Ecology and management of the invasive green crab (*Carcinus maenus*)

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Topics

1) Identification
2) Biology
3) Spread and Colonization
4) Dispersal and Recruitment
5) Population growth
6) Effects
7) Management options

Biological Invasion Terminology

Native species: species in native range or has increased its range through natural (non-human) dispersal (range extension)

Introduced/non-native species: species outside its native range due to human transport

Invasive species: species outside its native range due to human transport and that negatively affects native species and/or ecosystem processes

Stages of Biological Invasions

1) Introduction

2) Establishment (self-sustaining population, might require repeated introductions, lag phase)

3) Population Growth

4) Increasing Spatial Distribution

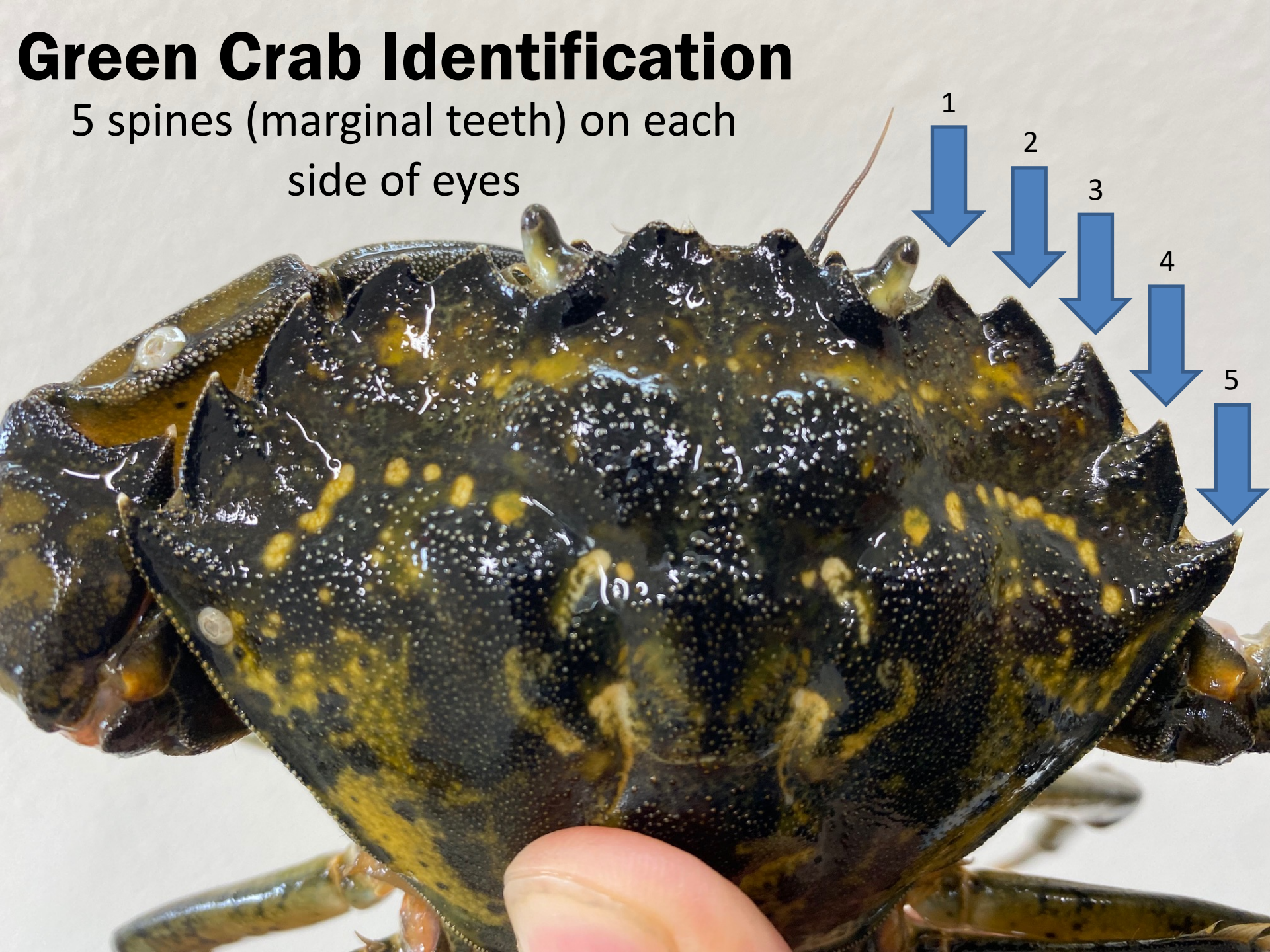
5) Effects (per capita impacts)

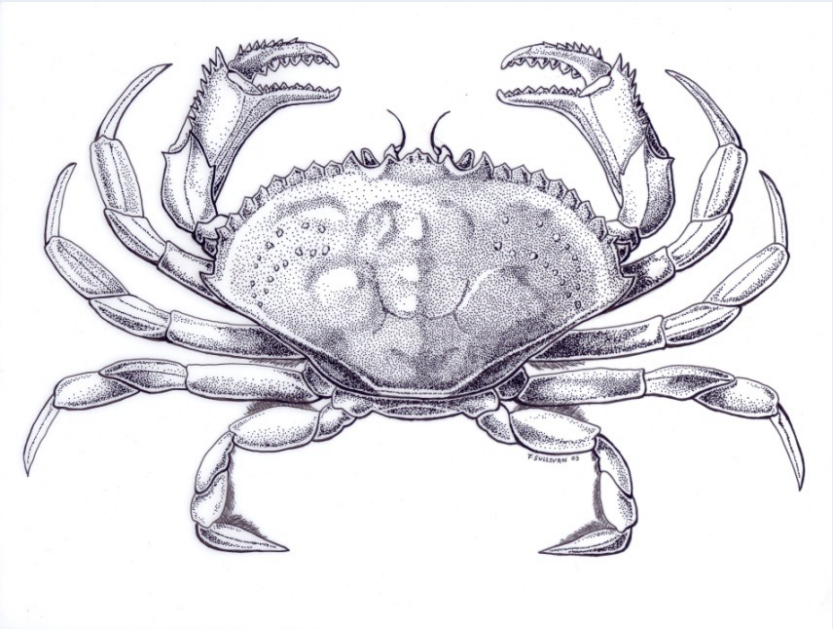
What is a green crab?

Green crabs aren’t always green

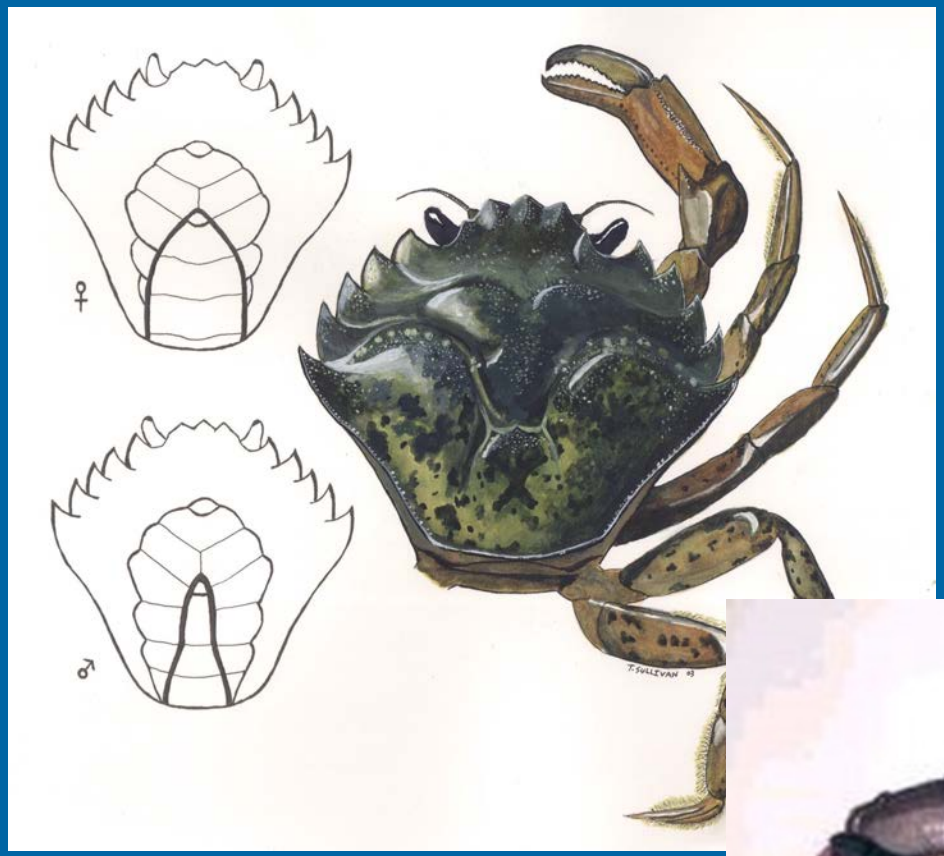
Green Crab Identification

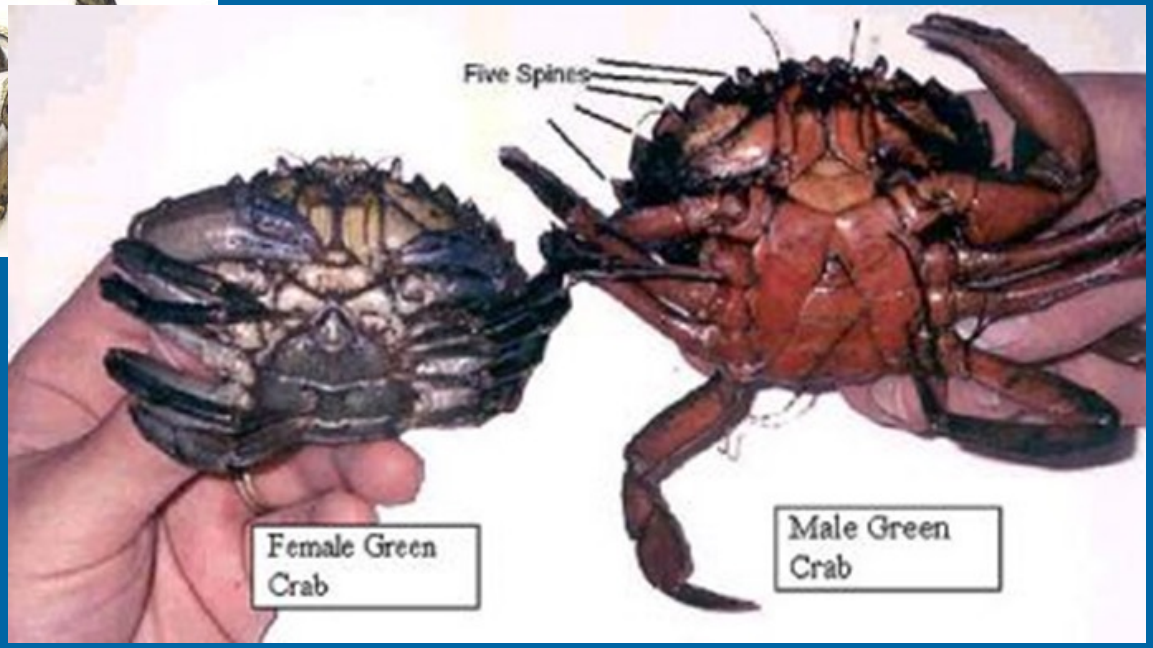
5 spines (marginal teeth) on each side of eyes



Green crab	Dungeness
5 teeth behind eyes	10 teeth behind eyes
	

Reproduction



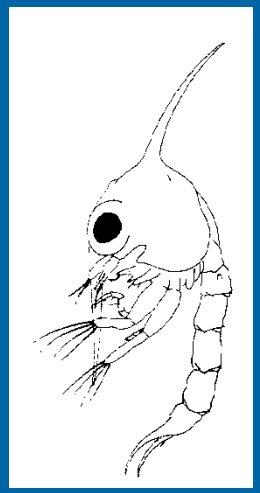


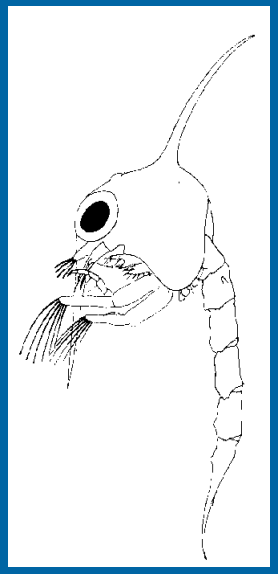
Egg number/brood: 185,000 (Broekhuysen 1936)
Reproductive adult: 1 year
Longevity: up to 6 years (Yamada 2001)

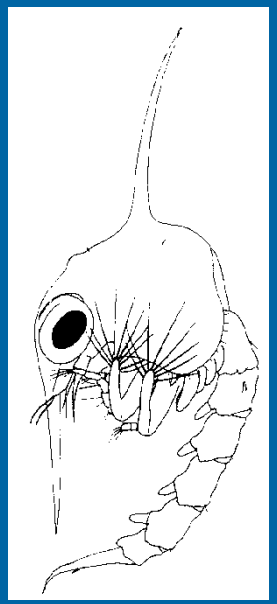
Planktonic life-cycle

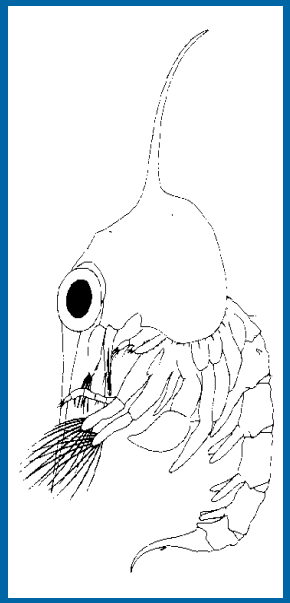
4 zoea stages

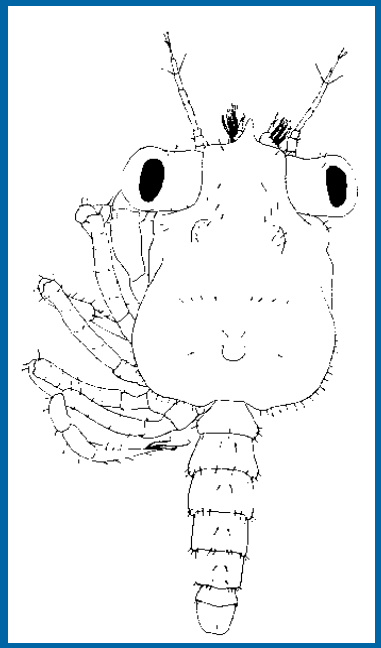
megalopa











planktonic stages

settles in estuary

Stages of Biological Invasions

1) Introduction

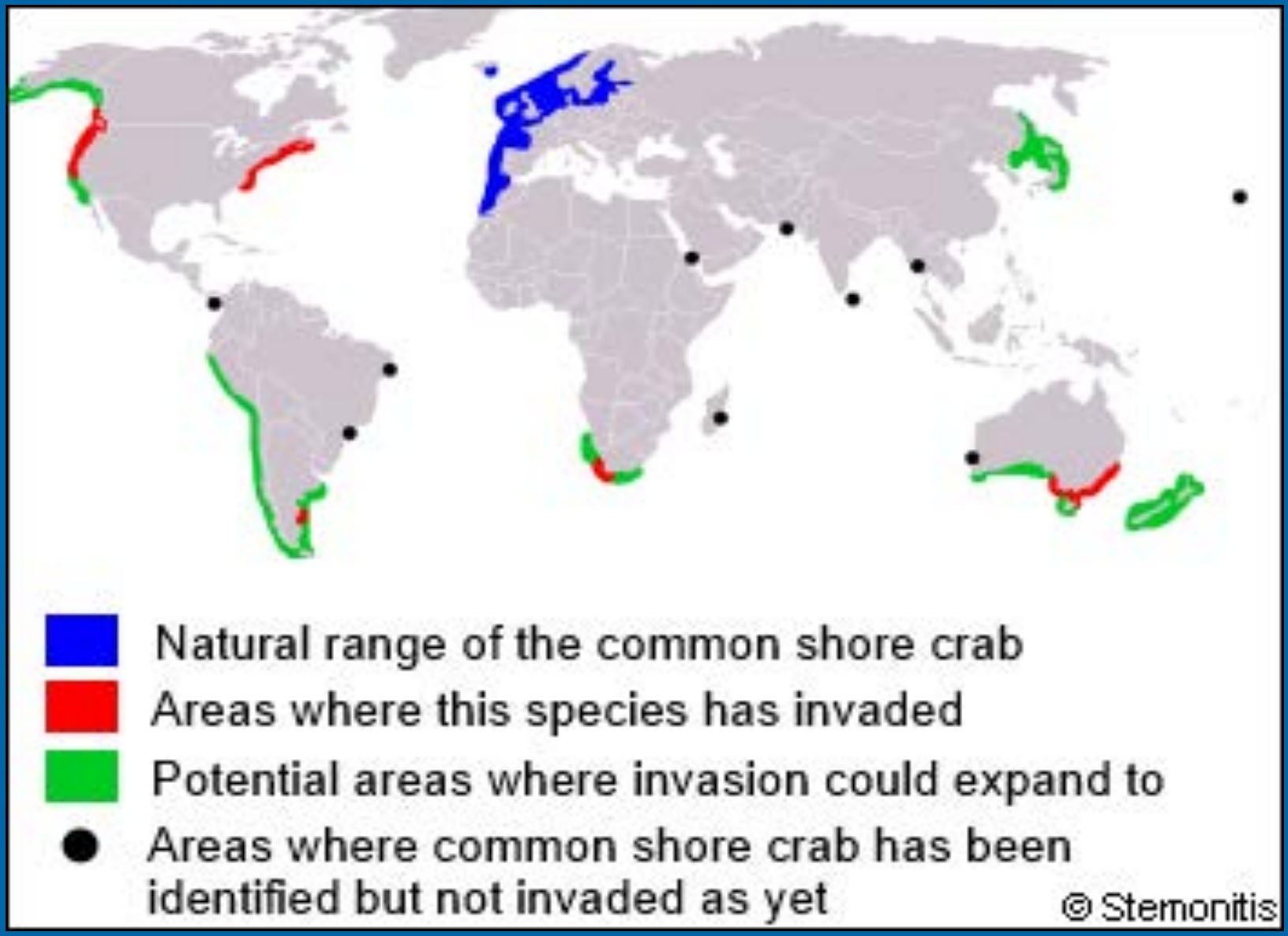
2) Establishment (self-sustaining population, might require repeated introductions, lag phase)

3) Population Growth

4) Increasing Spatial Distribution

5) Effects (per capita impacts)

Native and Introduced Range



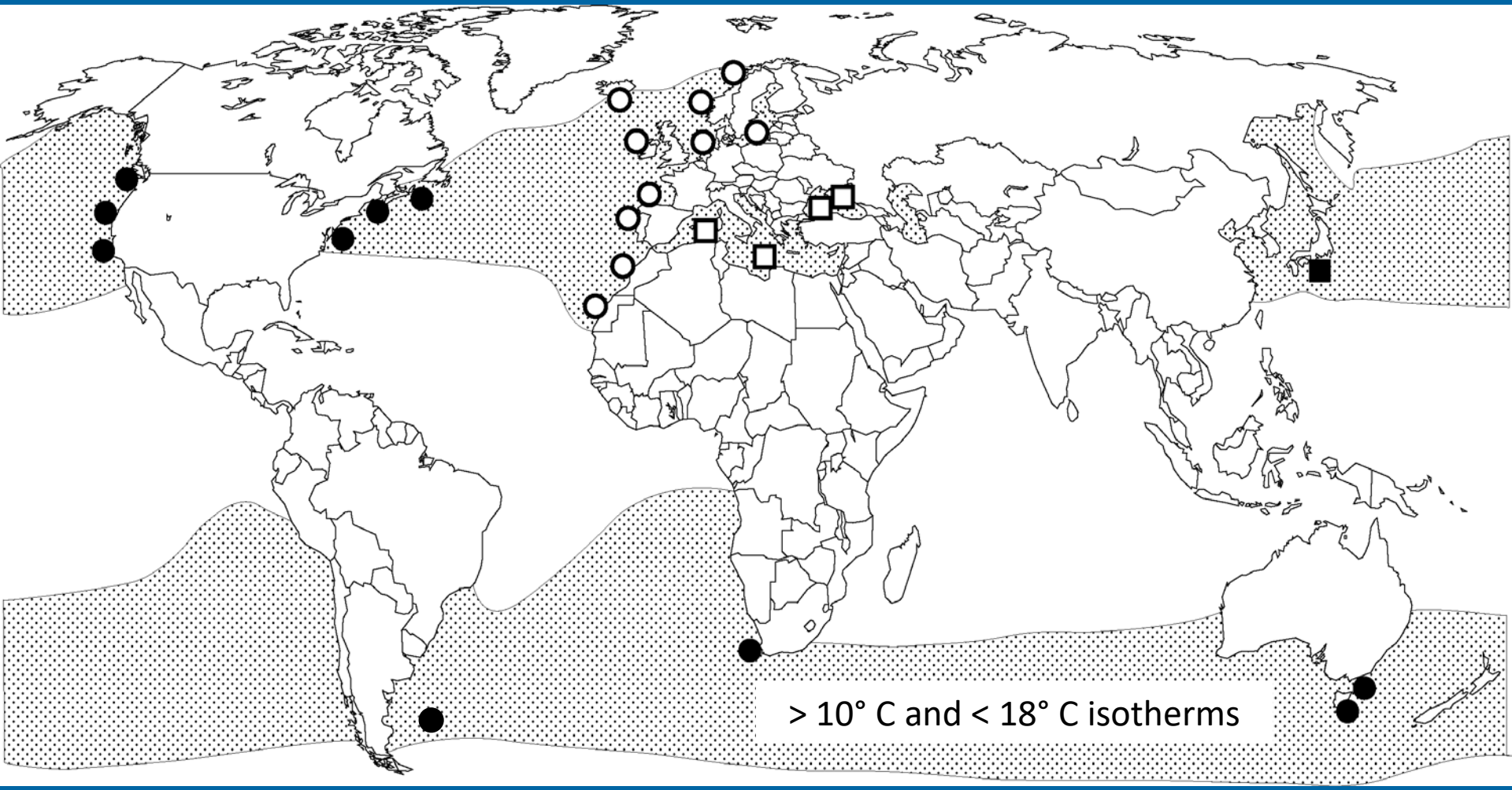
Temperature and salinity tolerances

Table 1. Summary of tolerance ranges for *Carcinus maenas*. Data based on Broekhuysen 1936, Ropes 1968, Crothers 1968, Rasmussen 1973, Wallace 1973, and Erikssen et al. 1975.

Air exposure	Field: 10 days in damp burrows in high tide zone Lab: 60 days if sheltered under seaweed
Temperature	
Range for short-term survival	0 to 33°C
Maximum	26°C
Minimum for growth	10°C
Minimum for feeding	7°C
Maximum to brood eggs	18°C
Salinity (sea water = 35‰)	
Range for short-term survival	4 to 54 ‰
Minimum for long-term survival	11‰
Minimum for larval development	17‰
Starvation (adults)	3 months

(Yamada 2001)

Potential Range

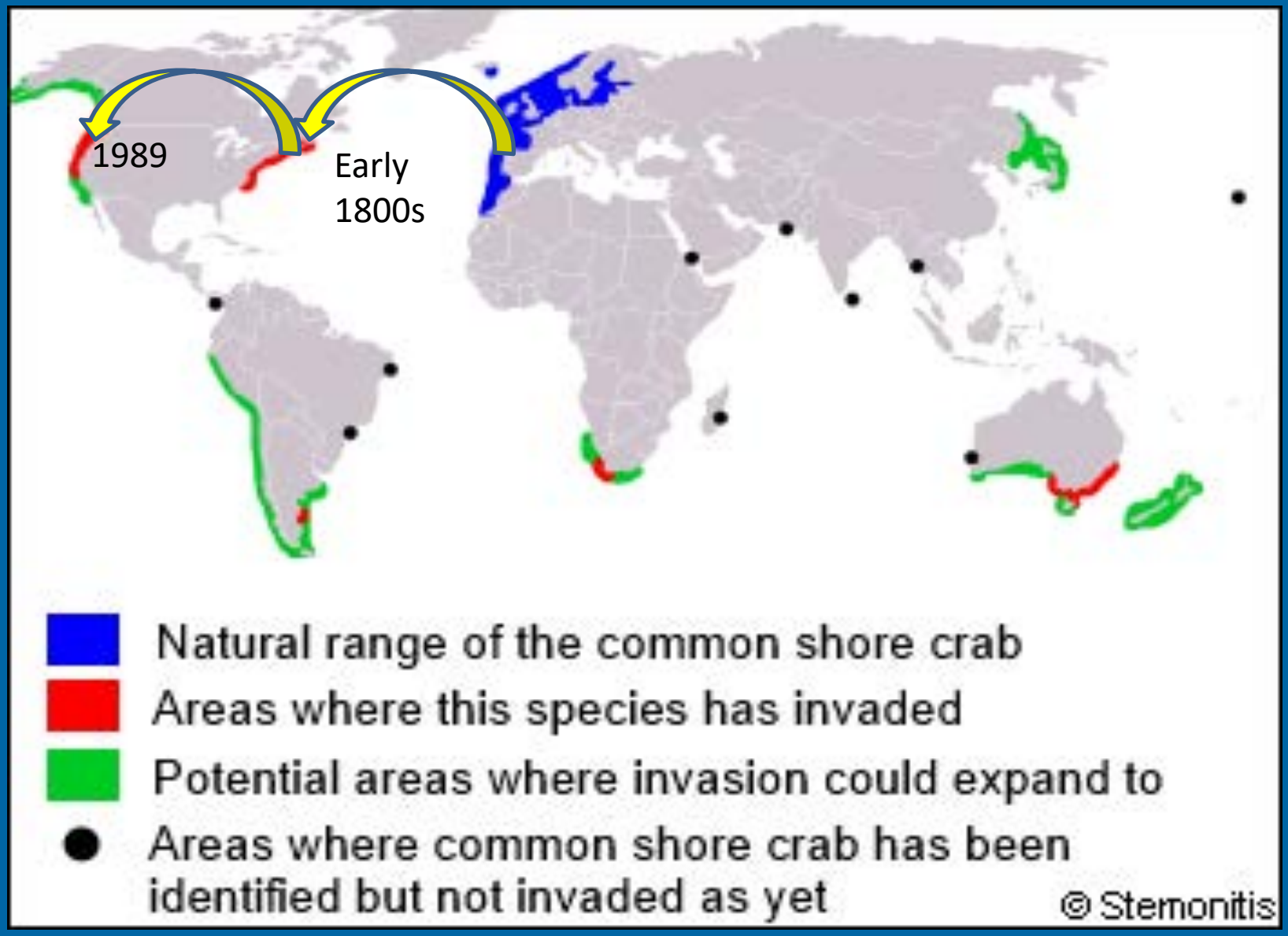


10° C minimum for growth

18° C maximum for brood development

(Yamada 2001)

Colonization of North America

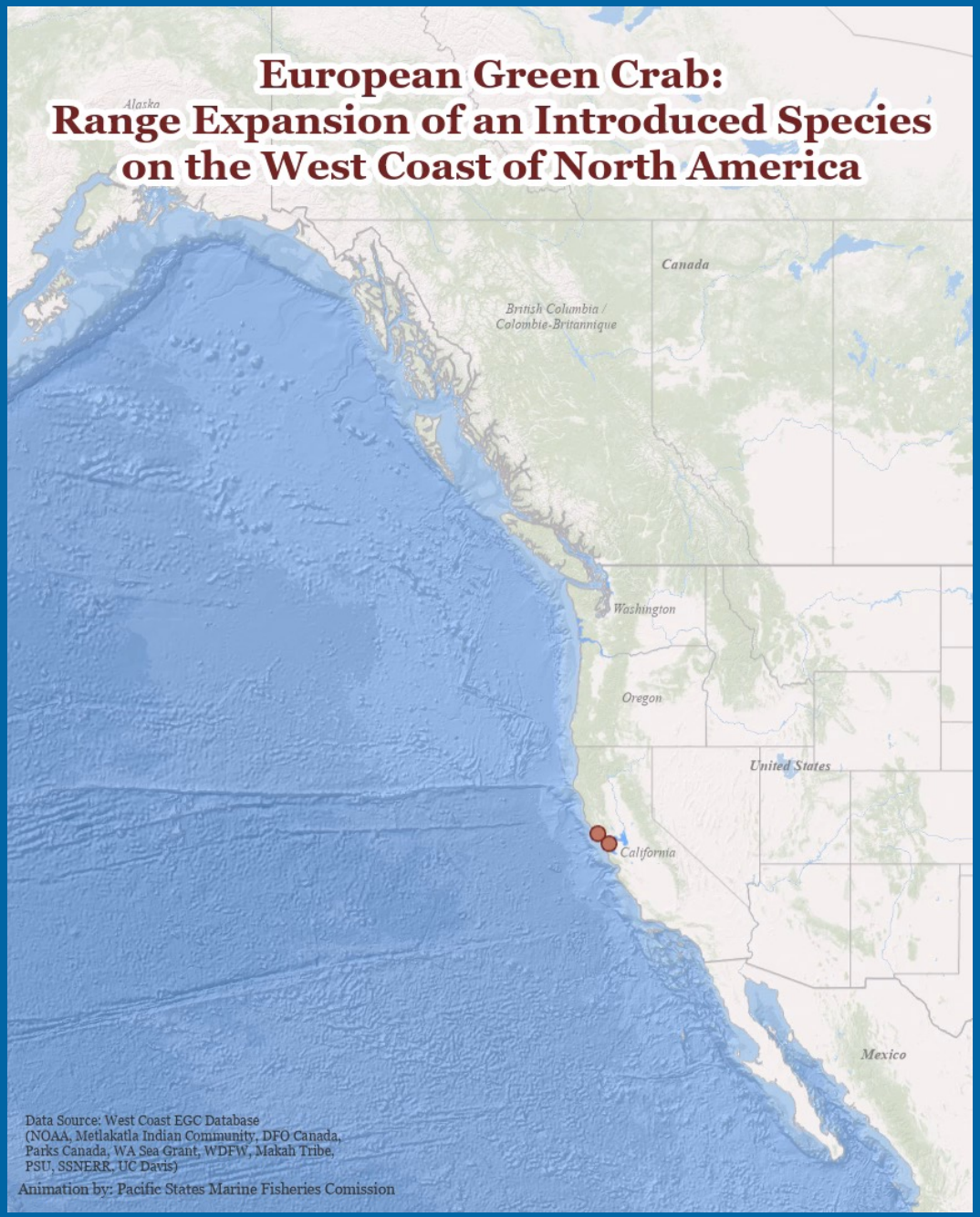


Green Crab Colonization West Coast

Coos Bay 1998

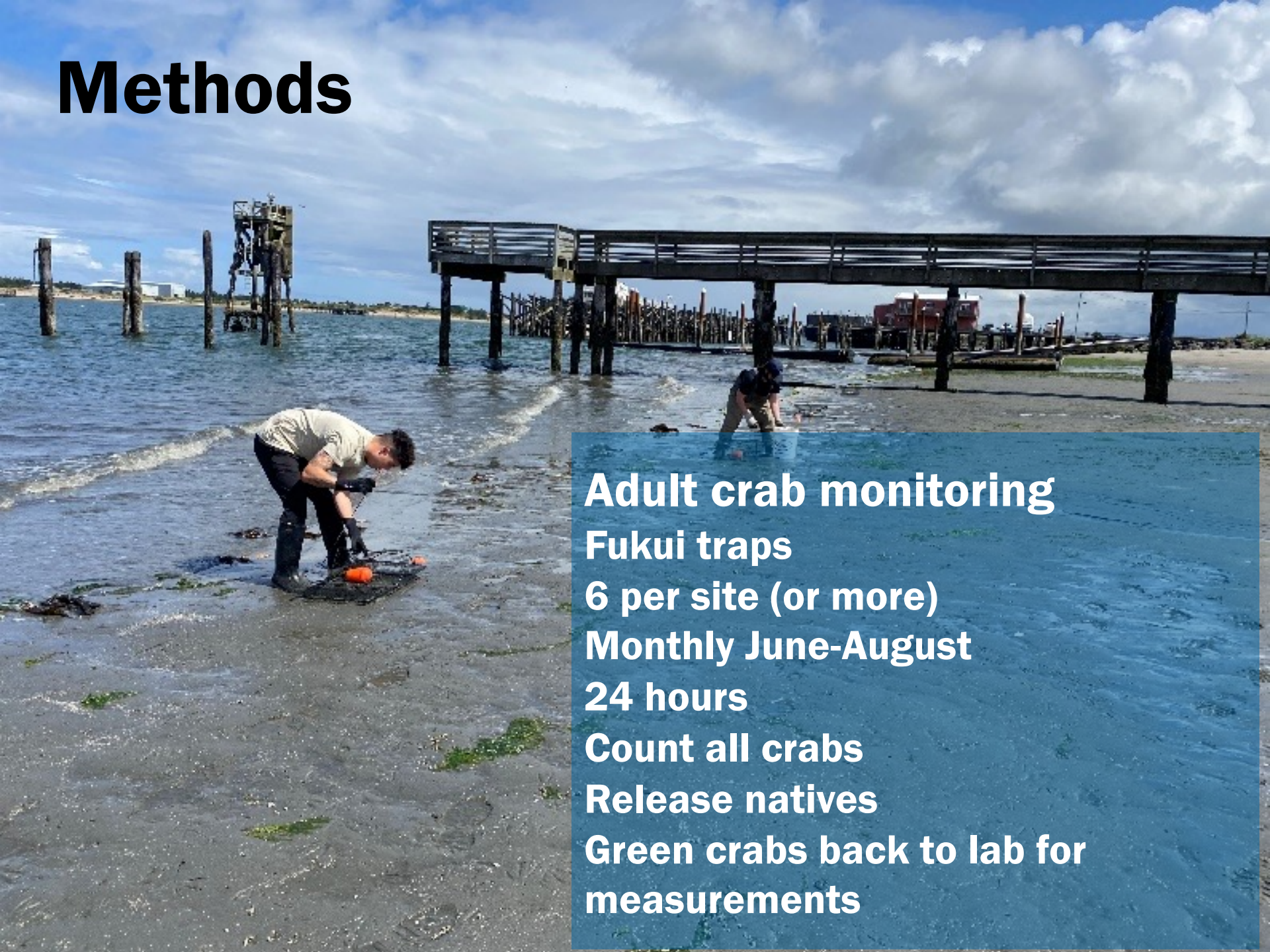
San Francisco 1989

- Figure 1. Davidson surface currents. Adapted from http://www.seasonsinthese.com/jan-feb/phys.shtml



Kate Sherman

Methods



Adult crab monitoring

Fukui traps

6 per site (or more)

Monthly June-August

24 hours

Count all crabs

Release natives

Green crabs back to lab for measurements

Methods

Young-of-the-year
Crayfish traps
6 per site (or more)
September
24 hours
Count all crabs
Release natives
Green crabs back to lab for measurements

Green Crab Measuring

Stages of Biological Invasions

1) Introduction

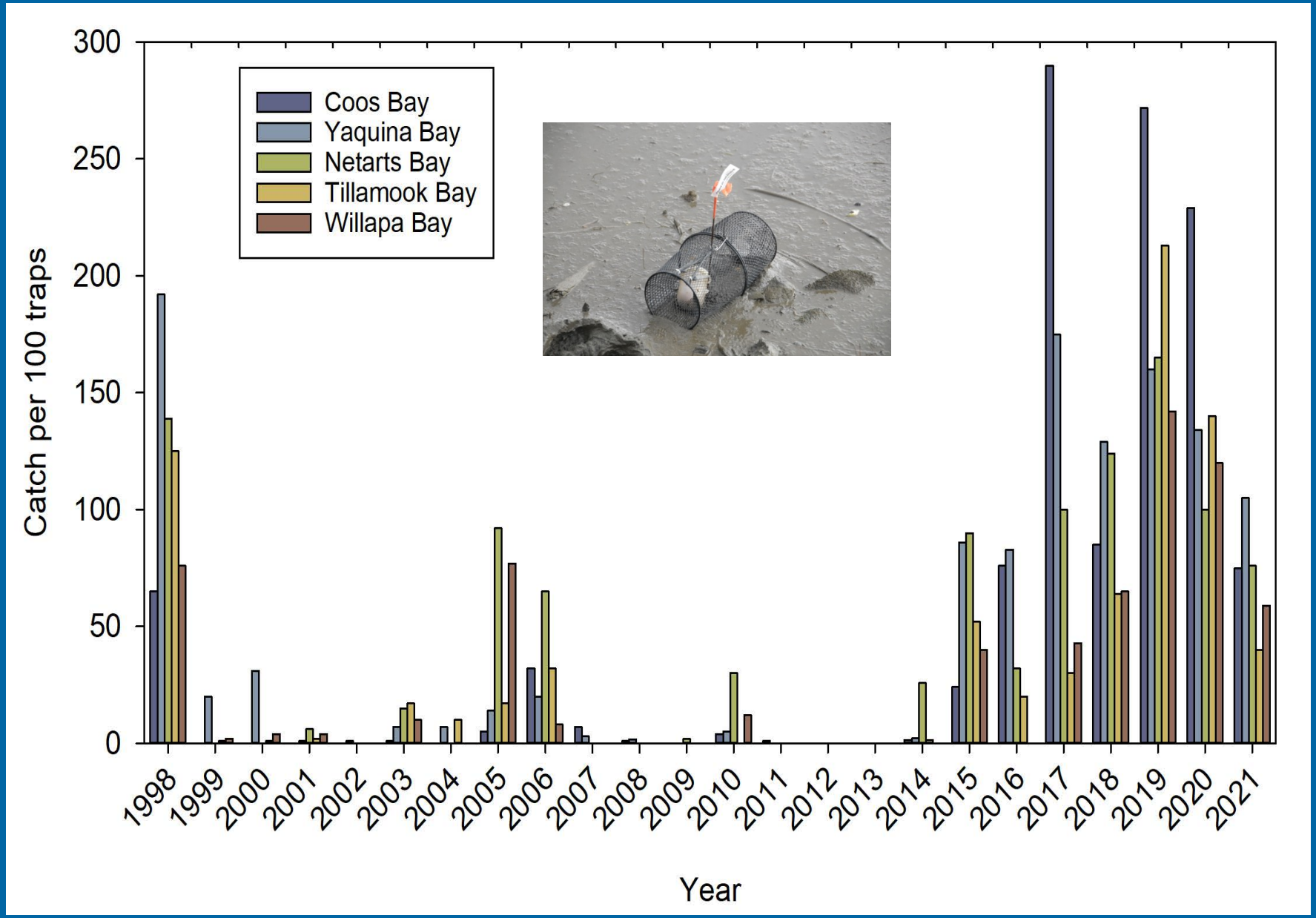
2) **Establishment** (self-sustaining population, might require repeated introductions, lag phase)

3) Population Growth

4) Increasing Spatial Distribution

5) Effects (per capita impacts)

Recruitment of young Green Crabs

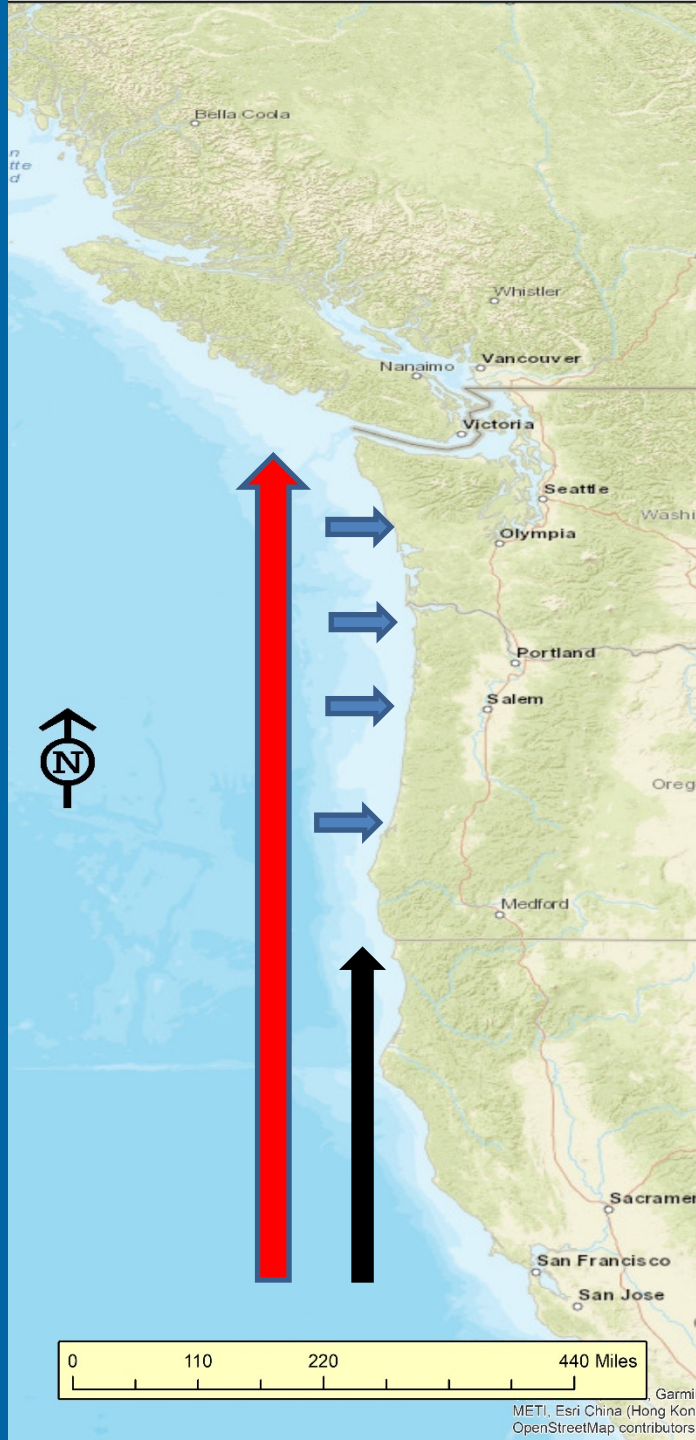


Updated from Yamada et al. 2021

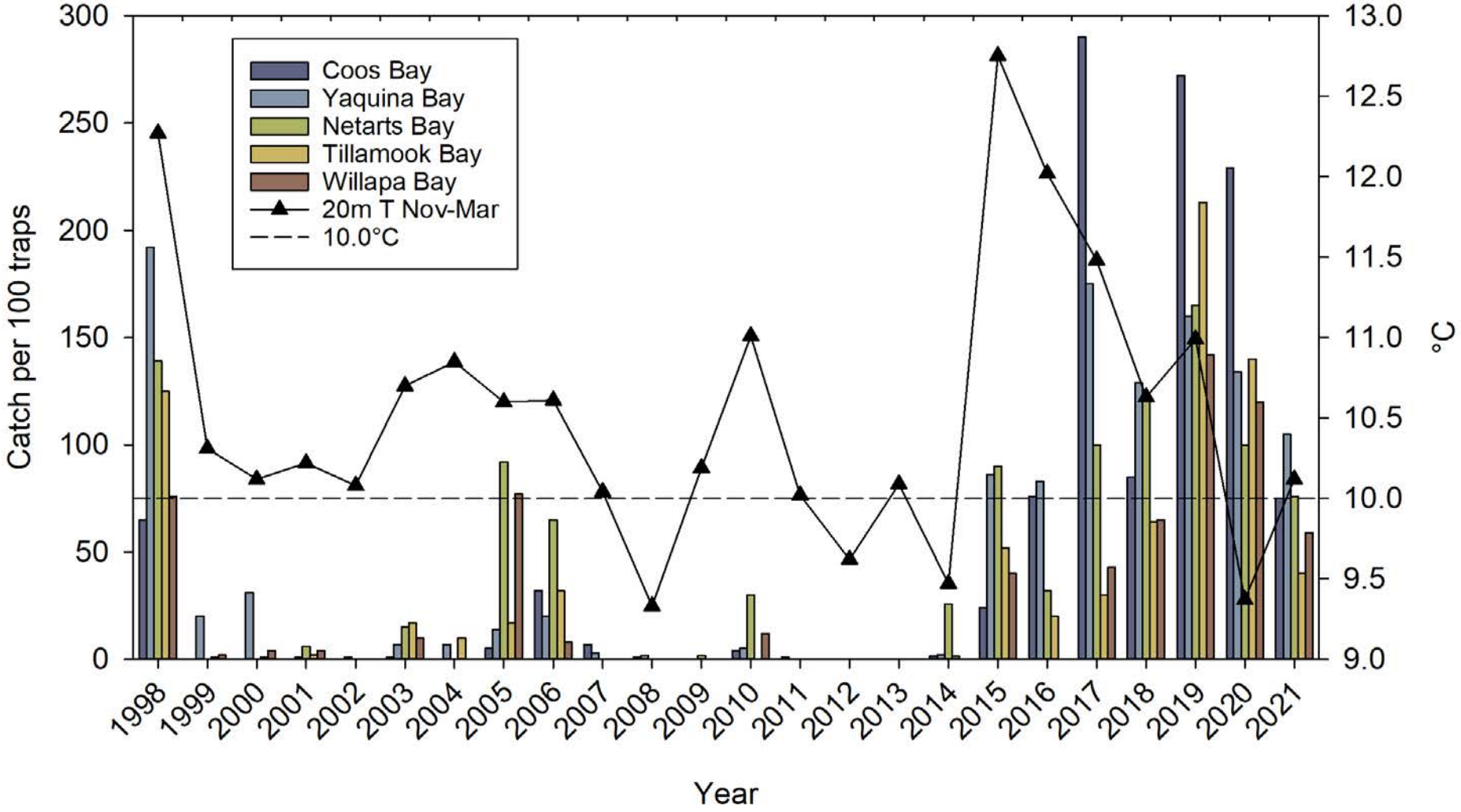
Data analysis: Jennifer Fisher

Potential northward transport of larvae

	Velocity Miles/day	*Days in plankton*	*Miles travelled*
Non-El Niño	*6*	*60*	*360*
El Niño	*30*	*60*	*1800*

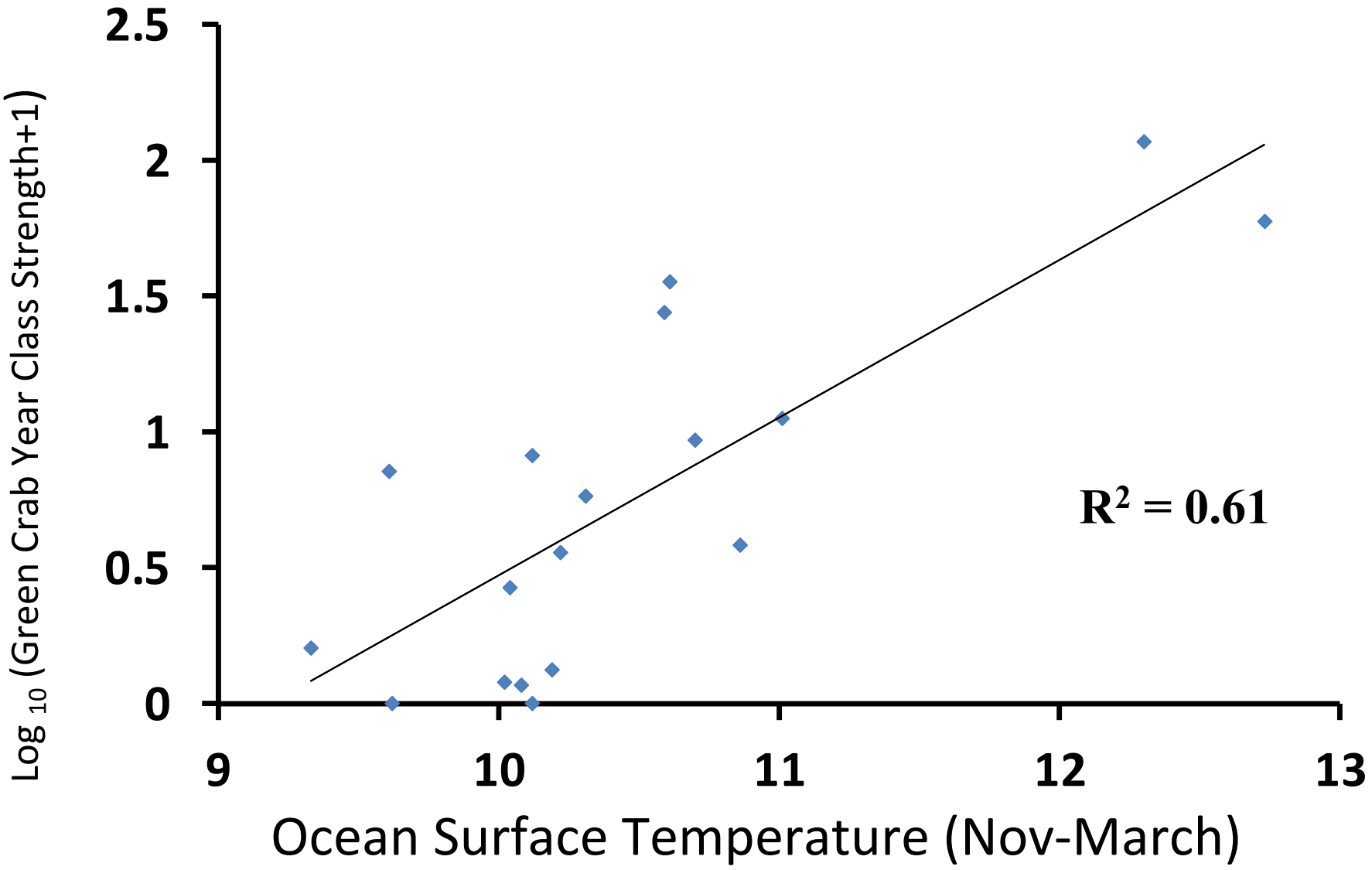


Recruitment of young Green Crabs



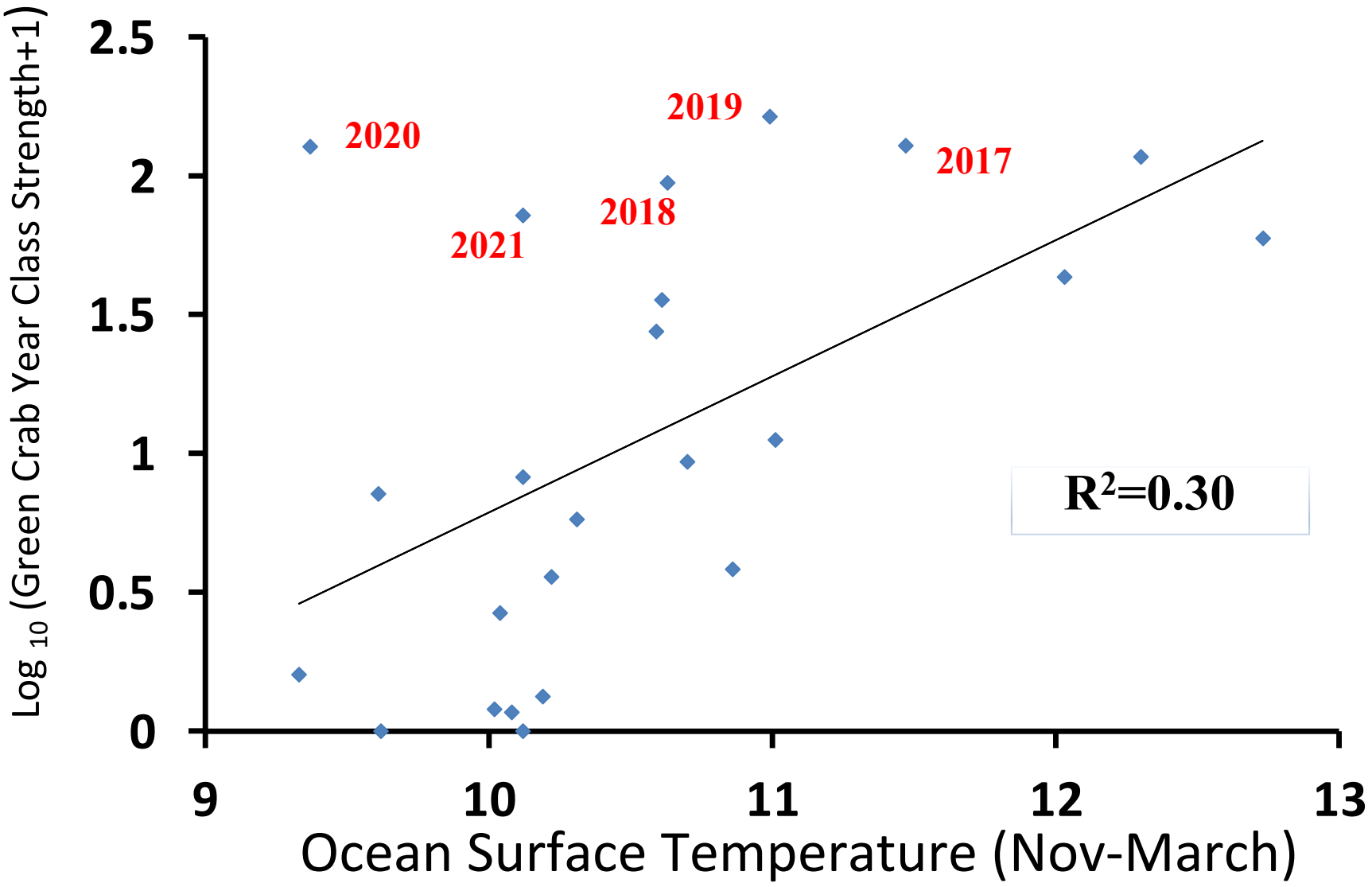
Data analysis: Jennifer Fisher

Warm winters → Strong Year Class (1998-2016)



Data analysis: Jennifer Fisher

Warm winters → Strong Year Class?



Data analysis: Jennifer Fisher

What is going on?

Prior to 2017

Larvae arrive from California in the Davidson Current.

Warmer winters favor growth and survival of larvae.

2017- present

There are now additional larval sources.

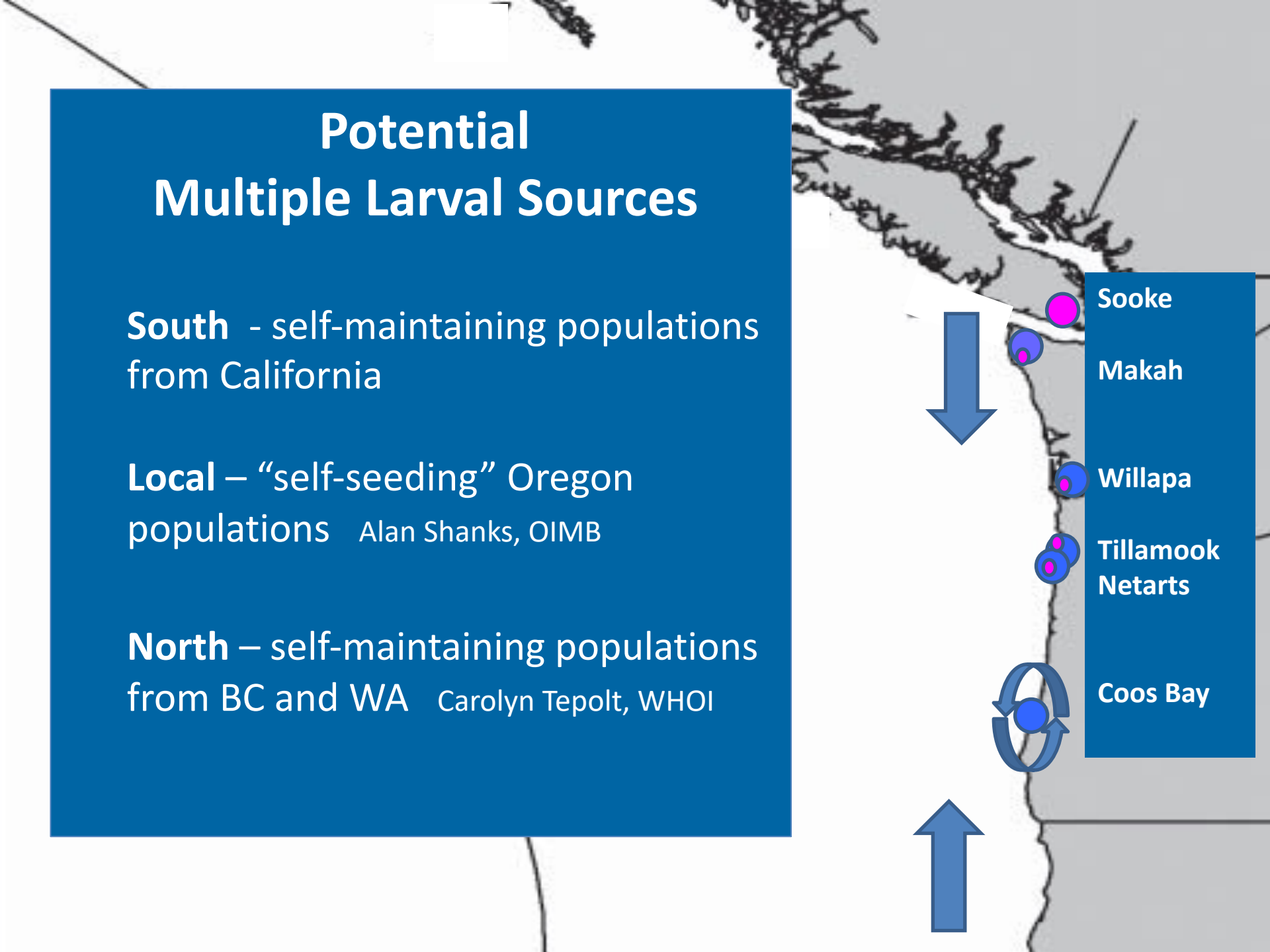
Green crab populations have built up in Oregon, Washington and British Columbia.

Potential
Multiple Larval Sources

South - self-maintaining populations from California

Local – "self-seeding" Oregon populations Alan Shanks, OIMB

North – self-maintaining populations from BC and WA Carolyn Tepolt, WHOI



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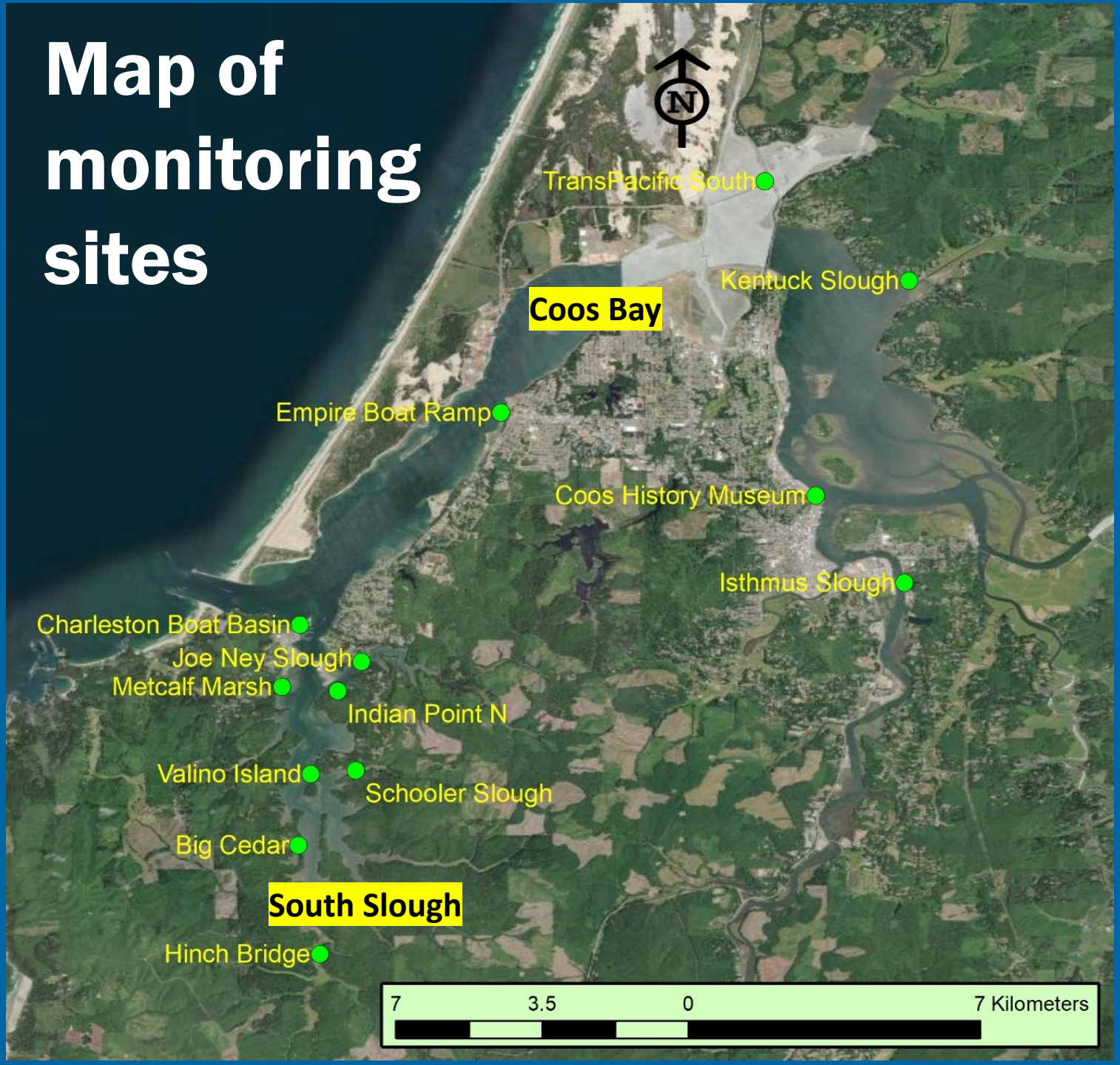
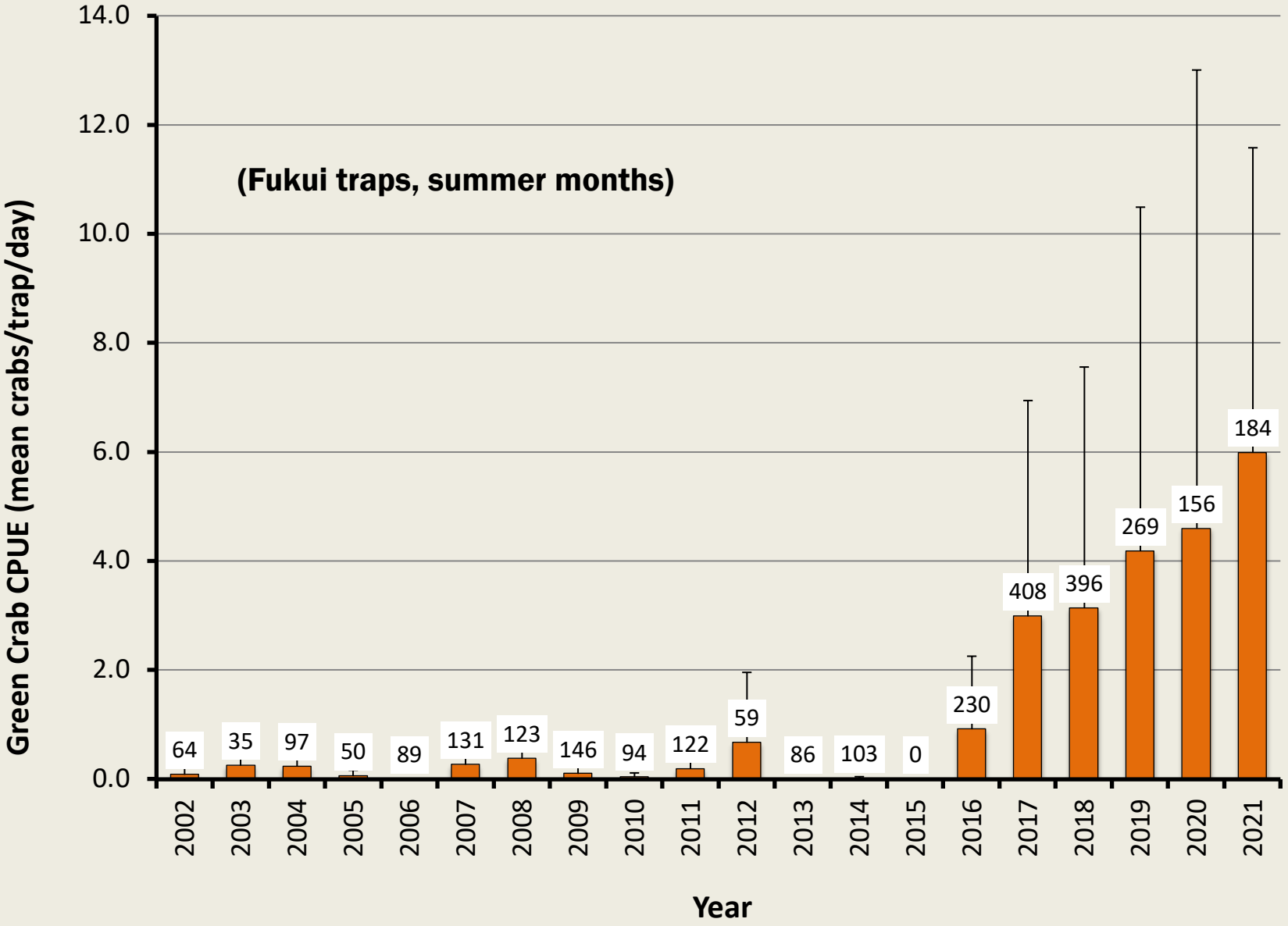
Green Crab Abundance in Coos Bay

Map of monitoring sites



Coos Bay adult green crab abundance (mean CPUE)



2021 Abundance along West Coast

Average CPUE (# crabs/trap/day)

Water Body	EGC Total	# Traps	CPUE
Dungeness Spit	12	947	0.01
Drayton Harbor	146	5,493	0.03
Lummi Sea Pond	86,028	16,591	4.16
Willapa Bay	10,335	2,460	3.44
Yaquina Bay	162	28	5.78
Coos Bay	1,164	184	6.33

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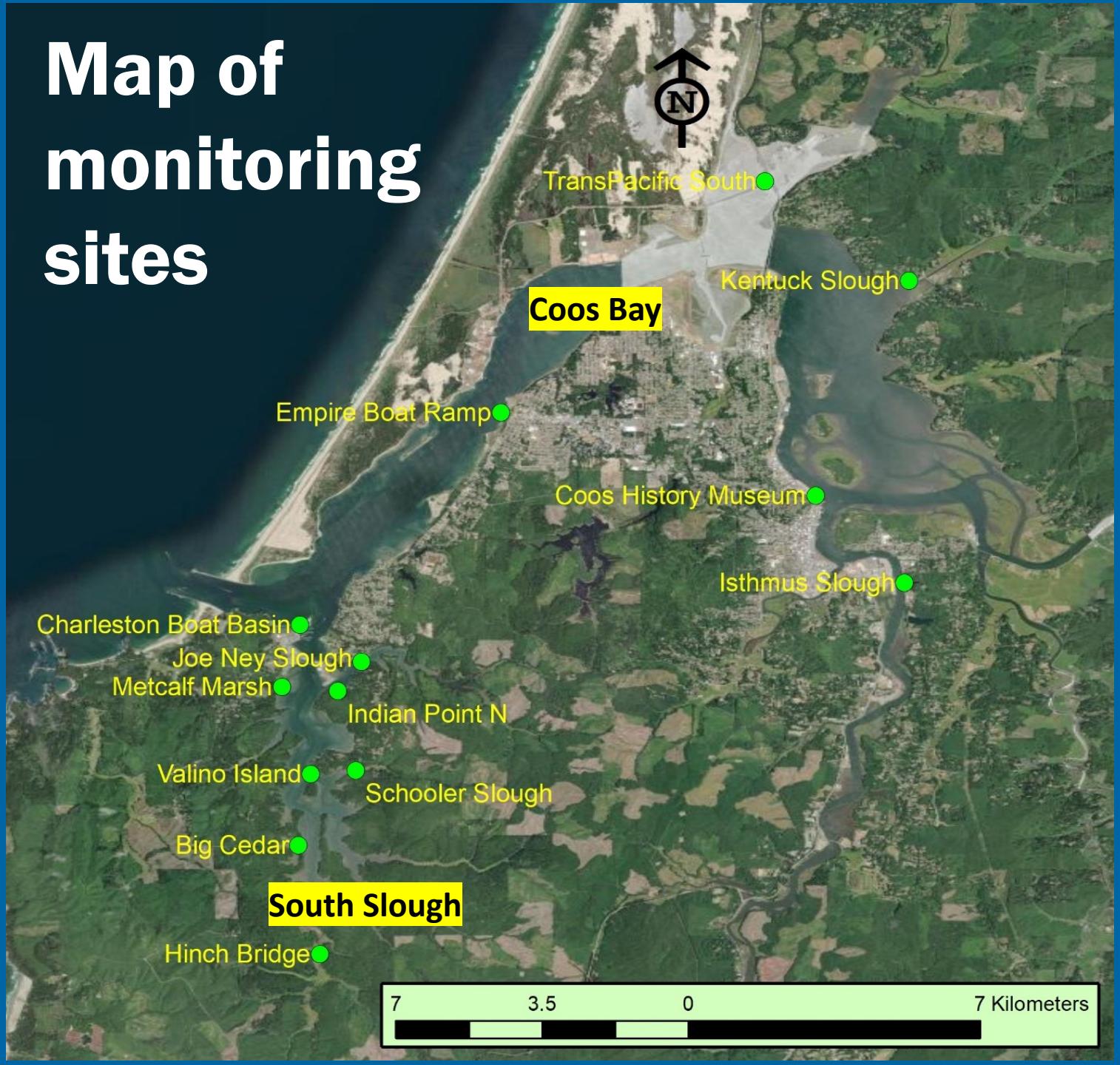

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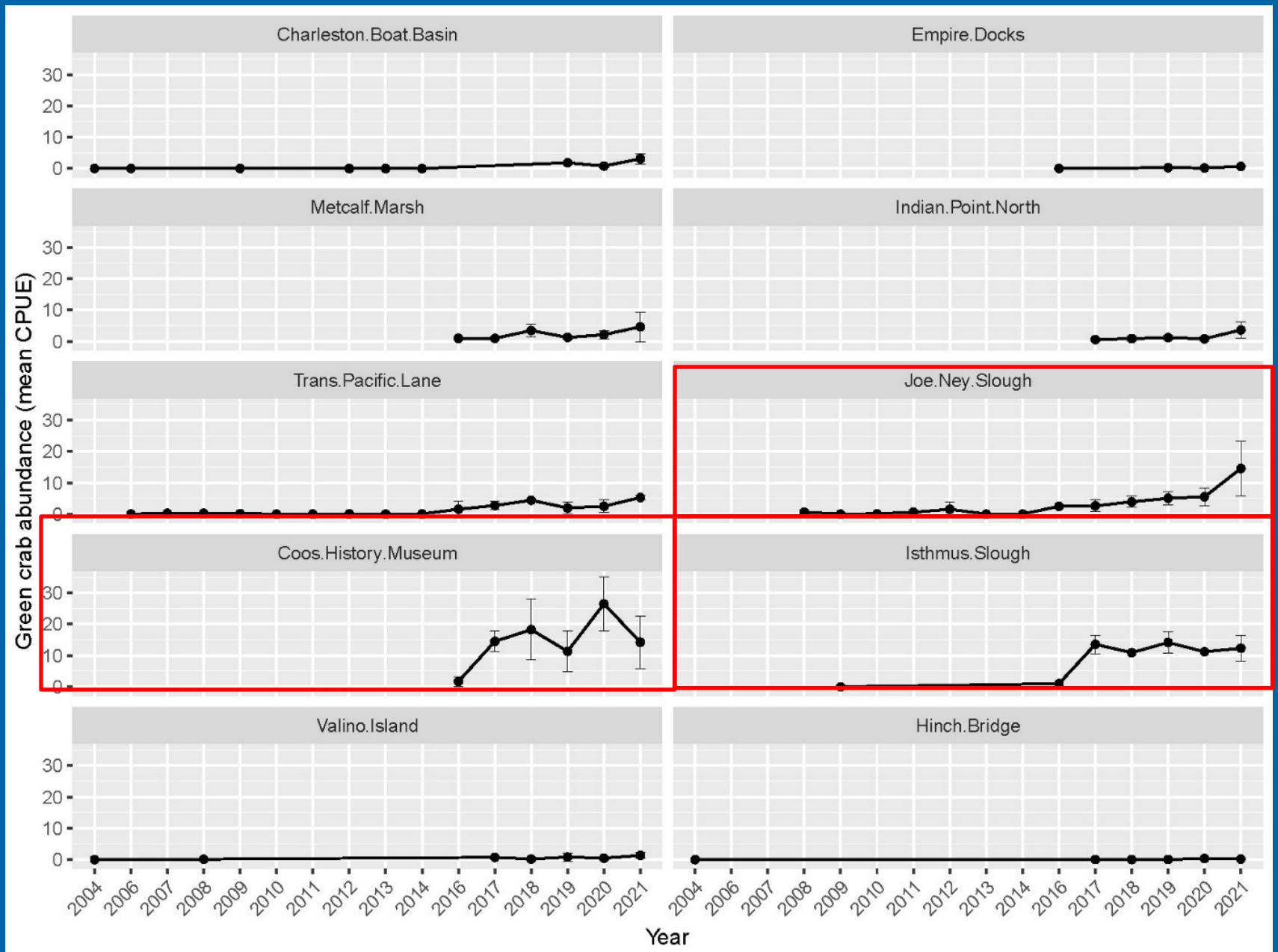

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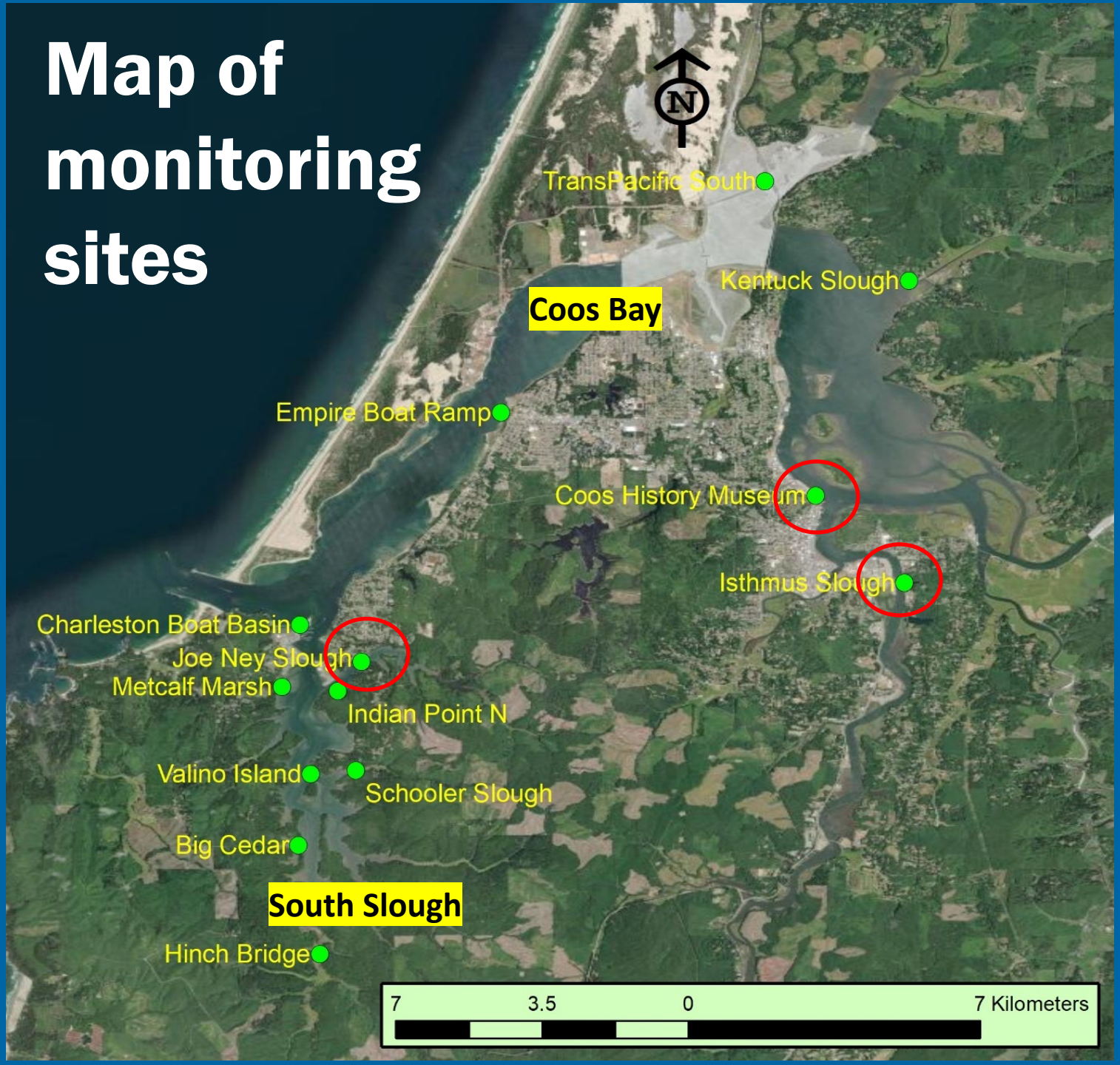
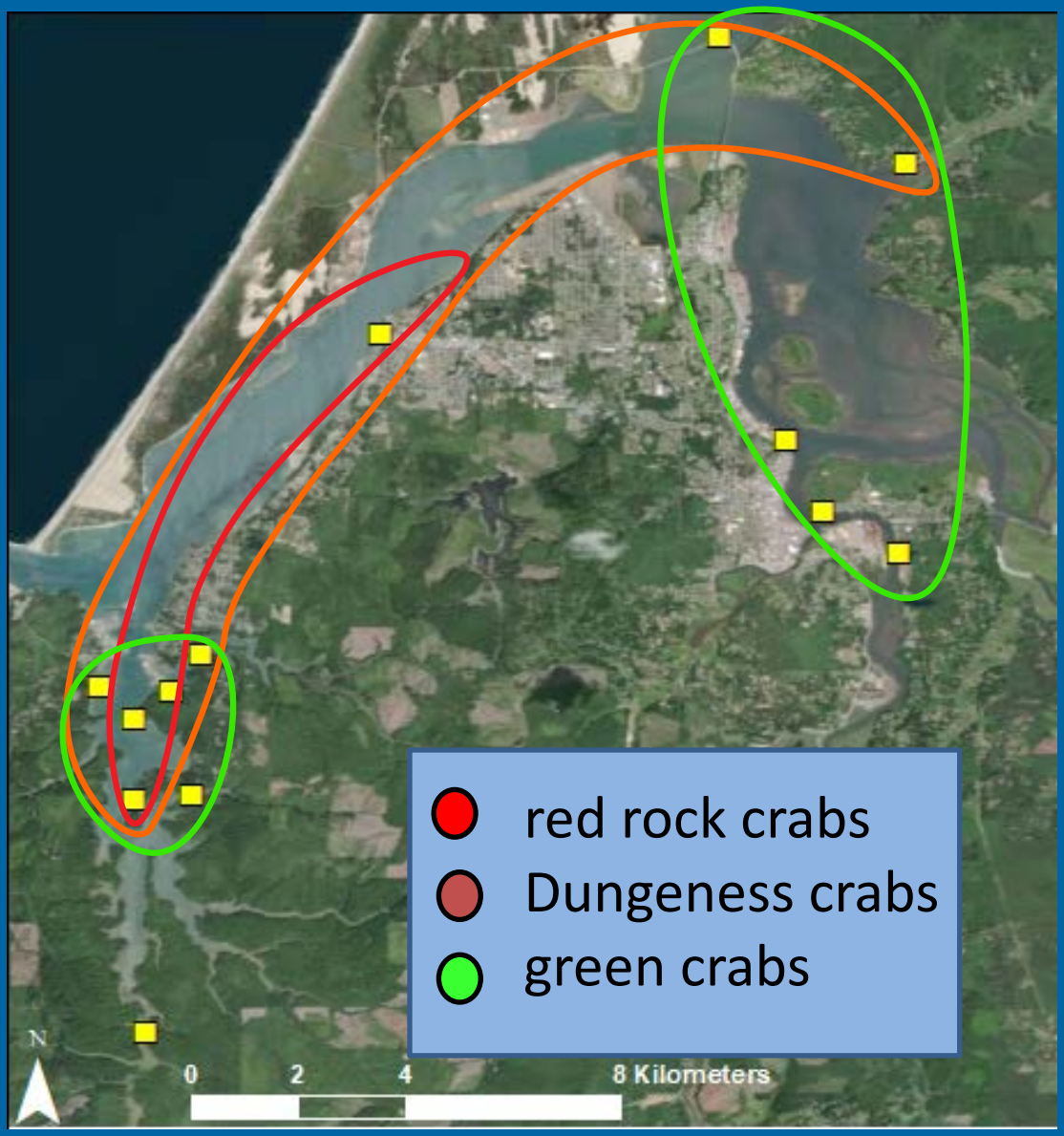


Overlap of crab species distributions



Crab interactions: Biotic resistance?

Inter and intra specific predation depending on size difference and species

Lined shore crab
(max size 48mm)

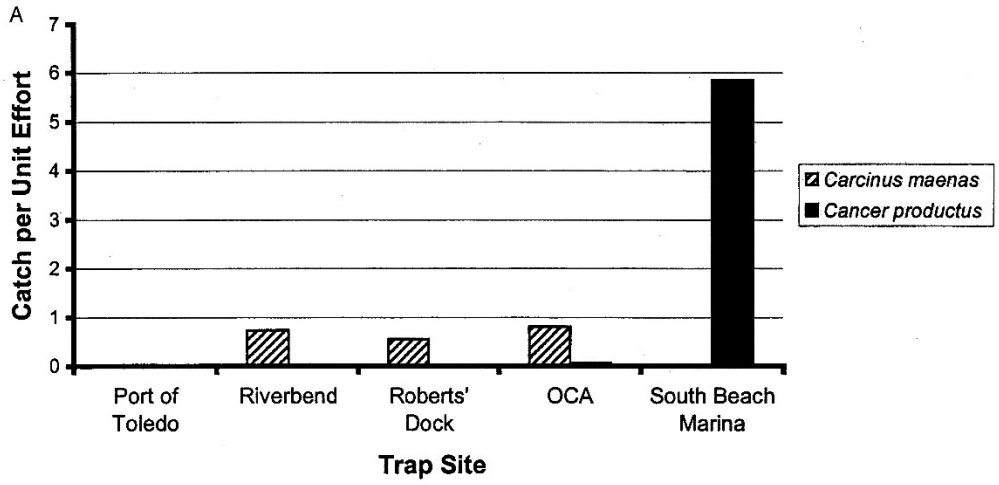
Oregon shore crab
(max size 50mm)

Green Crab
(max size 96mm)

Red Rock Crab
(max size 200mm)

Dungeness Crab
(max size 230mm)

Yaquina Bay



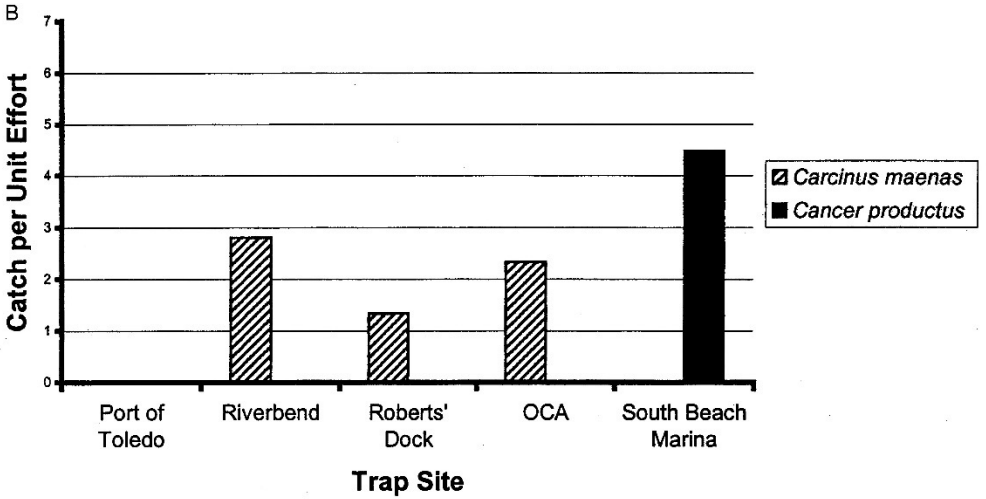


Figure 3. Primary site comparison: CPUE of *C. maenas* and *C. productus* at the five permanent trapping sites using Fukui fish traps (A) box traps (B).

Hunt and Yamada, 2003

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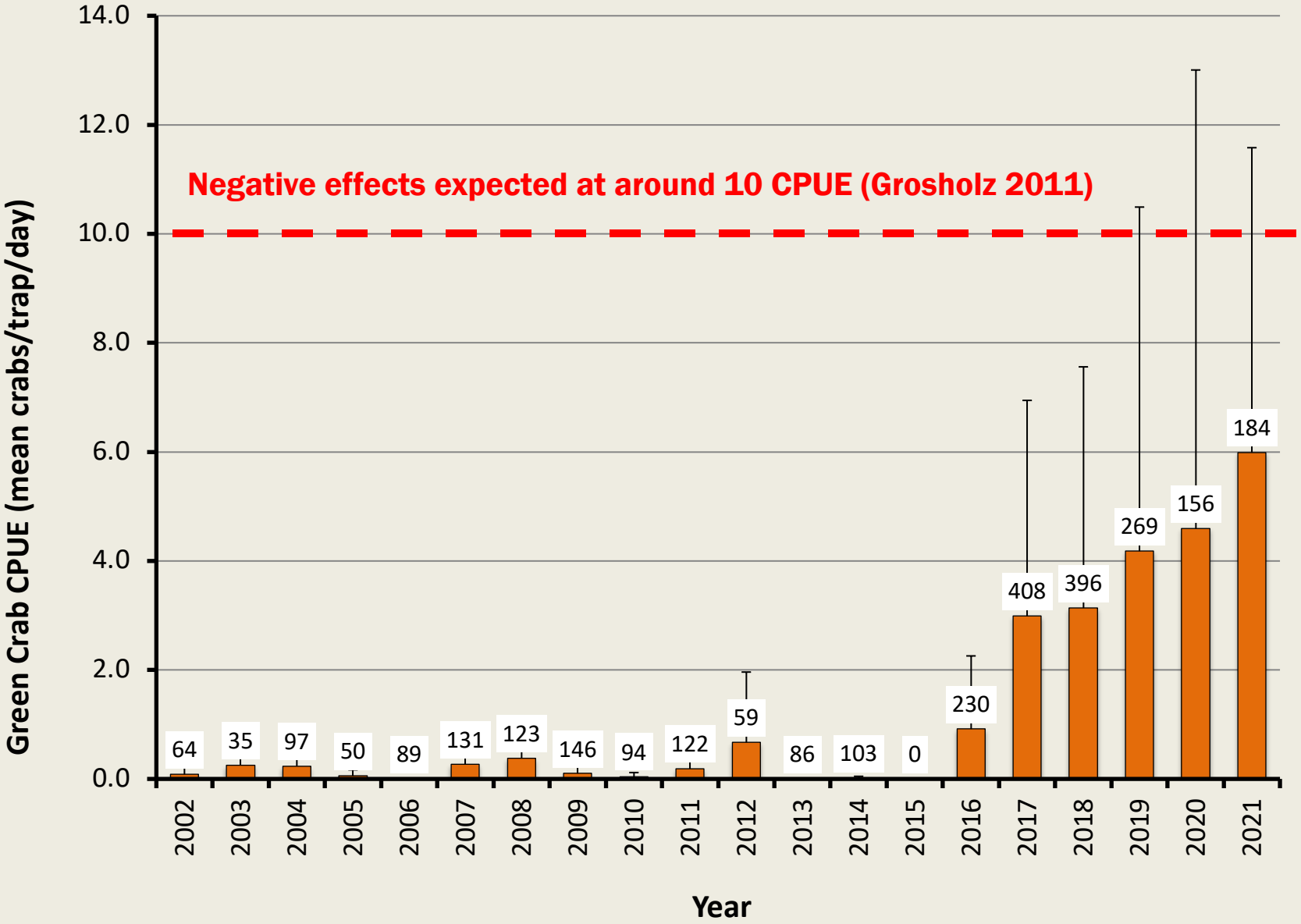
Green Crab Effects

Omnivores: primarily predators and scavengers
Preference: bivalve mollusks

Shellfish (clams, oysters, mussels, scallops)
Crabs (juvenile Dungeness, shore crabs)
Eelgrass (eat rhizomes and dig up beds)

*caused collapse of softshell clam industry on East Coast
** also reduce fish abundance by destroying eelgrass (Matheson et al. 2016)
***displace Dungeness crabs from protected habitats (McDonald et al. 2001)

Coos Bay adult green crab abundance (mean CPUE)

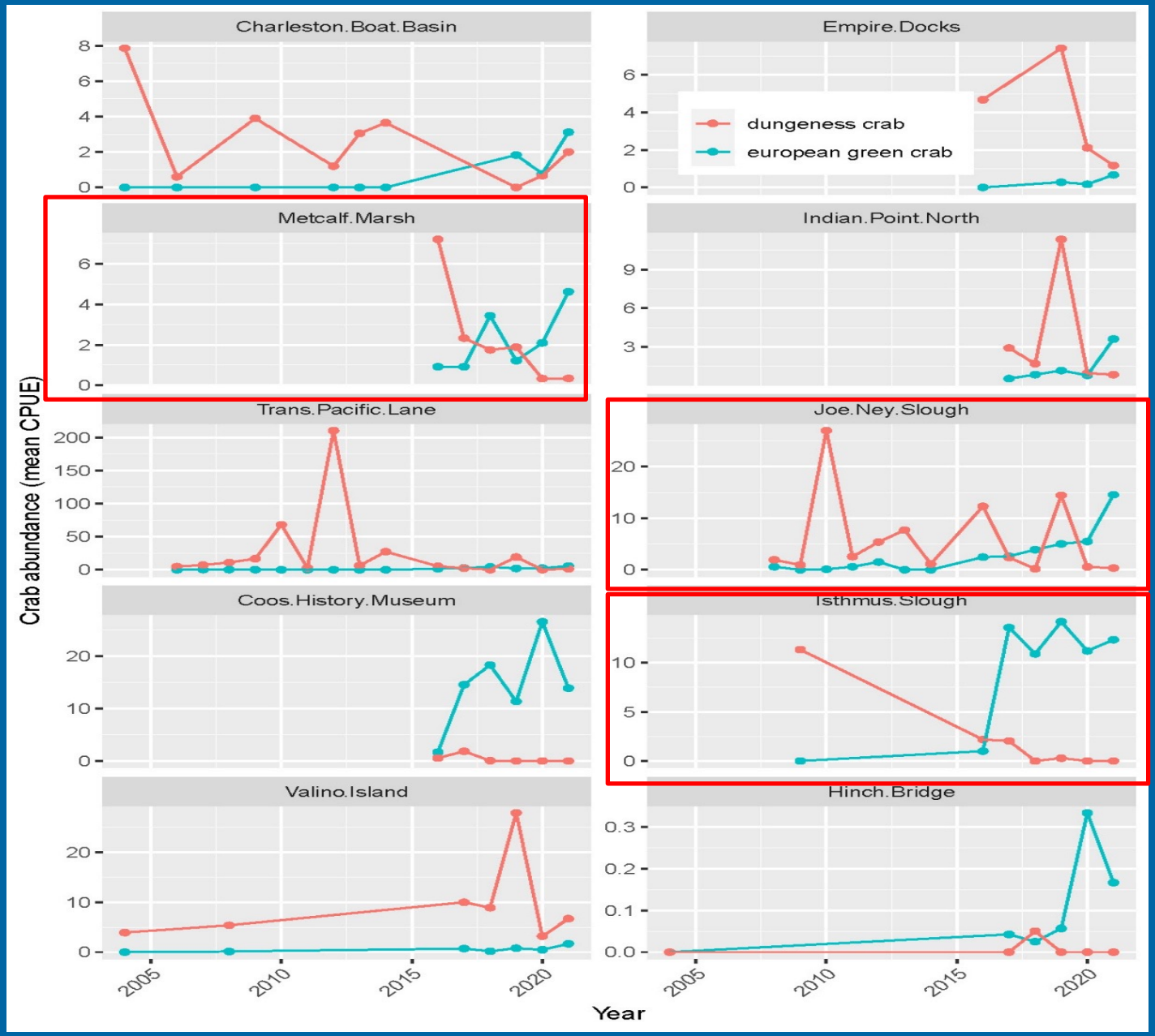


Effect on bivalve species?

Some recreational clam harvesters have noted declines in clam abundance in recent years.

Effect on Dungeness crabs?

Coos Bay adult green crab and Dungeness abundance (mean CPUE)



Green Crab Management

Eradication not feasible
Managing abundance is possible

Needs:
1) Monitoring to evaluate population growth
2) Experiments to understand per capita impacts (to set target levels, functional eradication)
3) Management: develop a sustained trapping program

How do we manage abundance?

- **Physical**: Trapping programs (government, volunteer, bounties), develop fishery
- **Biological** control: introducing host specific parasites, predators, diseases from native range
- **Chemical**: Pheromones (interfere with mating)
- **Ecological**: Increase ecosystem resistance (promote native predators, e.g. red rock crabs)

Can you eat green crabs?

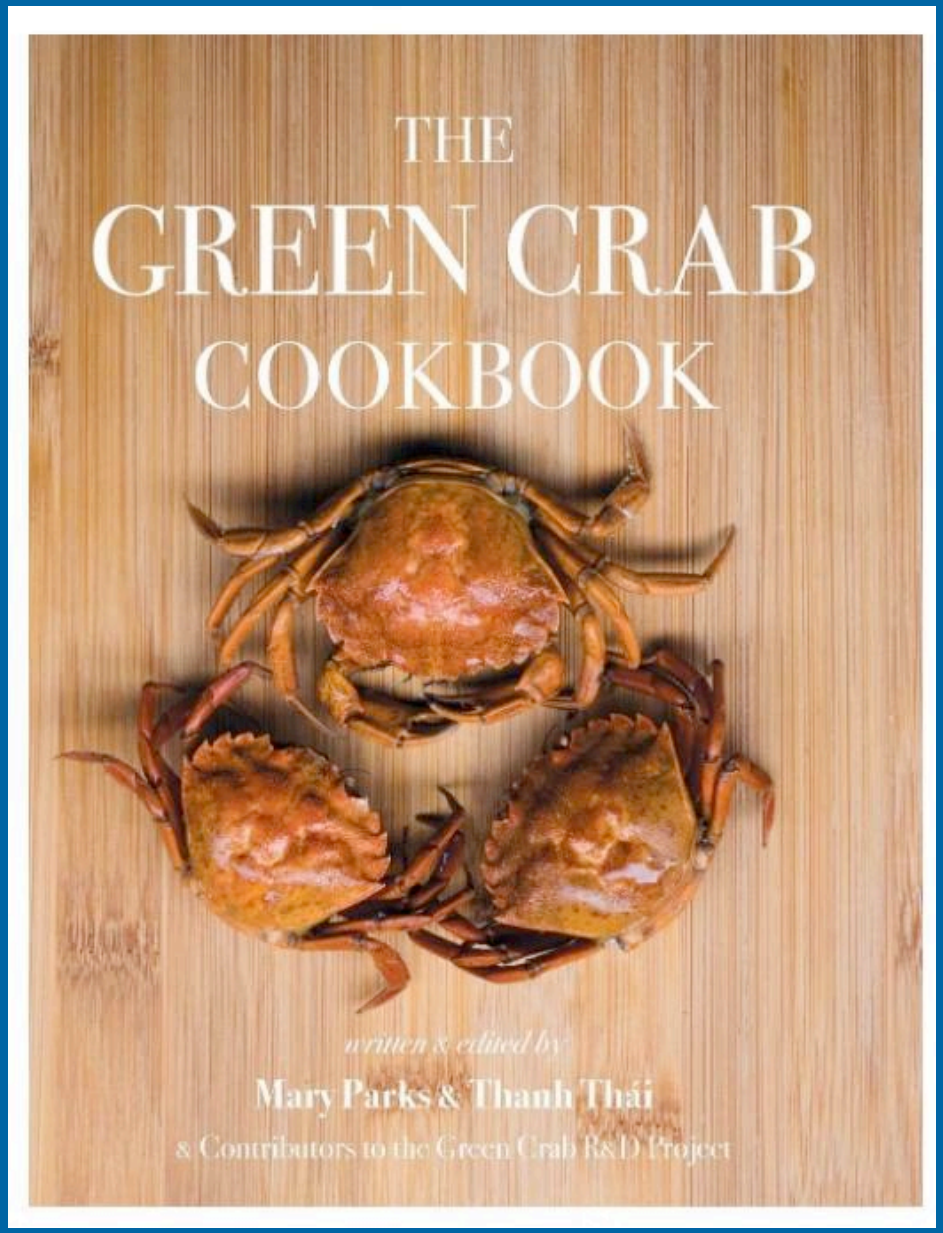
Seasonal fishery in Venice

Seasonal fishery

Spring	Fall
Moleche	Masinette
Soft-shelled	Caviar or roe

A traditional seasonal treat of Venice

Cookbook with numerous recipes



Soft-shell

Removing meat

Deep-fried

Broth

Roe

Deep-fried soft-shelled crab

Trapping green crabs in Oregon

Currently no commercial fishery

Can collect using a recreational shellfish license

$10/ year

Present limit: 35 crabs per person per day

Conclusions

Summary:

1) Green crabs are colonizing PNW estuaries
2) They have established self-sustaining populations
3) Populations are growing and are most abundant in the mid-estuary regions
4) Native crabs are providing some resistance to invasion, (but prefer to predate upon other native crabs)
5) Eradication is not possible
6) Physical removal to reduce effects is possible but requires coordinated and sustained trapping

Acknowledgements

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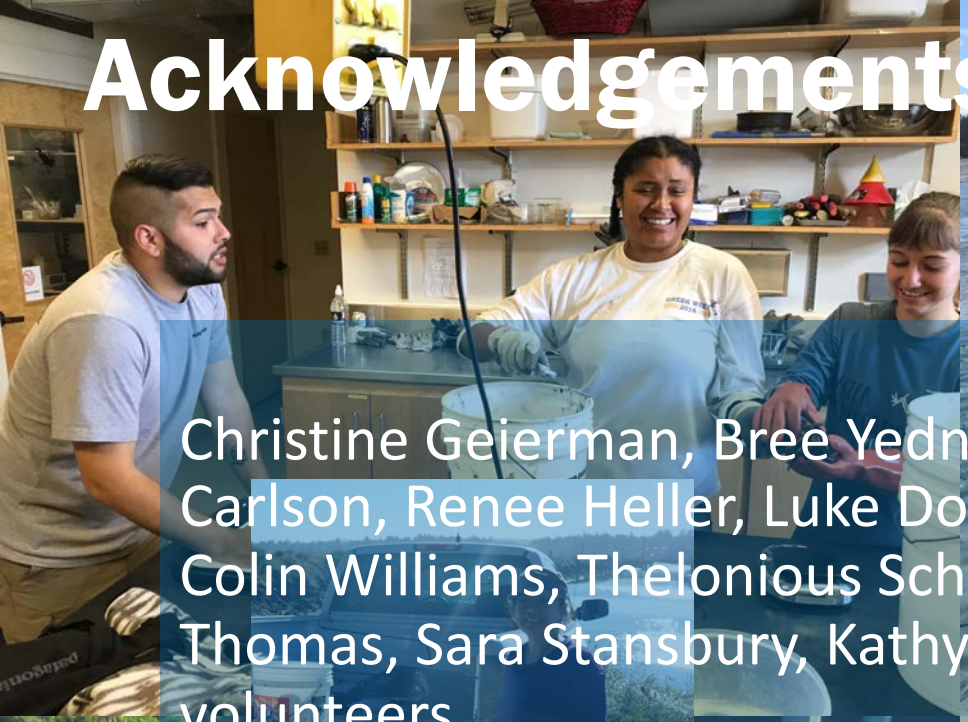

Thank You