Biological Invasions in Marine Systems

Outline

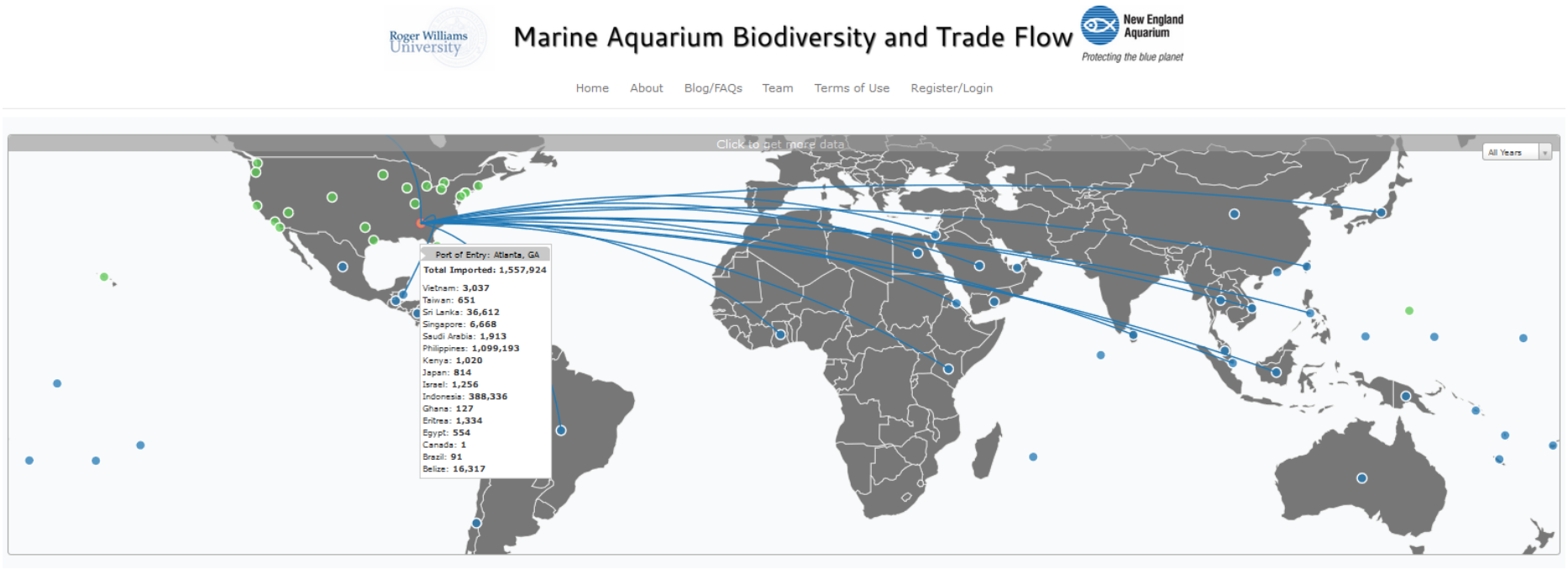
Pathways in Marine Systems

- Shipping (Boring, Fouling, Ballast Water)

- Global Aquaria Trade & Ornamental Escape

- Aquaculture

Global Aquaria Trade



→ Millions of imported individuals each year

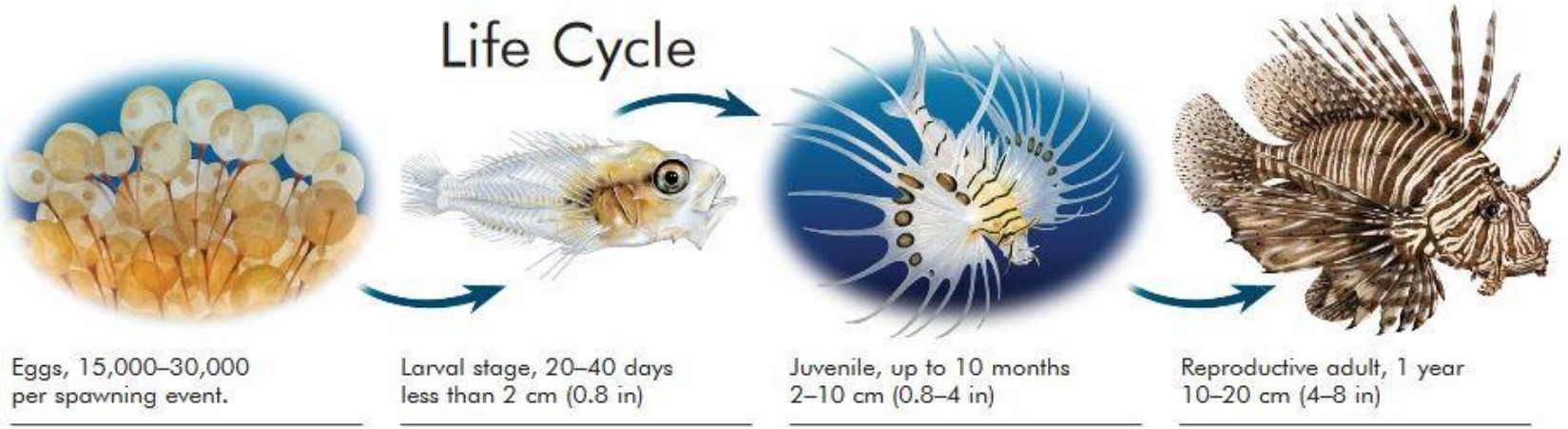
https://www.aquariumtradedata.org/

Ornamental Release: Red Lionfish

Pterois volitans

Indo-Pacific → West Atlantic, Caribbean

Red Lionfish



Reproduction: all year long, 2.000.000 eggs per female & year

Dispersal: Eggs & larvae are dispersed by currents

Release:

1985: first sighting (Miami)

1992: 6 individuals released from Miami Aquarium by Hurricane Andrew

http://lionfish.gcfi.org/

Red Lionfish

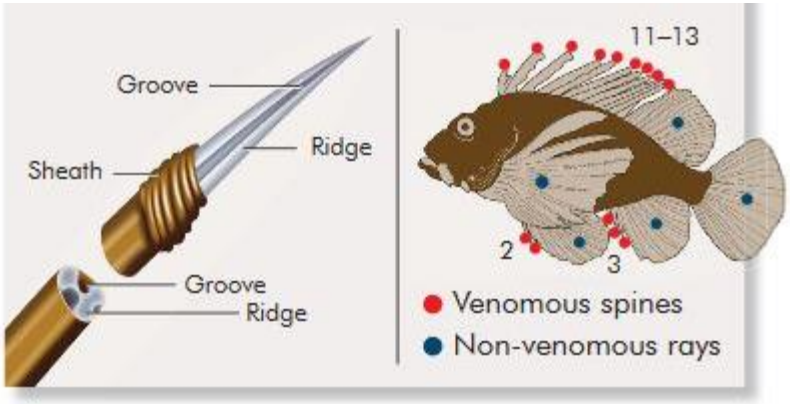
Lionfish findings 1985 - 2017

http://lionfish.gcfi.org/

Red Lionfish

Venomous spines

→ Protection from predation

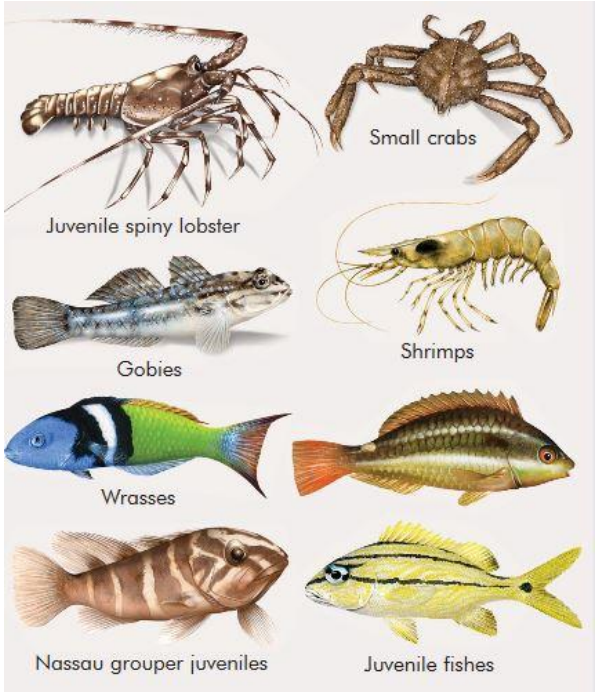


Wide prey spectre:

Ecological impact:
reduces prey populations by up to 90 %

Economic Impact:
Competitor to grouper & snapper

http://lionfish.gcfi.org/



Lionfish prey

Red Lionfish: Mitigation Measure

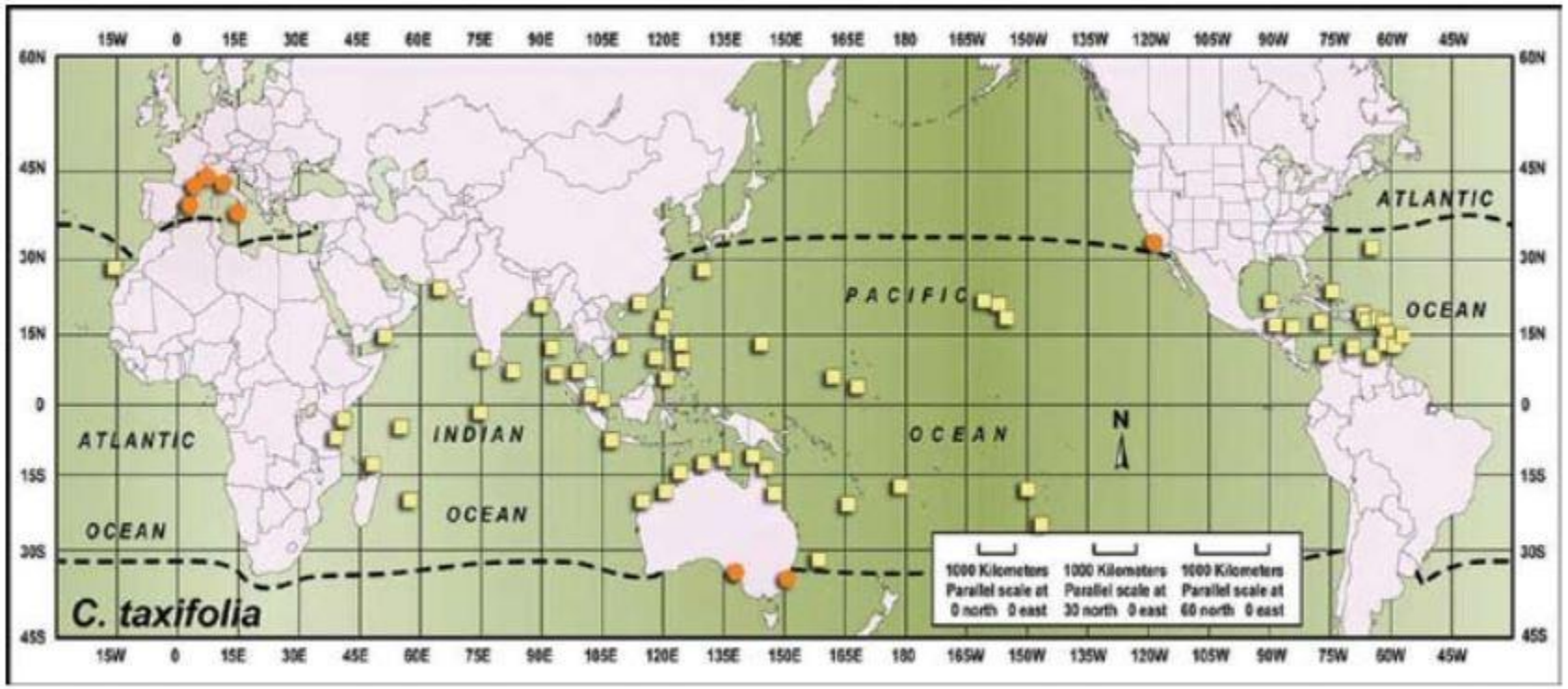
Harvesting
(all year long)

Regional Food Economy

National Geographic: Divers Fight the Invasive Lionfish
https://www.youtube.com/watch?v=GzaeYzAC8Ro

Ornamental Release: *Caulerpa taxifolia*

Caulerpa Distribution



Native — Pacific Ocean, Caribbean Sea

Invasive — Mediterranean Sea, California, Australia

http://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/invasive-species/toolkit/caulerpa.pdf

Caulerpa: The Killer Alga in the Mediterranean Sea

***Caulerpa* outcompetes native seagrass**

→ Loss of seagrass meadows
→ Loss of biodiversity

Seagrass (*Posidonia oceanica*)

***Caulerpa* produces effective toxin**

→ Hardly eaten by grazers

***Caulerpa* reproduces asexually (clonal)**

→Even fragments are viable

→ Quick spread

The *Caulerpa* Invasion in the Mediterranean Sea

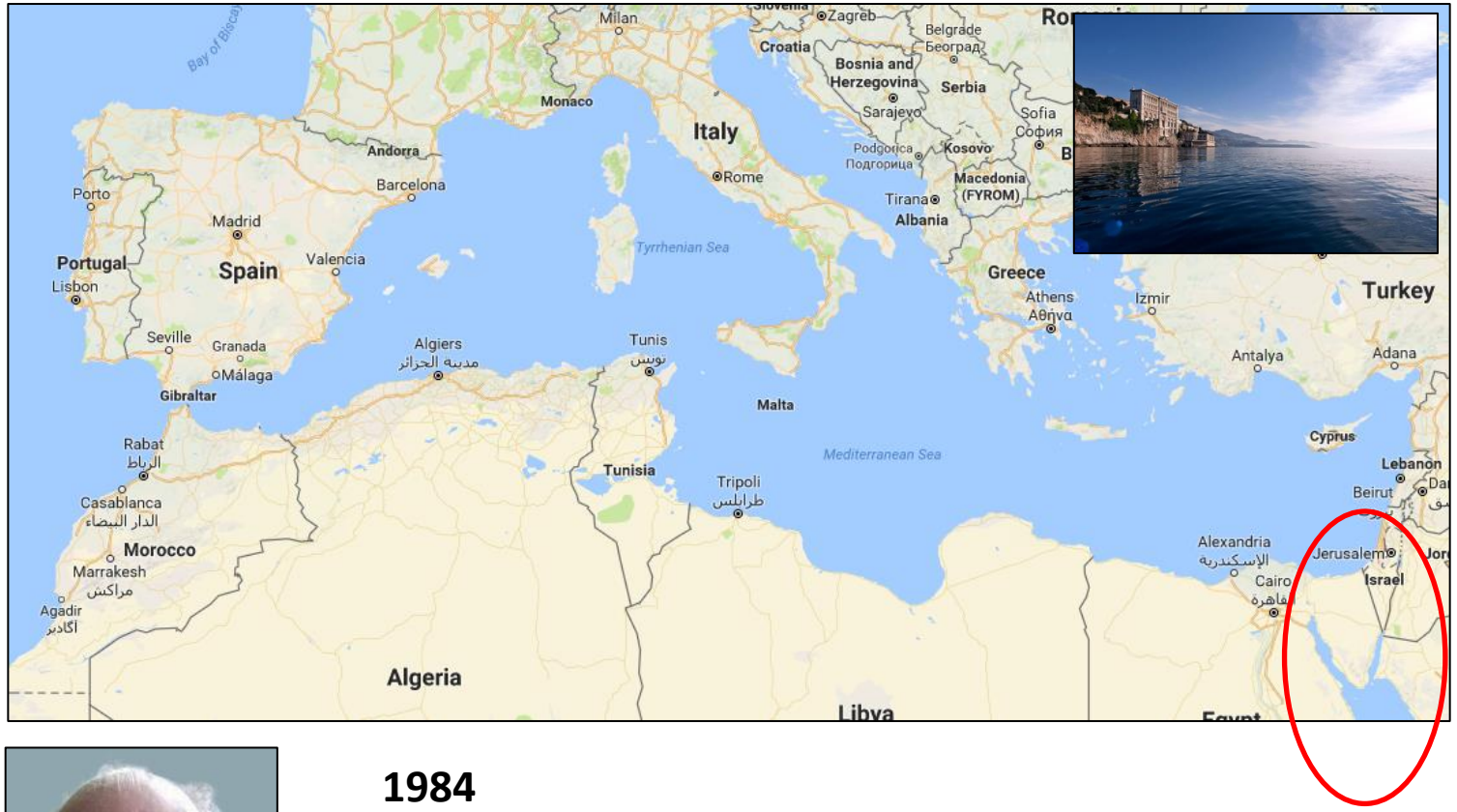
Alexandre Meinesz

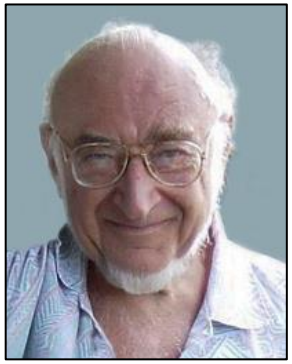
1984

Escape Hypothesis

Escape from the
Oceanographic Museum of Monaco

The *Caulerpa* Invasion in the Mediterranean Sea





François Doumenge

1984

Range expansion hypothesis:

Red Sea → Suez Canal → Mediterranean Sea

Caulerpa Genetics

Olivier Jousson,
Geneva University

<u>Molecular comparisons:</u>

Mediterranean VS Red Sea

Mediterranean VS Pacific

Mediterranean VS Caribbean

Mediterranean VS Monaco Museum

→ Where did *C. taxifolia* come from?

Caulerpa Genetics

Olivier Jousson,
Geneva University

<u>Molecular comparisons:</u>

Monaco Museum VS Monaco Museum Supply

→ **Match with**
Wilhelma Botanical Garden,
Stuttgart, Germany

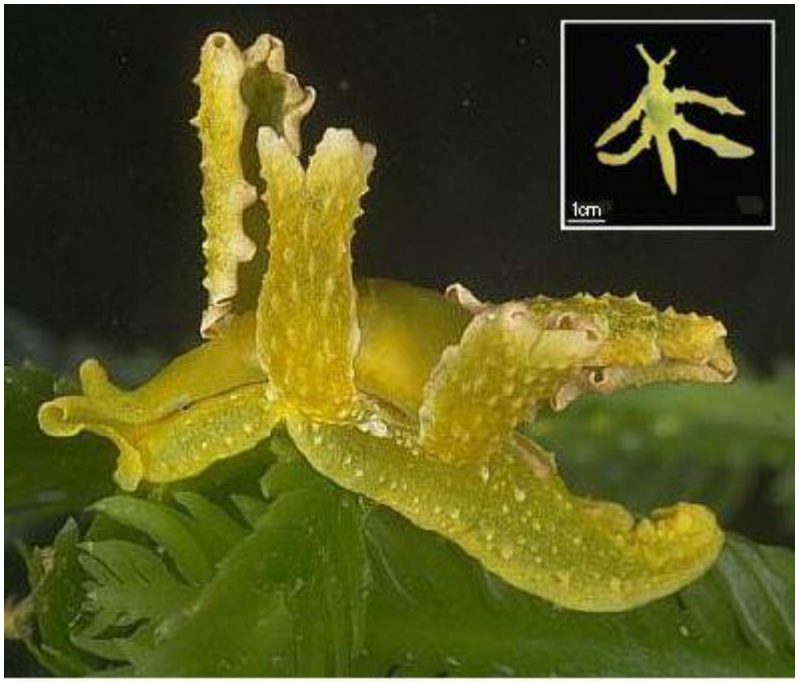
<u>Pacific *Caulerpa* strain:</u>

collected in 1970ies

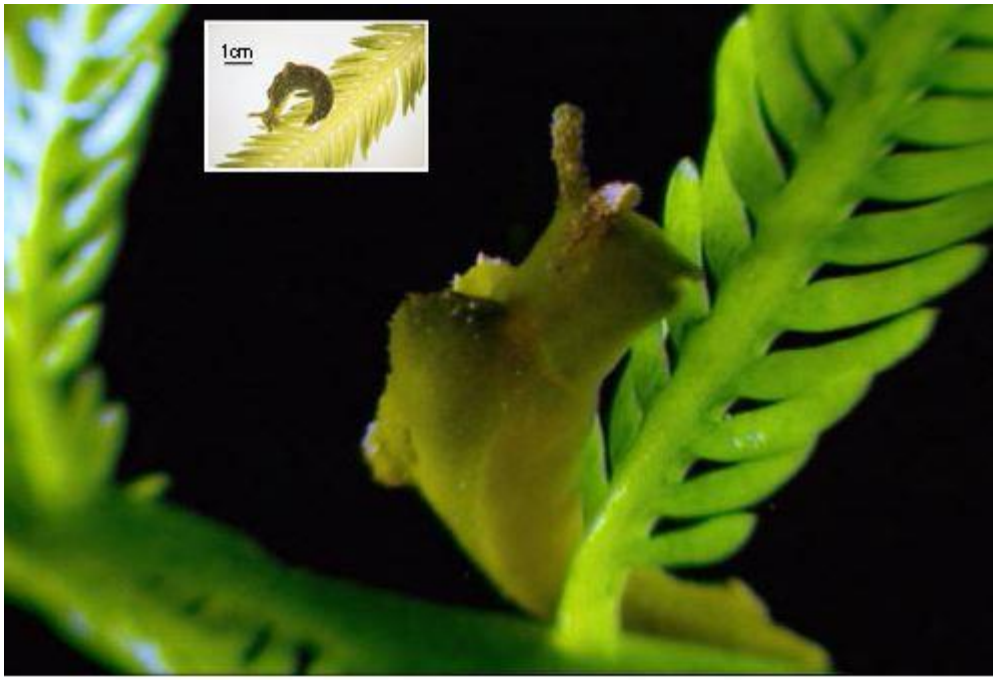
exported worldwide since then

Caulerpa Mitigation Measures

Sea Slugs sucking out *Caulerpa,* use enzyme degrading the toxin



Lobiger serradifalci: Mediterranean



Elysia subornata: Tropic

Caulerpa Mitigation Measures

Table 15.1 Control methods tested to eradicate invasive *Caulerpa taxifolia*

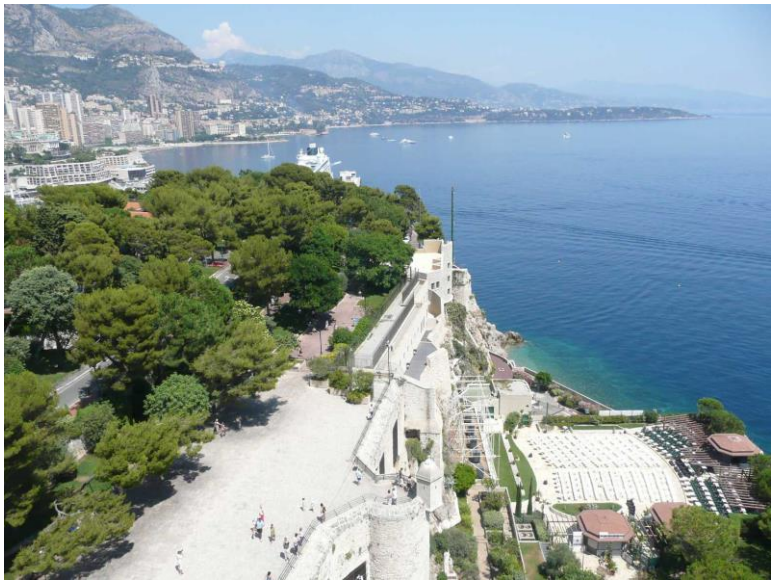
Method	Location	Success?
Manual harvest	Mediterranean, Australia	Not successful due to fragmentation, costs
Suction pumps	Mediterranean, Australia	Not successful due to fragmentation, residual attached biomass
Opaque tarpaulins	USA	Successful when combined with liquid chlorine (tarpaulins not tested alone in USA)
	Mediterranean	Not successful due to damage to tarps
	Australia	Not successful due to damage to tarps, cost for labor, nontarget mortality
Altering salinity	Australia	Successful
Liquid chlorine	USA	Successful
Copper	Mediterranean, USA	Not successful with short exposures as 100% mortality not achieved
Hydrogen peroxide	Mediterranean	Not successful with short exposures as 100% mortality not achieved
Aquatic herbicides	USA	Not successful with short exposures as 100% mortality not achieved
Coarse sea salt	Australia	Successful
Dry ice	Mediterranean	Not successful as 100% mortality not achieved
Heated water	Mediterranean	Not successful as 100% mortality not achieved
Ultrasound	Mediterranean	Not successful as 100% mortality not achieved
Biological control	Mediterranean	Not successful due to limited numbers of native herbivores and government restrictions on nonnative herbivores

(Walters 2009)

BBC: Killer Algae

https://www.youtube.com/watch?v=VLBzLmh5plg

Oceanographic Museum of Monaco



Biological Invasions in Marine Systems

Picture: Karsten Reise, Cartoon: Kochmann et al. 2008

Biological Invasions

Introduction & Establishment of species beyond their historical range

Introduction:

I. Natural range expansion

II. Human introductions

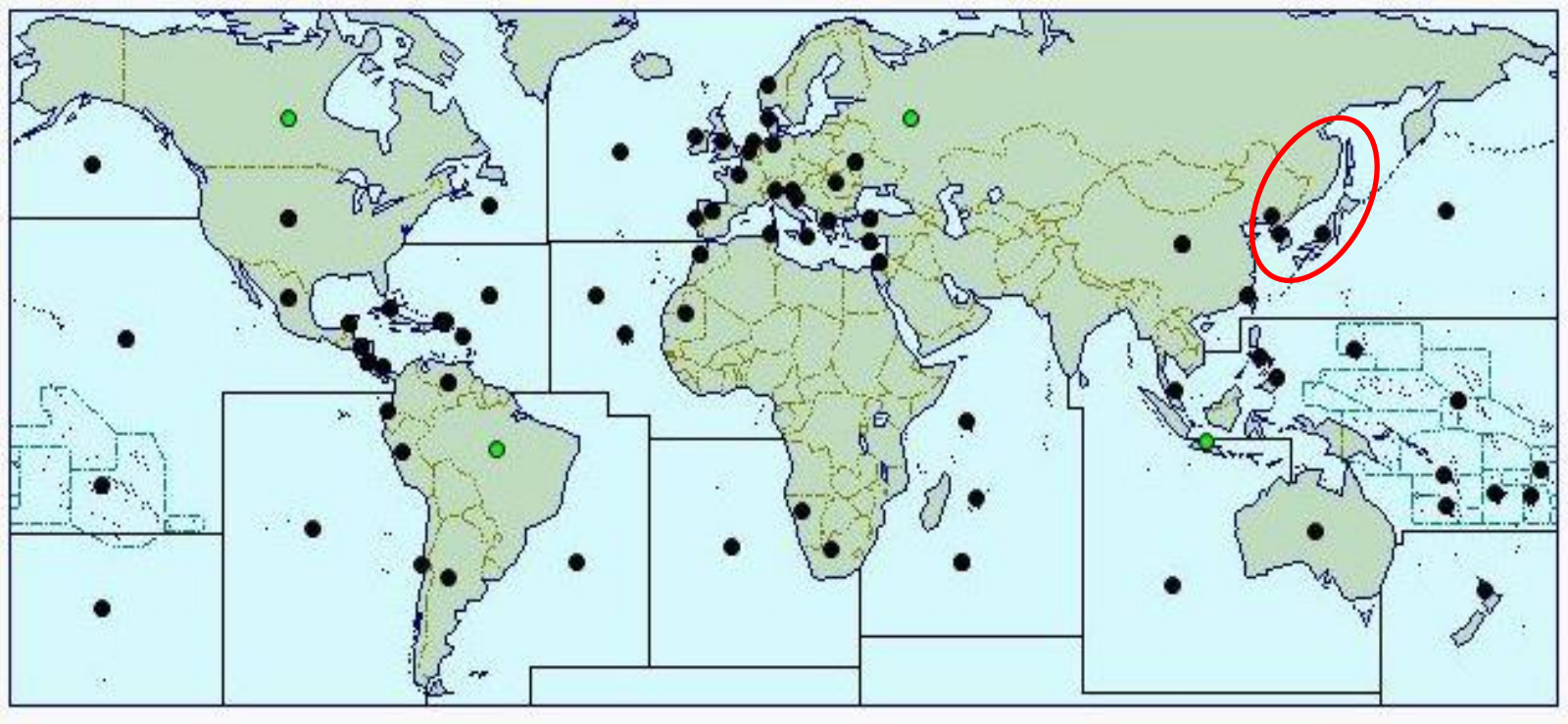
Establishment:

III. Survival

IV. Reproduction

Pacific Oyster ***Crassostrea gigas*** (Thunberg, 1793) Aquaculture

Crassostrea: Global Distribution



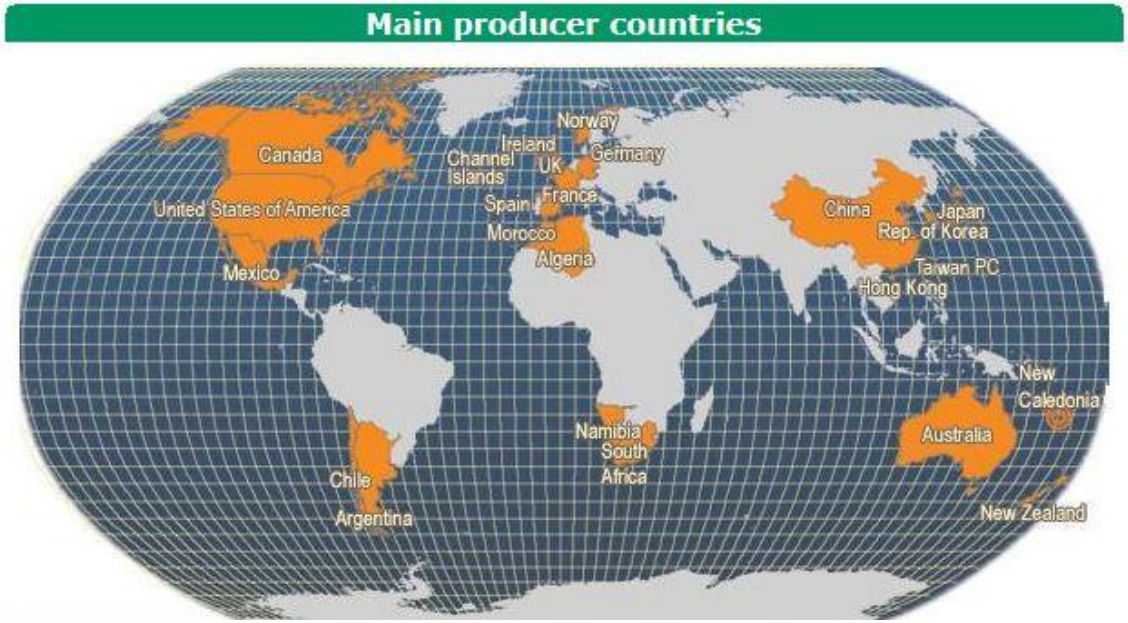
http://www.cabi.org/isc/datasheet/87296

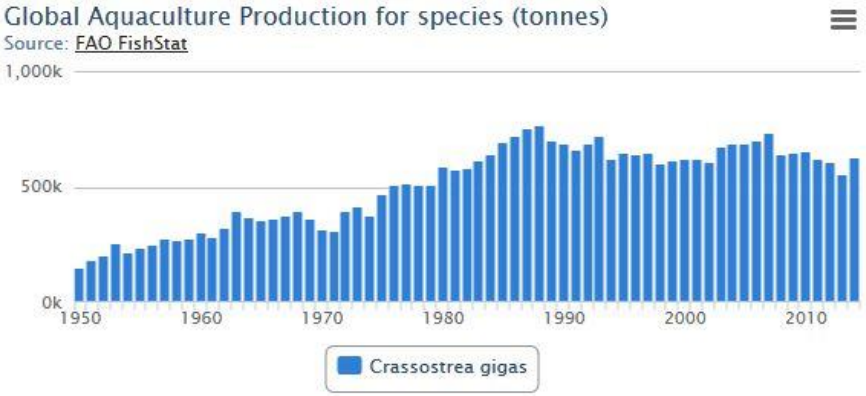
Crassostrea: Native Range

Fig. 3. Native range of the Pacific oyster *C. gigas*.

Troost 2010

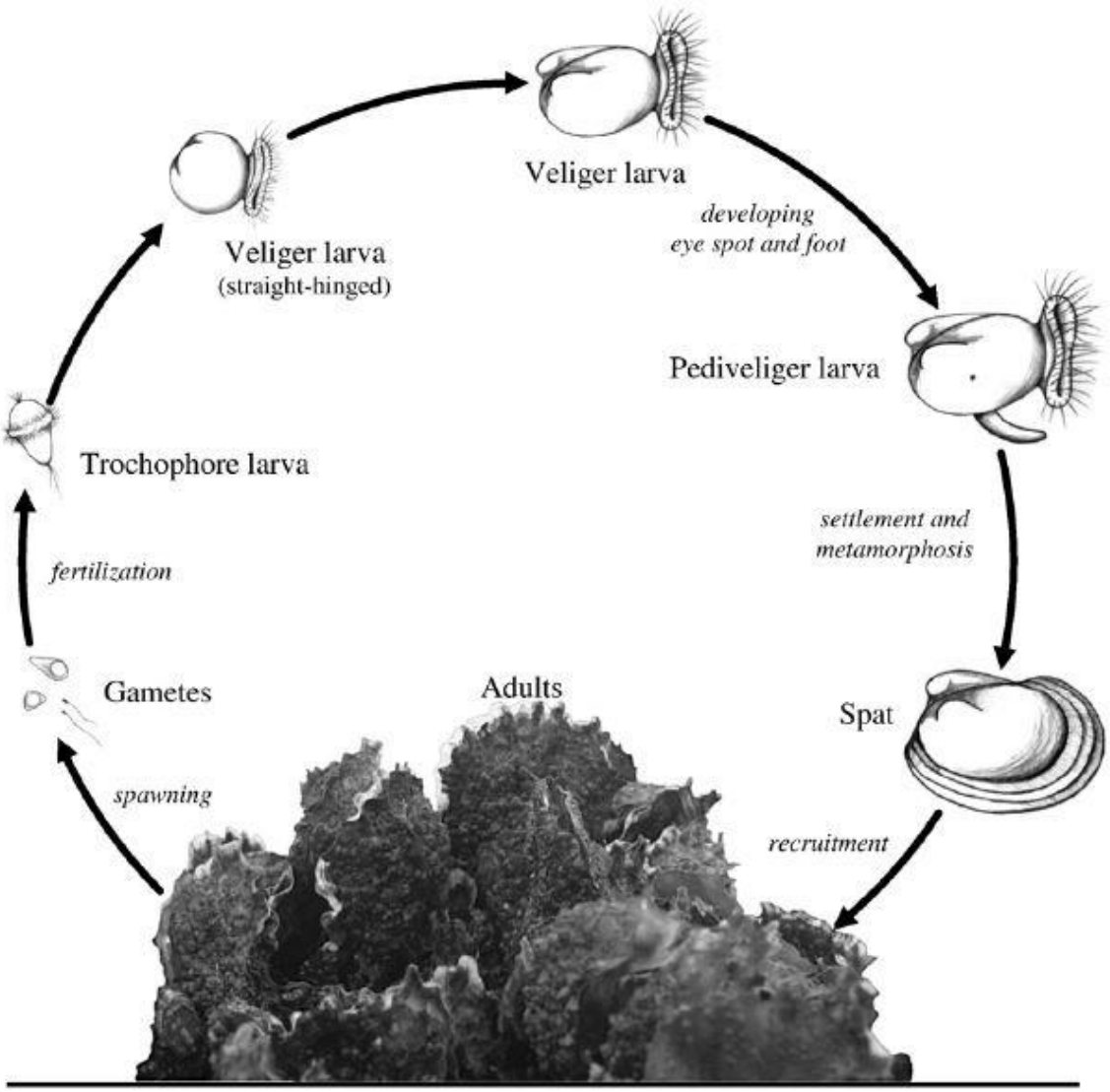
Crassostrea: Global Aquaculture





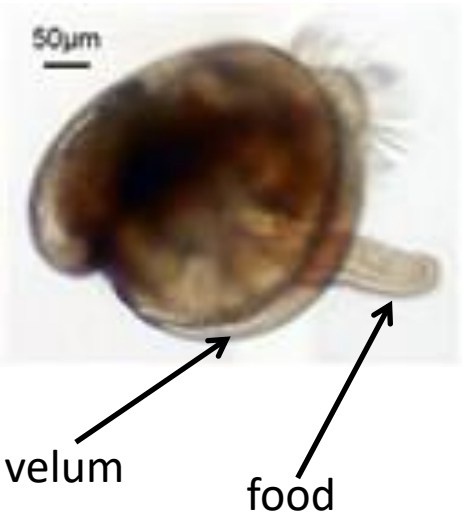
http://www.fao.org/fishery/culturedspecies/Crassostrea_gigas/en

Crassostrea: Life Cycle



Troost 2010

pediveliger



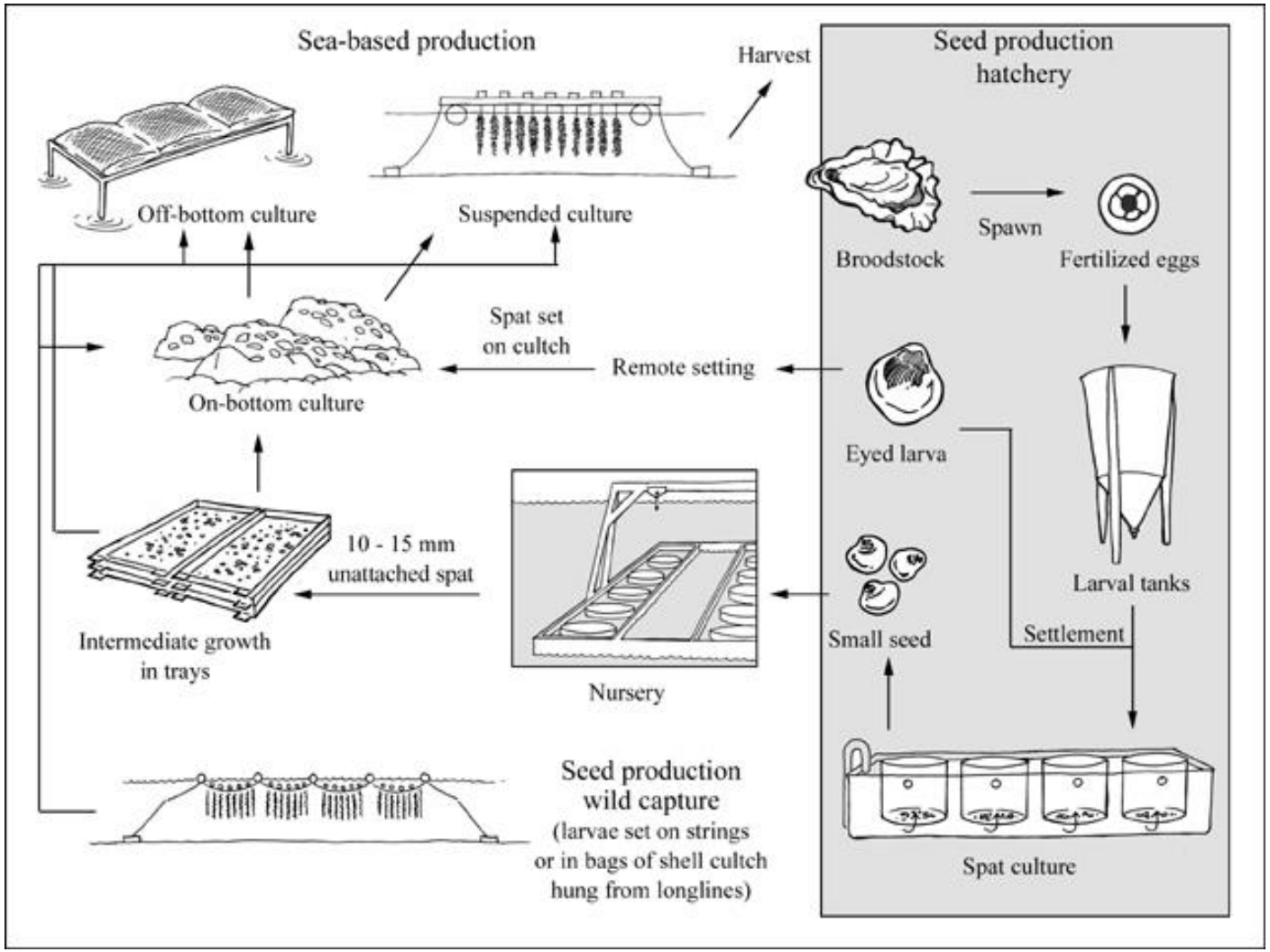
Pediveligers
are attracted by chemical cues of adult oysters (gregarious settlement)

Recruitment: Occurrence of new benthic individuals some time after settlement

Tamburri et al. 2007

Wild Larvae Capture & Adult Collection

Oyster Culture



On- & Off-bottom Culture

→ Multiple introductions, accidental escapes and releases, dispersal…