high as 50 km/day.

YEAR CLASS	Mean Monthly sea level anomalies for San Francisco during the first four months of the year				Observed Green Crab Recruitment
	January	February	March	April	
1997	141	-10	-23	-48	No recruitment
1998	**156**	**233**	**83**	**91**	**Very Good**
1999	-56	-20	-6	-15	Poor
2000	-71	44	-4	5	Poor
2001	-42	-66	-11	-52	Poor
2002	-22	-42	-40	-15	Very Poor
2003	Data for	20003	not	available	Good

Conclusions

Green crab recruitment strength and range expansions along the North Eastern Pacific coast appear to be linked to 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 two years have remained stable at around 0.07 green crabs per trap per day. Even though the initial colonists (98 year class) are dying of old age, and coastal currents have not been favorable for larval transport from source populations in California, green crabs do persist in Oregon and Washington estuaries. It appears that local reproduction and recruitment is high enough to keep these populations from going extinct.

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Appendix 1. Physical data for *Carcinus maenas* sampling sites in Oregon estuaries during 2003.

Coos Bay

Site	Date	Location Description	S ‰	Water Temp.	Air Temp.	Green Crabs Found?
Jordan Cove	6/16/03	Beach, Marsh	29	14	14	no
	7/18/03	Marsh	34	18	18-22	no
	9/09/03	Marsh	30	15	14-19	**yes**
Causeway to Roseburg Lumber	9/10/03	Rip rap	32	15.5	16	no
Roseburg Lumber	6/16/03	Parallel to road	30	15	17	no
Glasgow	6/17/03	Quail road, mudflat	28	19.5	16	no
	9/19/03	Quaii road mudflat	29	15	15	no
Russell Point	6/17/03	Below bridge/oyster flats, pools by bridge pilings	30	17	17	**yes**
	7/18/03	Pools by pilings below McCullough Bridge	30-33	18	18-22	**yes**
	9/10/03	Pools by pilings below McCullogh Bridge	29	15	15	**yes**
Pony Point/Airport	6/16/03	boat ramp and mudflat near rip rap	26-28	16-17	16-17	**yes**
	9/10/03	boat ramp and mudflat near rip rap	32	15	15	**yes**
Pigeon/Fossil Point	6/16/03	Cement structures, tidal channels carved through sandstone strata	32-34	14-18	16-19	no
Charleston Bridge	6/17/03	Under bridge, pools, pilings, sand flat	32-34	13-16	14-16	no
Eastside Road	9/10/03	South of Kentuck inlet, along road, next to tidal channel	20	15	15	no

Alsea Bay

Lint Slough	7/24	By high school	28	20	24	no
	8/2/03	By high school	31	18	26	no
	8/20/03	On either side of bridge by the High School	19	19	21	no

Yaquina Bay

Sawyer's Landing	6/26/03	Rock and cobble, sandy mudflat, below trailer sites	27-30	14-19	14-20	no
	7/14/03		25	19.5	17	no
Idaho Point Marina	6/27/03	Marina on large tidal creek, riprap and mudflat	34	15	18	no
	7/15/03		30-31	18-19	20-21	**yes**
HMSC Pump house	6/27-28	Rip rap around dock, sandy mudflat and boulders	34	14-19	20-23	no
	7/14/03	*Zostera marina*	30-13	16-18	17-20	**yes**
Johnson Slough	6/26/03	Below bridge, dry mudflat around creek, *Salicornia* patches	23-24	18-20	16-22	**yes**
	10/ 2-3		31-32	15	17-18	**yes**
Sally's Bend A	4/16/03	At elbow near road entrance, mudflat, large *Scirpus* patches	22			no
	May 03		27-29	17	21	no
	June 03		28-32	18	22	no
	July 03		29-31	18	22	no
	Aug. 03		30-3`	18	22-26	**yes**
	Oct 03		32	13	16	**yes**
	10/14/03		31	17	19	no
	10/23/03		32	12.5	12.4	no
Sally's Bend B	6/26/03	Across from George St., *Scirpus* patches			24	no
	10/14/03				18	**yes**
	10//23/03		32	12.5	12.5	no
Sally's Bend C	4/29/03	Fishing platform	29			**yes**
	May 03		27-29	17	21	no
	June 03		28-32	18	22	**yes**
	July 03		29-31	18	21-22	**yes**

	Aug. 03		30	18-19	22	**yes**
	Oct. 10		30	16	18	no
	Nov.6		31	10	10	no
	Nov. 11		28.5	9.5	12	no
Oregon Coast Aqua.	4/16/ 03	Tidal channel draining mudflat, along nature trail	23	11.5-15	13-15	**yes**
	May 03		27-29	17-19	21-22	**yes**
	June 03		27-32	19	22	**yes**
	July 03		29-31	17-18	22	**yes**
	Aug. 20		30-32	18-21	19-22	**yes**
	10/10.03		29	17	19	no
	10/14/03		34	15	15	**yes**
	10/23/03		32	12.5	12.5	**yes**
	Nov. 6		35	9	8	no
	Nov.11		28			no

Tillamook Bay

Tillamook Spit	7/02/03	mudflat- vegetation ecotone/rip rap	25-26	17-19	15`	**yes**
	9/25-26		30	15.5	15-17	**yes**
Garibaldi Docks	7/02/03	Garibaldi Boat Docks	30	14.5	19	no

Netarts Bay

Whiskey Creek	7/02/03	Tidal Creek, washed up *Z. marina* and algae	10	20	20	no
	9/25-26		20-34	20	17	**yes**
Boat Ramp	7/02/03	Deep basin by marina and marsh				no
Intersection	7/02/03	Pools by culvert Netarts- Whiskey Creek intersection	27	18	20	**yes**
	9/25-26		34	19	17	**yes**
Marsh just north of intersection	9/25-26	Pool by culvert and marsh channel	34	17	17	no

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
Roseburg Lumber	6/16/03	Fish	*Zostera marina*	0	0	0	12.2	0	0.7	1.5	10
Russell Point	6/18/03	Fish	*Zostera marina*	**0.3**	0	0	29.9	0	0	3.3	10
	7/18/03	Fish	*Pools under bridge*	**0.4**	0	0	21.5	0	0	0.4	5
	9/10-11	Fish	*Pools under bridge*	**0.1**	0	0	48.9	0	0	0.7	10
Pony Point/Airport	6/17/03	Fish	*Zostera marina*	**0.3**	0	0	22.2	0	0.5	1.6	10
	9/10/03	Fish	*Zostera marina*	**0.25**	0	0.1	13.8	0	3.6	1	12
Pigeon/Fossil Point	6/17/03	Fish	*Zostera marina*	0	0	0	0.7	0.1	3.6	4.3	10
Jordan Cove	6/16/03	Minnow	*Scirpus*	0	0	0	0.1	0	0	0.9	7*
	7/18/03	Minnow	*Scirpus*	0	0	0.1	0	0	0	0.3	10
	9/09-10	Minnow	*Scirpus*	**0.03**	0	0	0.3	0	0	0.5	29
Outside Jordan Cove	9/10/03	Minnow	*Fucus/sand*	0	0	0	0	0	0	1.2	10
Glasgow	6/18/03	Minnow	*Scirpus*	0	0	0	0.5	0	0	0	20
	9/09/03	Minnow	*Scirpus*	0	0	0	1.2	0	0	0.6	10
Causeway to Roseburg Lumber	9/10/03	Minnow	*Fucus*	**0.1**	0	0	0.2	0	0	0.2	10
Pony Point/Airport	6/17/03	Minnow	*Fucus/rip-rap*	0	0	0.2	0	0	0	0.8	10
Pigeon/Fossil Point	6/17/03	Minnow	*Fucus*	0	0	1.0	0	0.1	0	1.2	10
Charleston Bridge	6/17/03	Minnow	*Fucus*	0	0.1	0.3	0	1.5	0	3.4	10
Eastside Road	9/09/03	Minnow	*Scirpus/ Z. japonica*	0	0	0	0.1	0	0	1.7	10

Alsea 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
Lint Slough	7/27/03	Fish	Low intertidal	0	0	0	0.4	0	0	0	5

	8/2/03	Fish	Low intertidal	0	0	0	0.8	0	0	0	5
	8/20/03	Fish	Low intertidal	0	0.6	0	14.6	0	0	2	5
	7/27/03	Minn0w	*Fucus*	0	0	0	0	0	0	0	5
	8/2/03	Minnow	*Fucus*	0	0.2	0	0	0	0	0	5
	8/20/03	Minnow	*Fucus*	0	3.2	0	0.6	0	0	0	5

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	6/26/03	Fish	Below Bridge	**0.5**	0	0	1	0	0	0.5	2
	10/2-3	Fish	Below Bridge	**0.75**	0	0	3.25	0	0	0.75	4
Sawyer's Landing	7/16/03	Fish	*Zostera marina*	0	0	0	0.55	0	3.2	2.4	9*
Idaho Point Marina	7/16/03	Fish	*Zostera marina*	**0.1**	0.1	0	9.4	0	0	4.9	10
HMSC Pump house	7/16/03	Fish	*Zostera marina*	**0.4**	0	0	1.8	0.2	3	2.9	10
Sally's Bend C	4/16/03	Fish	*Zostera marina*	**0.2**	0	0	0	0	0	0	5
	May 03	Fish		0	0.07	0	0	0	0	0	30
	June 03	Fish		**0.08**	0.28	0	0	0	0	0.12	25
	July 03	Fish		**0.09**	0.14	0	0.38	0	0	0.15	80
	Aug.03	Fish		**0.02**	0	0	1.17	0	0	0.74	35
	Oct. 03	Fish		0	0.05	0.45	0.9	0	0	0.2	20
Oregon Coast Aqua.	4/16/03	Fish	Subtidal	**0.2**	0.4	0	2.6	0	0	0	5
	4/25/03	Fish		0	0	0	0	0	0	0	5
	May 03	Fish		**0.07**	0.01	0	0.11	0	0	0	85
	June 03	Fish		**0.07**	0.07	0.69	0.22	0	0	0.69	45
	July 03	Fish		**0.03**	0.03	0.36	0.6	0	0	0	70

	Aug. 03	Fish		**0.07**	0.3	0	0.93	0	0	0.23	30
	Oct. 03	Fish		**0.13**	0	0	0.33	0	0	0.53	15
Johnson Slough	6/26/03	Minnow	*Fucus/Scipus*	0	0	0	0.1	0	0	0.6	10
	10/2-3	Minnow		**0.1**	0	0.05	0	0	0	0.1	20
Sawyers'Landing	6/26/03	Minnow	*Fucus*	0	0.9	0.9	0	0	0	1.2	10
HMSC Pump house	6/27/03	Minnow	*Fucus*	0	0.2	0	0	0	0.6	0.9	10
Idaho Point Road	6/27/03	Minnow	*Fucus*	0	0	0.6 *Pachygrapsus*	0	0	0	0.3	10
Sally's Bend A	4/16/03	Minnow	*Zostera japonica*	0	0	0	0	0	0	1.2	5
	7/15/03	pitfall		**0.3**	0.6	0	0	0	0	0	3
	July 03	Minnow		0	0.02	0	0.71	0	0	0.11	35
	Aug. 03	Minnow		**0.02**	0.05	0	0.31	0	0	0	35
	10/2-3	Minnow		**0.09**	0.14	0.05	0	0	0	0.09	22
	10/14/03	Minnow		0	0.2	0.4	0	0	0	0	10
	10/23/03	Minnow		0	0	0	0	0	0	0.3	5
Sally's Bend B	4/16/03	Minnow	*Zostera japonica*	0	0	0	0	0	0	0	5
	6/26/03	Minnow	*Scirpus/ Zostera japonica*	0	0.2	0	0	0	0	0.2	10
	10/14/03	Minnow		**0.1**	0.8	0	0	0	0	0.3	10
	10/23/03	Minnow		0	0	0.2	0	0	0	0	5
Sally's Bend C	May 03	Minnow		0	0	0	0	0	0	0.37	30
	June 03	Minnow		**0.08**	0.28	0	0.48	0	0	0.24	25
	July 03	Minnow		**0.09**	0.02	0	0.05	0	0	0.05	80
	Aug. 03	Minnow		**0.17**	0	0	0	0	0	0.20	35
	Oct. 03	Minnow		**0**	0.3	0	0.4	0	0.05	0	20
Oregon Coast Aqua.	4/16/03	Minnow	*Fucus*	0	0.2	0	0	0	0	1.8	5
	May 03	Minnow		0.03	0.01	0	0	0	0	0.37	85

	June 03	Minnow		0	0.02	0	0.38	0	0	0.56	45
	July 03	Minnow		**0.04**	0.2	0	0.41	0	0	1.0	70
	Aug. 03	Minnow		**0.07**	0	0	1.43	0	0	0	30
	10/13/03	Minnow		**0.05**	0.10	0.05	0.37	0.16	0	0.05	19

Tillamook 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
Tillamook Spit	7/03/03	Fish	*Zostera japonica*	**0.09**	1.36	0	0.09	0	0	2.2	11
Tillamook Spit	9/25-26	Fish	*Zostera japonica*	0	2.67	0	11.5	0	0	0.3	6
Garibaldi Docks	7/02/03	Fish	Subtidal	0	0	0	15.2	0	0	0	3
Tillamook Spit	7/03/03	Minnow	*Salicornia/ Scirpus/Fucus*	0	1	0	0	0	0	0.75	20
	9/25-26	Minnow	*Salicornia/ Scirpus/Fucus*	**0.17**	0.53	0	0	0.01	0	1.6	30

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
Boat Ramp	7/03/03	Fish	Vegetation/pools	0	0	0	2	0	3	1	3
Intersection	7/03/03	Fish	pools	**1.3**	0	0	4.3	0	0	1	3
	9/25-26	Fish	Pools	**0.33**	**0.5**	0	1.7	0	0	2	6
Marsh near intersection	9/25-26	Fish	Channel	**0**	0	0	22.7	0	0.7	1.33	3
Whiskey Creek	9/24-25	Fish	Channel and mudflat	**0.5**	1.17	0	9.8	0.5	0	0	4
Whiskey Creek	7/03/03	Minnow	*Fucus*/mudflat	0	0.2	0.4	0	0	0	0.2	5*
	9/25-26	Minnow	*Fucus*/mudflat	**0.15**	0.6	0.7	0.1	0.05	0	0.05	20

Appendix 3. ***Carcinus maenas*** **catches and sightings in Oregon Estuaries in 2002 and 2003. Year Classes are estimates based on crab size, carapace coloration, hardness and presence of large barnacles. Missing limbs are numbered in sequence: 1= Right claw; 5= last leg on right side, 6= left claw, 10=last leg on left side. Asterisk indicates that carapace was initially measured in inches and converted to mm.**

Bay	Site	Date	Sex	CW	Color	Year Class	Condition/Comments
Coos Bay	Russell Point	6/26/2002	Male	97.4	Yellow	98	Leg #1 missing
		6/26/2002	Male	86.8	Red	98	Legs 4, 7 missing; barnacles
	Russell Point	**6/18/03**	**Male**	**83.1**	**Yellow**		
		6/18/03	**Male**	**93.6**	**Yellow**	**98**	
		6/18/03	**Male**	**97.2**	**Yellow**	**98**	
		7/19/03	**Male**	**85.0**	**Yellow-orange**	**98**	**4 barnacles, 9mm diameter**
		7/19/03	**Female**	**71.7**	**Yellow-green**		**Leg 6 regenerating**
		9/11/03	**Male**	**86**	**Orange-red**	**98**	**Leg# 3 missing, 12 mm barnacles**
Coos Bay	Pony Point	6/27/2002	Female	69	Green		
		6/27/2002	Male	87.9	Orange	98	
		6/27/2002	Male	92.8	Yellow-Green	98	
		6/27/2002	Male	89.4	Red	98	barnacles
		6/27/2002	Male	87	Orange-Red	98	Dead: legs 1,2,4,10 missing and puncture in carapace
		6/27/2002	Male	92.2	Orange-Red	98	Dead: leg 8 missing
		6/27/2002	Male	82.3	Orange-Red	98	Dead: legs 5,8,10 missing
		7/15/2002	Male	75.6	Hard/Green		Collected by Dave Smith
	Pony Point	**6/17/03**	**Male**	**83.1**	**Orange**	**98**	
		6/17/03	**Male**	**86.8**	**Orange**	**98**	**Nine barnacles, 7.5 mm diameter**
		6/17/03	**Male**	**88.2**	**Yellow-orange**	**98**	**Leg 2 missing**
		6/17/03	**Male**	**97.6**	**Yellow**	**98**	
		9/10/03	**Male**	**92.6**	**Yellow-orange**	**98**	
		9/10/03	**Male**	**73.1**	**Orange**		
		9/10/03	**Female**	**70.9**	**Yellow-green**		
Coos Bay	**Jordan Cove**	**9/09/03**	**Male**	**59.4**	**Yellow-green**	**03**	**First Recruit for Coos Bay since 1998**

Alsea Bay	Middle of Bay,	8/23/2002	Male	89.2	Yellow	98	Unknown sports fisher
	Public Dock	**9/19/03**	**Male**	**87.5**	**Yellow**		**Unknown sports fisher**
Yaquina Bay	Sally's Bend A	8/13/2002	Male	38.9	Green	02	*only recruit found in 2002*
	Sally's Bend A	**7/15/03**	**Male**	**83**	**Orange-red**		**Leg 2 missing- pit fall trap**
		10/03/03	**Female**	**42.9**	**Green**	**03**	
		10/03/03	**Female**	**41.7**	**Green**	**03**	
	Sally's Bend B	**10/14/03**	**Male**	**41.2**	**Green**	**03**	
Yaquina Bay	Sally's Bend C	7/2/2002	Male	89.3	Orange-Red	98	Barnacles
		7/2/2002	Male	90.3	Orange-Red	98	Barnacles
		7/27/2002	Male	85.4	Yellow		Legs 6,9,10 Missing
		8/7/2002	Male	84.6	Yellow		
	Sally's Bend C	**4/16/2003**	**Male**	**80**	**Yellow-orange**		
		6/29/03	**Male**	**91**	**Orange**	**98**	**Barnacles, Leg 6 missing**
		6/29/03	**Male**	**80**	**Orange**		
		6/29/03	**Male**	**32**	**Yellow-orange**	**03**	**First Recruit/pitfall trap**
		6/29/03	**Male**	**81**	**Orange**		**Barnacles , Leg 1 missing; 10 broken**
		7/05/03	**Male**	**89**	**Orange**		**Legs 1, 10 missing**
		7/05/03	**Male**	**83**	**Orange**		
		7/06/03	**Male**	**80**	**Yellow**		**Legs 4, 7 missing**
		7/06/03	**Male**	**81**	**Orange**		
		7/08/03	**Male**	**75**	**Yellow**		
		7/09/03	**Male**	**72**	**Orange**		
		7/10/03	**Male**	**81**	**Yellow**		
		7/10/03	**Male**	**65**	**Orange**		
		7/11/03	**Male**	**73**	**Yellow-orange**		
		7/12/03	**Male**	**76**	**Orange**		**Leg 7 missing**
		7/15/03	**Male**	**87**	**Yellow-orange**		**Legs 1,3,5 missing**
		7/17/03	**Male**	**83**	**Orange**		

		7/27/03	**Male**	**76**	**Yellow-green**		
		7/31/03	**Female**	**72**	**Orange**		
		8/02/03	**Male**	**63**	**Yellow**	**02**	
		8/09/03	**Male**	**81**	**Yellow-green**		**Leg 1 missing**
		8/11/03	**Male**	**90**	**Orange**	**98**	**Algae on back, collected by public**
Yaquina Bay	Idaho Point Marina	7/17/2002	Male	91.2	Yellow	98	
		7/17/02	Male	88.8	Yellow	98	
		7/16/03	**Male**	**84**	**Yellow**		
Yaquina Bay	Johnson Slough	8/7/2002	Male	86.8	Orange	98	1 dactyl missing, 7, Barnacles
		8/7/02	Male	92.5	Orange	98	7 missing, Barnacles
	Johnson Slough	**6/27/03**	**Male**	**81.9**	**Yellow-green**		**6 missing, dactyl on 1 damaged**
		10/02/03	**Female**	**42.8**	**Green**	**03**	
		10/02/03	**Male**	**45.9**	**Yellow-green**	**03**	
		10/02/03	**Male**	**45.6**	**Yellow-green**	**03**	
		10/03/03	**Male**	**79.6**	**Yellow-green**		
		10/03/03	**Male**	**79.3**	**Orange**		
Yaquina Bay	**Science Center pump house**	**6/15/03**	**Male**	**96.6**	**Orange**	**98**	
		6/15/03	**Male**	**78**	**Yellow**		**Legs 1,2,3 missing**
		6/15/03	**Male**	**80**	**Orange**		
		6/15/03	**Male**	**79**	**Yellow**		
Yaquina Bay	Oregon Coast Aqua.	8/13/2002	Male	82.2	Orange		1 dactyl missing, 5 tip gone, Barnacles
		8/16/2002	Male	88.4	Yellow	98	5 missing
		8/16/2002	Male	81.85	Orange		
		8/16/2002	Male	82.85	Orange/white		
		8/16/2002	Male	70.2	Green		
		8/16/2002	Male	67.65	Green	01	
		8/16/2002	Male	58.65	Green	02 or O1	6 missing
		8/16/2002	Female	57.3	Green	02 or 01	

		8/16/2002	Male	89.2	Green		
		8/16/2002	Male	74.9	Orange/White		2 newly re-grown, barnacles
		8/16/2002	Male	71.9	Yellow-Green		
		8/16/2002	Male	85.2	Yellow		
		8/16/2002	Male	83.7	Orange		7missing, barnacles
		8/21/2002	Male	62.45	Green	01	
		8/21/2002	Male	65.25	Orange	01	6 missing
		8/28/2002	Male	58.6	Yellow	01	6 dactyl missing
		8/28/2002	Male	74.5	Yellow		4, 5 missing
		8/28/2002	Male	68	Yellow	01	
		8/28/2002	Male	55.4	Yellow	01	
	Oregon Coast Aqua.	**4/16/2003**	**Male**	**71**	**Yellow**		**Leg 7 missing**
		5/11/03	**Female**	**84**	**Green**		
		5/11/03	**Female**	**64**	**Green**	**02 or 01**	
		5/11/03	**Male**	**42**	**Green**	**02**	
		5/12/03	**Male**	**68**	**Yellow-green**	**01 or 02**	
		05/12/03	**Male**	**72**	**Yellow-orange**		**Legs 4, 8 missing**
		05/12/03	**Female**	**61**	**Green**	**02**	
		05/15/03	**Female**	**63**	**Green**	**02**	
		05/24/03	**Male**	**60**	**Yellow orange**	**01 or 02**	**Leg 9 missing**
		5/26/03	**Male**	**76**	**Green**	**01**	
		6/06/03	**Male**	**63**	**Green**	**01 or 02**	
		6/08/03	**Male**	**74**	**Green**	**01**	
		6/28/03	**Male**	**77**	**Yellow-green**		
		7/01/03	**Male**	**70**	**Orange**		**#1 missing**
		7/01/03	**Male**	**76**	**Orange**		
		7/12/03	**Male**	**71**	**Orange**		
		7/12/03	**Male**	**72**	**Orange**		**Leg 10 missing**
		7/16/03	**Female**	**84**	**Yellow**		
		7/17/03	**Male**	**66**	**Orange**		
		8/11/03	**Female**	**46**	**Yellow**	**03**	

		8/14/03	**Male**	**71**	**Orange**		
		8/20/03	**Female**	**36**	**Yellow-orange**	**03**	
		8/20/03	**Male**	**79**	**Green**		
		10/10/03	**Male**	**61**	**Yellow-green**	**02 or 03**	
		10/14/03	**Male**	**44.8**	**Yellow**	**03**	
		10/14/03	**Male**	**40.5**	**Yellow-green**	**03**	
		10/23/03	**Female**	**58.7**	**Green**	**03**	
Tillamook	Tillamook Spit	7/12/2002	Female	61.9	Green	01	
	Tillamook Spit	8/20/2002	Male	60.7	Yellow-green	01	
Tillamook	**Tillamook Spit**	**7/03/03**	**Male**	**88.7**	**Orange**	**98**	**Legs 2 and 6 missing**
		9/25/03	**Female**	**49.8**	**Yellow-green**	**03**	
		9/25/03	**Male**	**50.9**	**Yellow-green**	**03**	
		9/25/03	**Male**	**49.0**	**Green**	**03**	
		9/25/03	**Male**	**54.5**	**Yellow-green**	**03**	
		9/26/03	**Female**	**46**	**Green**	**03**	
	Hayes oyster farm	9/15/2002	Male	86*	Green		Found by Jesse Hayes
	Hayes oyster farm	9/15/2002	Male	70*	Green		Found by Jesse Hayes
Netarts	**Pool by Netarts Bay Rd. & Whiskey Creek Rd.**	**7/03/03**	**Male**	**86.4**	**Orange**	**98**	
		7/03/03	**Male**	**90.8**	**Yellow-green**	**98**	
		7/03/03	**Male**	**93.6**	**Green**	**98**	
		7/03/03	**Male**	**94.6**	**Yellow**	**98**	
		9/25/03	**Female**	**45.6**	**Yellow-green**	**03**	
		9/26/03	**Female**	**69.5**	**Green**	**02 or 01**	
	Whiskey Creek	**9/25/03**	**Male**	**54.5**	**Yellow-green**	**03**	
		9/25-26/03	**Male**	**49.6**	**Yellow-green**	**03**	
		9/25/03	**Male**	**48.9**	**Yellow-green**	**03**	
		9/26/03	**Female**	**52.7**	**Green**	**03**	
		9/26/03	**Female**	**45.1**	**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."