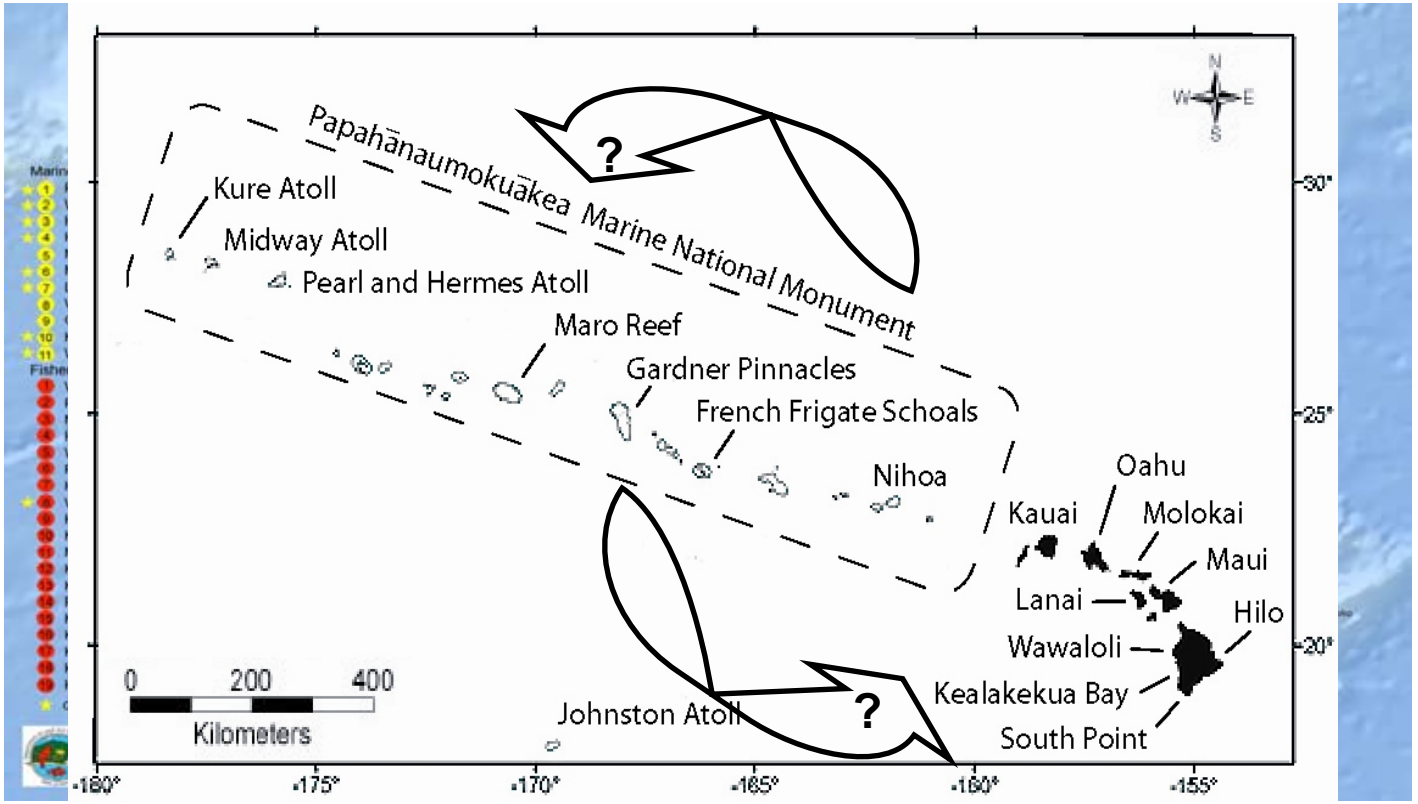
Endemism and dispersal: comparative phylogeography of three surgeonfishes across the Hawaiian Archipelago

Jeff A. Eble, R.J. Toonen, and B.W. Bowen

Hawai'i Institute of Marine Biology

NSF
Hawaii Coral Reef Initiative Research Program
National Marine Sanctuaries
NOAA

Marine Reserves



Goals:

1) Restoration and maintenance of protected populations
2) Mitigate impacts on unprotected populations

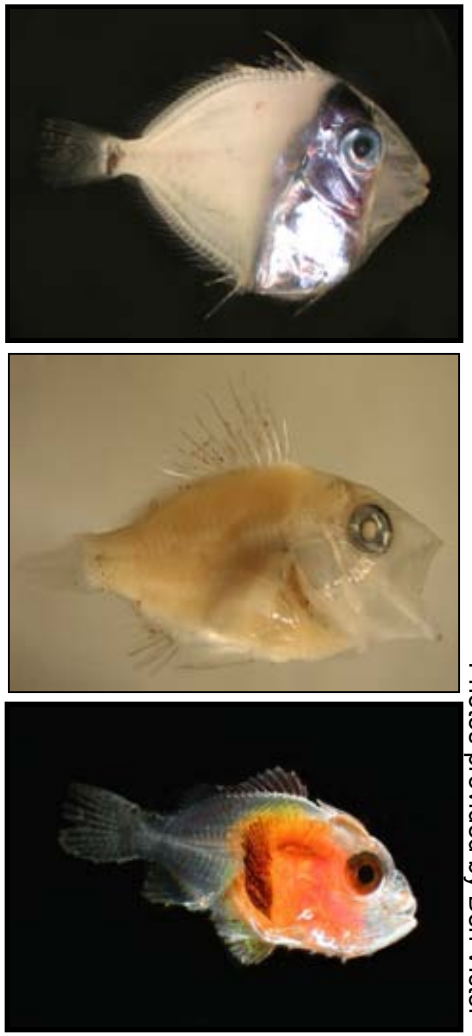
Marine population connectivity

Most marine species:

- Exhibit relatively sedentary adult phase and potentially dispersive larval phase
- Planktonic larval duration (PLD) of 30 to 60 days common
- Direct tracking of larvae not possible

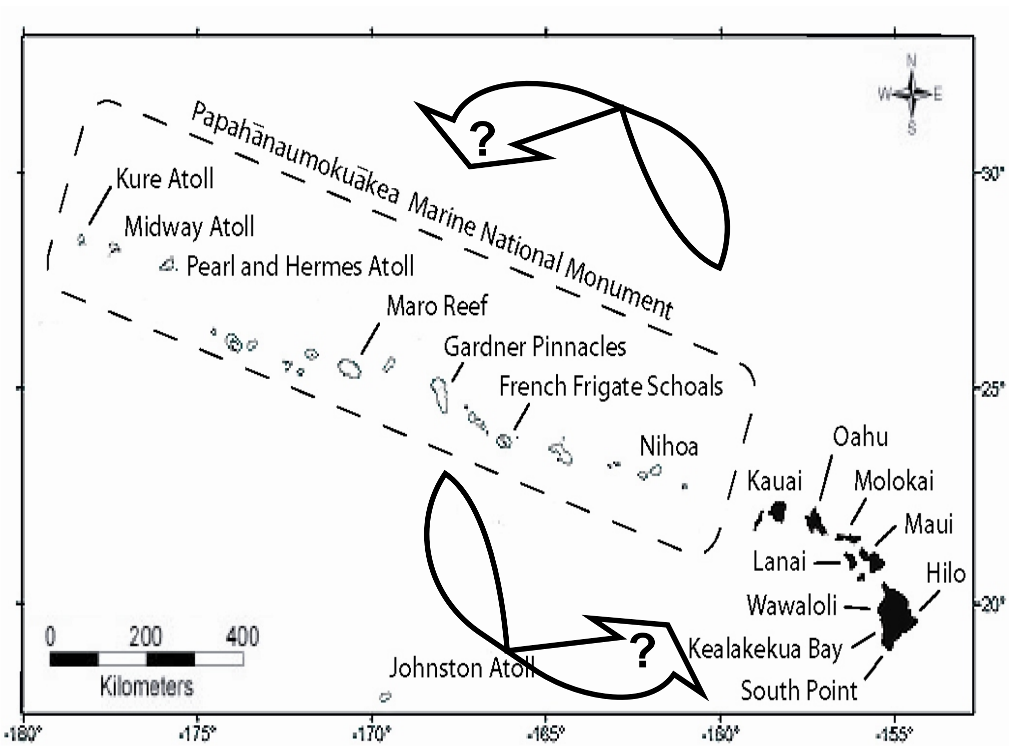
Estimating dispersal

- Otolith microchemistry
- Population genetics
- Multi-species surveys are expensive and labor intensive



Photos provided by Ben Victor

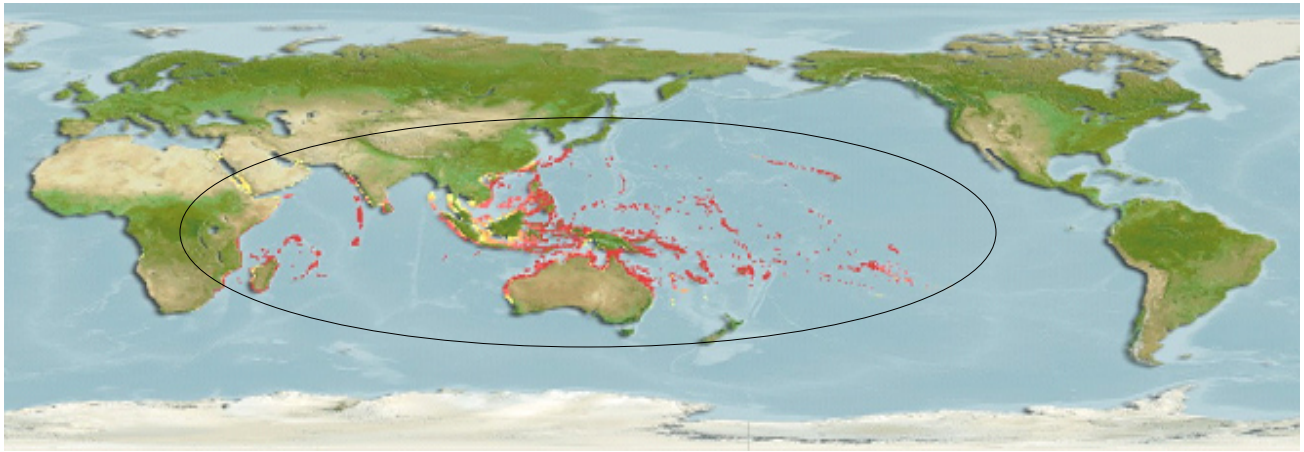
Ecosystem level processes



Planktonic larval duration (PLD) as dispersal proxy? (Weersing and Toonen submitted)

Good correlation	Poor or no correlation
Taylor and Hellberg (2003)	Teske *et al.* (2007) Mar. Biol.
Bohonak (1999) Quar. Rev. of Biol.	Nishikawa and Sakai (2005) Zool. Sci.
Zatcoff *et al.*(2005) Mar. Biol.	Ayre *et al. (*1997) Mar. Biol.
Murray-Jones & Ayre (1997) Mar. Biol.	Rocha *et al.(*2005) Proc. Roy. Soc. Lon. B
Waples (1987) Evolution	Severance and Karl (2006) Mar. Biol.
Lacson & Morizot (1991) Mar. Biol.	Bowen *et al. (*2006) Mar. Biol
Planes et al. (1996) J. Evol. Biol.	Goldson et al. (2001) Mar. Biol.
Duffy (1993) Mar. Biol.	Borsa & Benzie (1996) Mar. Biol.
Staton *et al.*(2000) J. Crust. Biol.	Benzie & Williams (1997) Evolution
Doherty et al. (1995) Ecology	Shulman (1998) Aust. J. Ecol.
Hellberg (1994) Evolution	Planes (1993) Mar. Ecol. Prog. Ser.
McMillan-Jackson et al. (1994) Mar. Biol.	Gaarde & McClenaghan (1982) SW. Nat
Addison and Hart (2004) Mar. Biol.	Janson (1987) Bio. J. Linn. Soc.
Hellberg (1996) Evolution	Hunt & Ayre (1989) Mar. Biol.
Todd *et al.* (1998) J. Exp. Mar. Biol. Ecol.	Sole-Cava et al. (1994) J. Mar. Biol. Ass.

Biogeographic range as dispersal proxy?

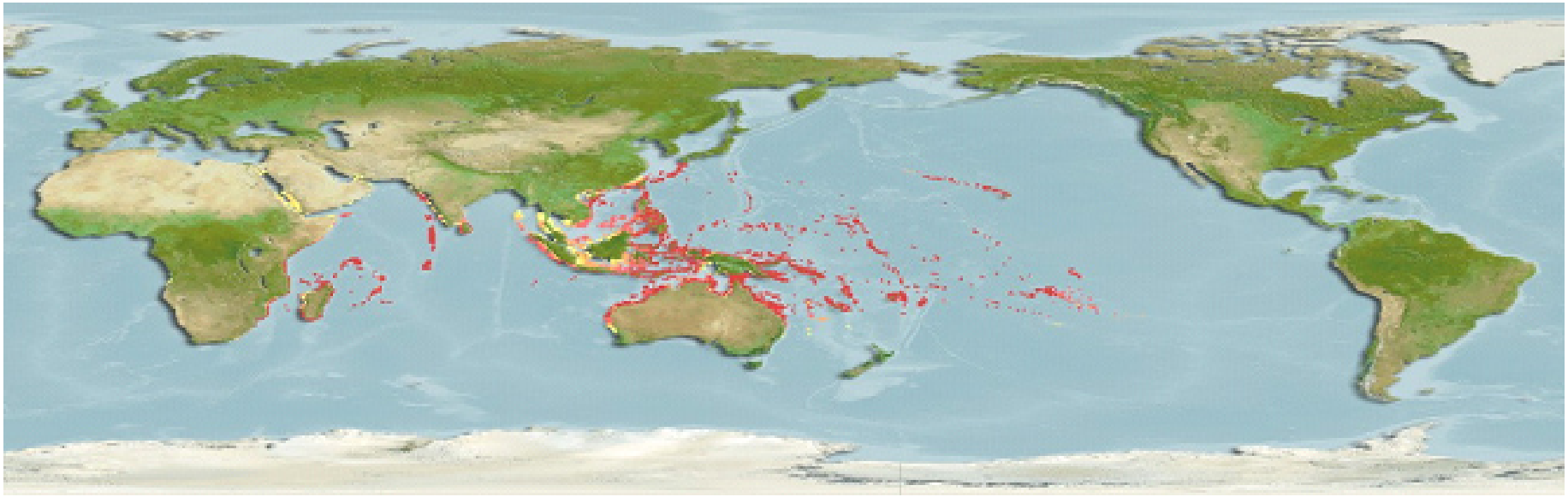


Biogeographic range

Product of multiple behavioral and life-history traits

- Habitat specificity
- Environmental tolerance
- Fecundity
- Generation time
- Larval duration
- Larval behavior

Does range size predict species dispersal ability?



Range / dispersal hypothesis

Acanthurus nigrofuscus
(brown surgeonfish)

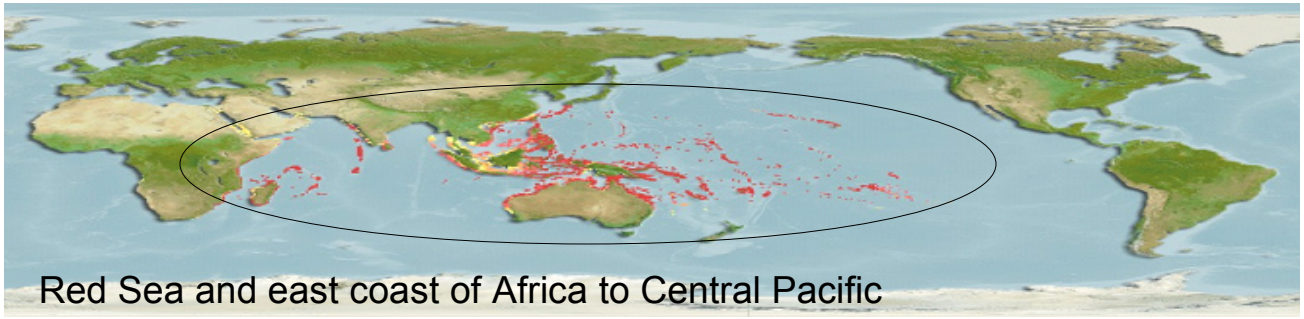
Zebrasoma flavescens
(yellow tang)

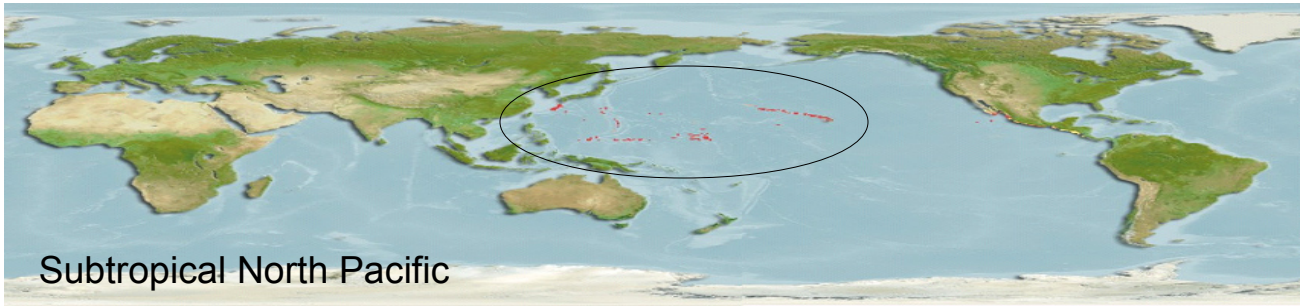
Ctenochaetus strigosus
(goldring surgeonfish)

All three species share:

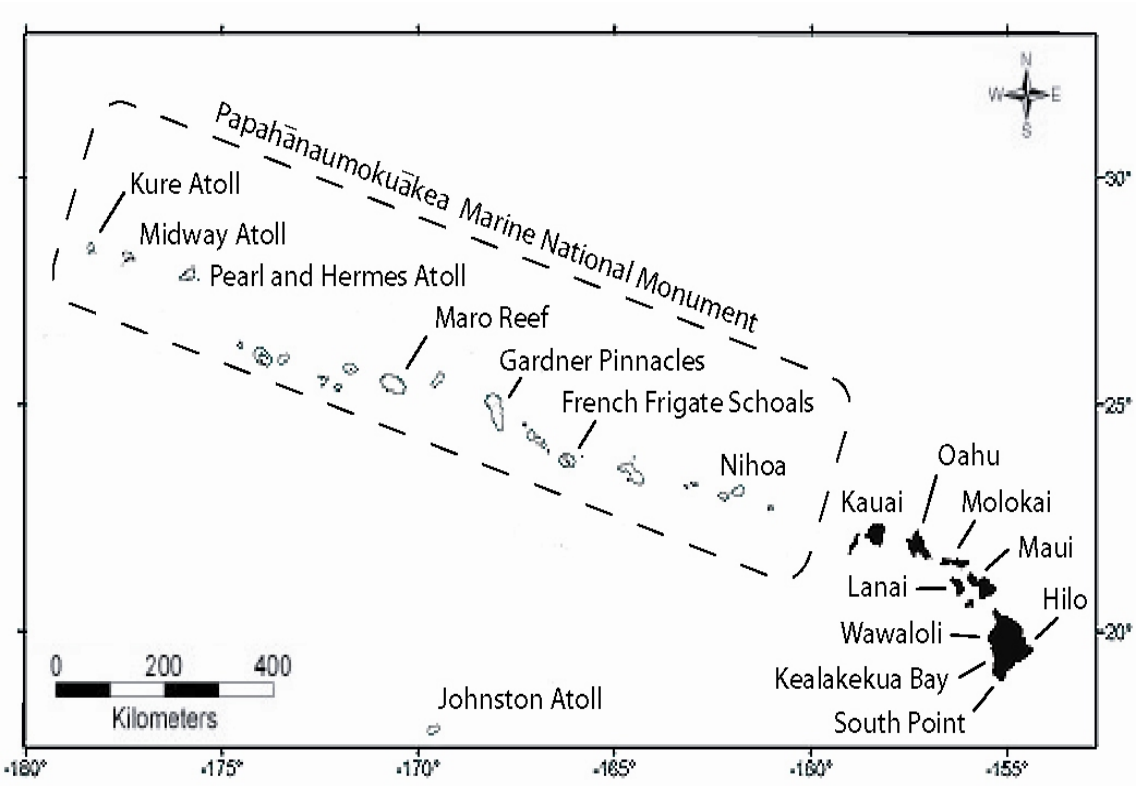
- Habitat preference (Randall 2007)
- Local abundance (Walsh 1987; DeMartini and Friedlander 2004)
- Timing and periodicity of spawning and recruitment (Walsh 1987)
- Estimated PLD of 55 – 60 days (Doherty et al. 1995; Fisher 2005; D. Schaffer pers. comm.)

Range / dispersal hypothesis





Sampling / genetic analysis



N ≈ 400 – 500 samples / species

n ≈ 30 sample / site

mtDNA sequencing: 620bp fragment of cytochrome *b*

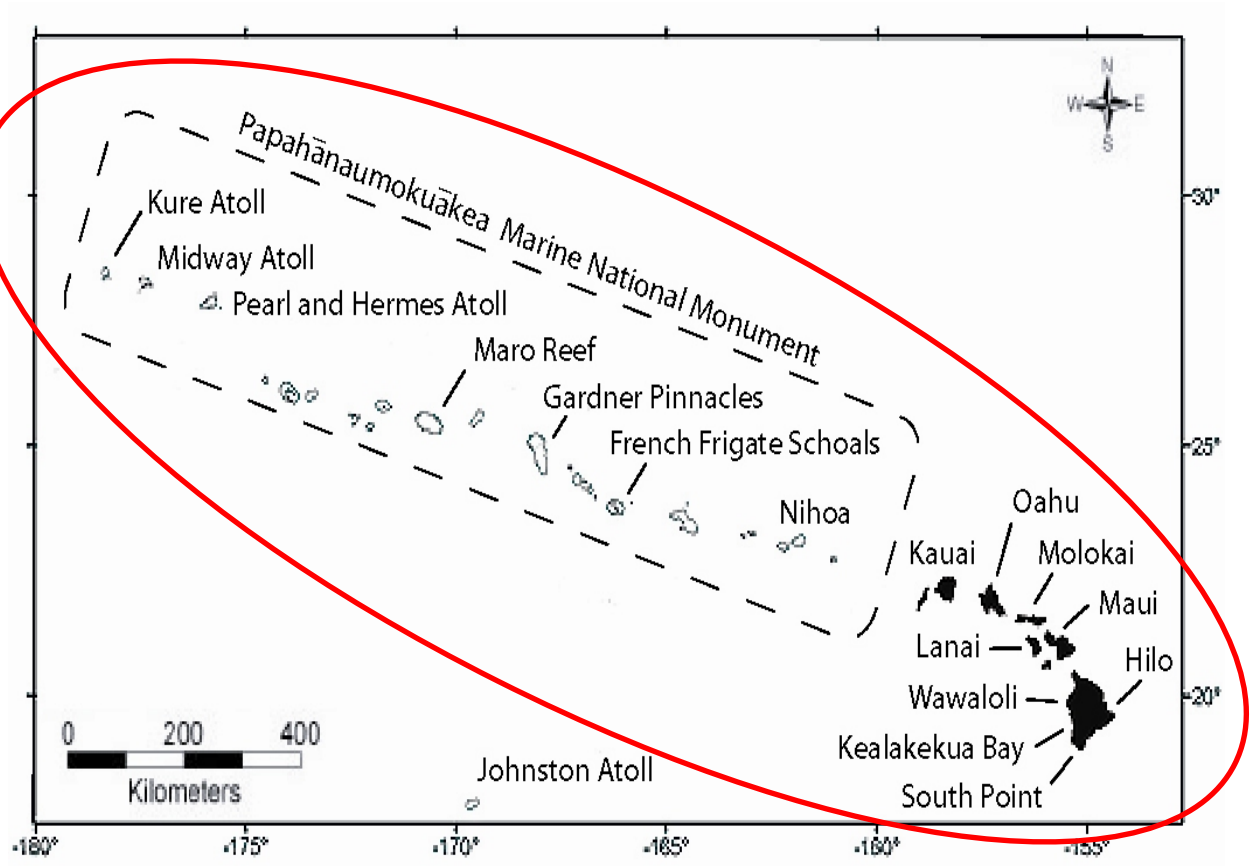
Population structure: Indo-Pacific spp.

Φ_{st} = NS

Avg. pairwise Φ_{st} = -0.004

Φ_{st} = NS

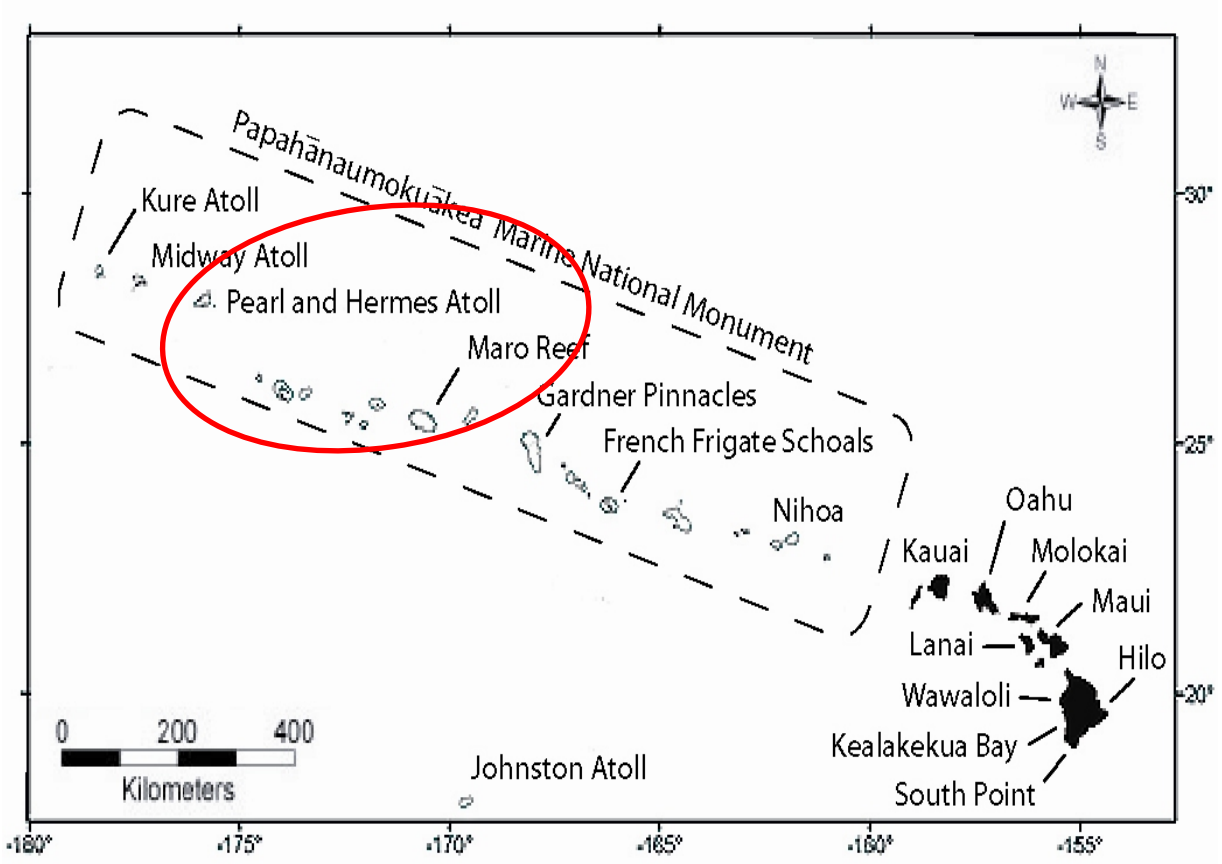
Avg. pairwise Φ_{st} = 0.001



Population structure: Hawaiian endemic

Φ_{st} = 0.04 P = 0.008

Avg. pairwise Φ_{st} = 0.003



Hawaiian endemics vs. wide ranging spp.

Indo-Pacific
= high connectivity

Hawaiian endemic
= reduced dispersal

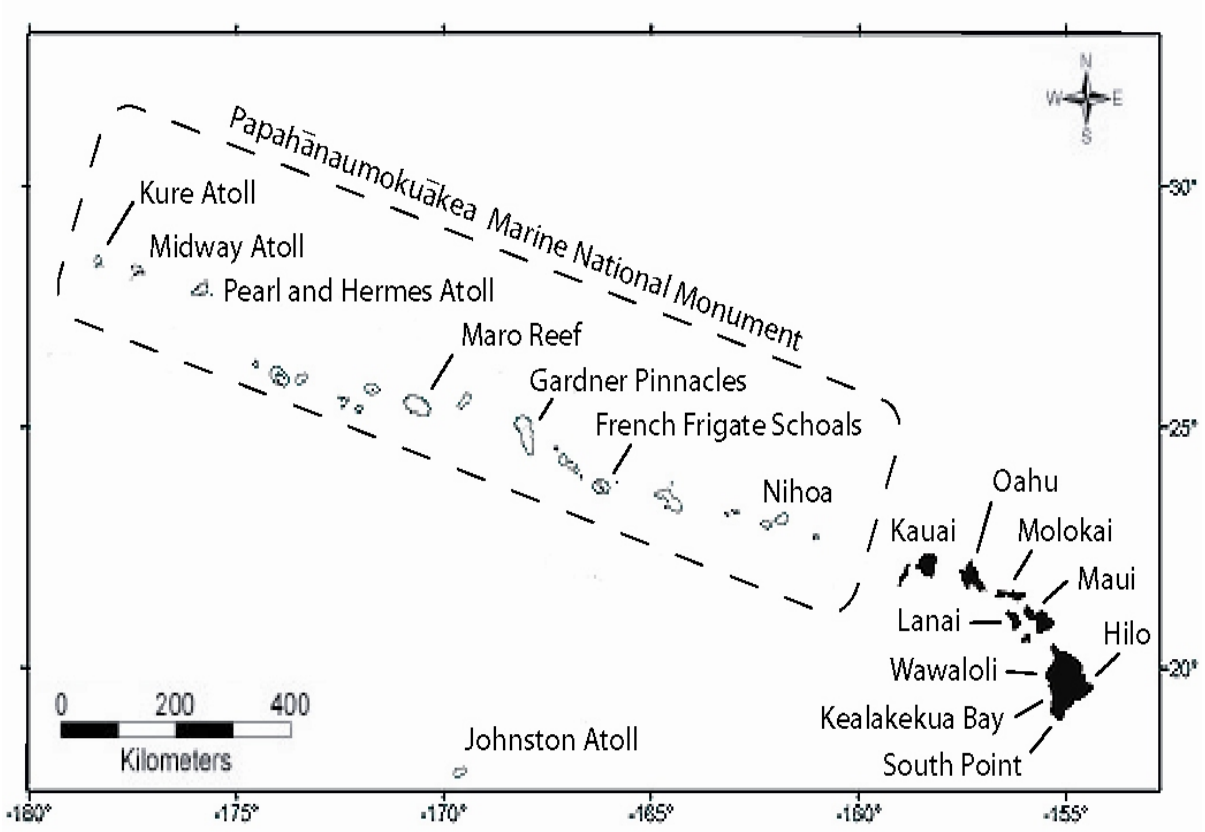
Hawaiian endemics exhibit lower dispersal relative to Indo-Pacific spp.

25% Hawaiian reef fish endemism

(Randall 2007)

Endemic reef fish = poor dispersers

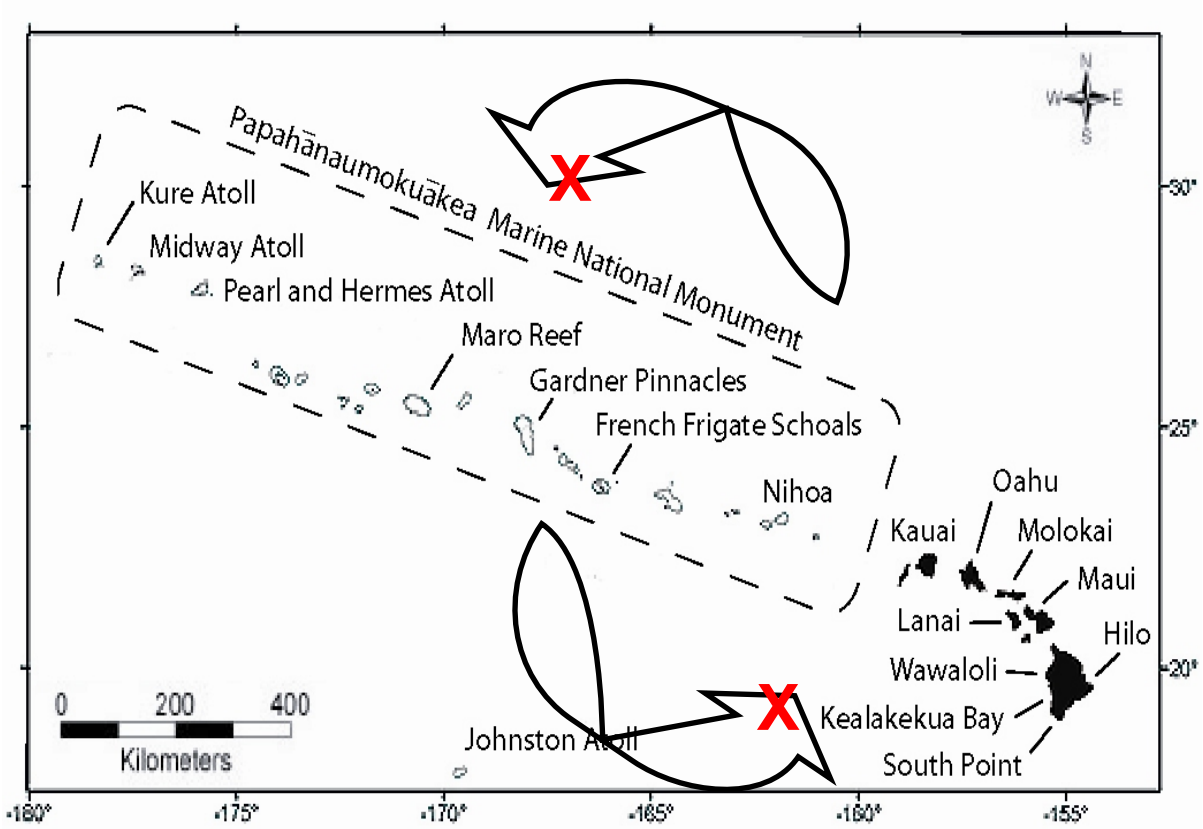
(Hourigan and Reese 1987)



Management implications

Endemic reef fish = poor dispersers

(Hourigan and Reese 1987, Eble et al. submitted)



Acknowledgements

Funding

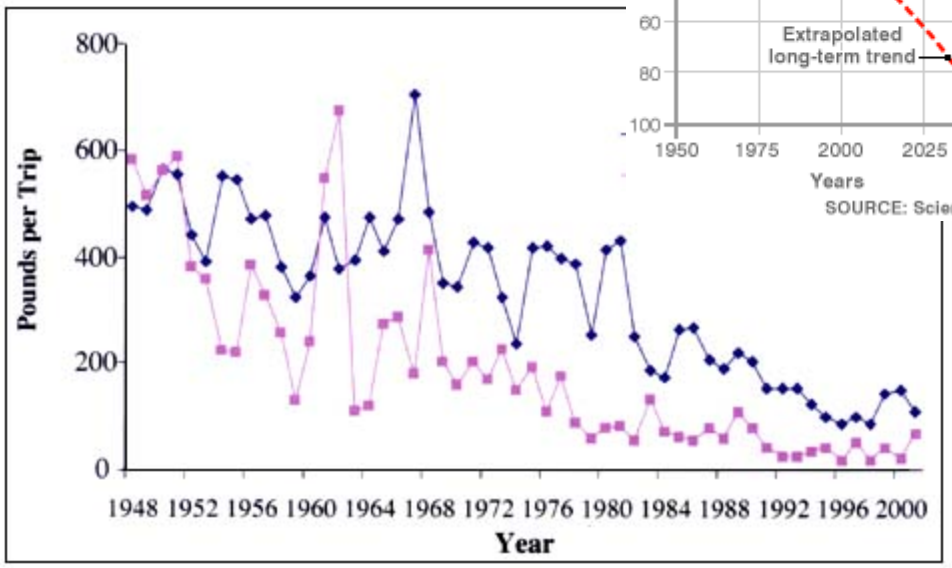
- NSF (OCE 0454873)
- Hawai'i Coral Reef Initiative Research Program (#NA05NOS4261157)
- HIMB-NWHI Coral Reef Research Partnership (NMSP MOA 2005-008/66882)
- University of Hawaii Pacific Cooperative Studies Unit
- University of Hawai'i Graduate Student Organization
- University of Hawai'i EECB Research Grant (DGE05-38550)
- Watson T. Yoshimoto Scholarship

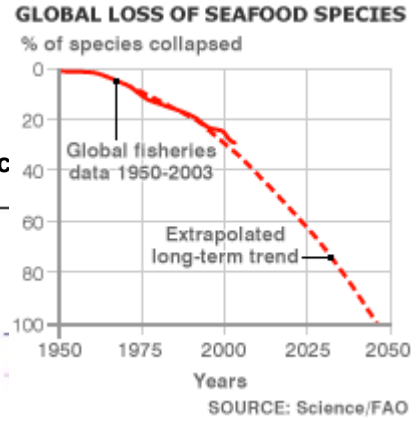
Sample collection/lab assistance

- Hawai'i Division of Aquatic Resources
- US Fish and Wildlife Service
- Crew of the NOAA RV Hi'ialakai
- Toby Daly-Engel, Laurie Sorenson, Craig Musberger, Darla White, Michelle Gaither, Greg Concepcion, Matt Iacchi, Randy Kosaki, Carl Meyer, Yannis Papastamatiou, Matt Craig, Luiz Rocha, Bill Walsh, Brent Carmon, Steve Cotton and Jeremy Claisse

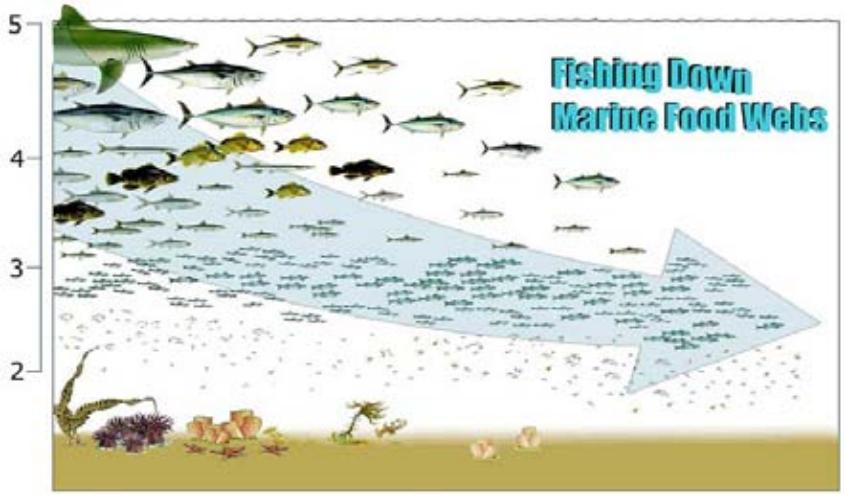
Photo credits: Keoki Stender and others

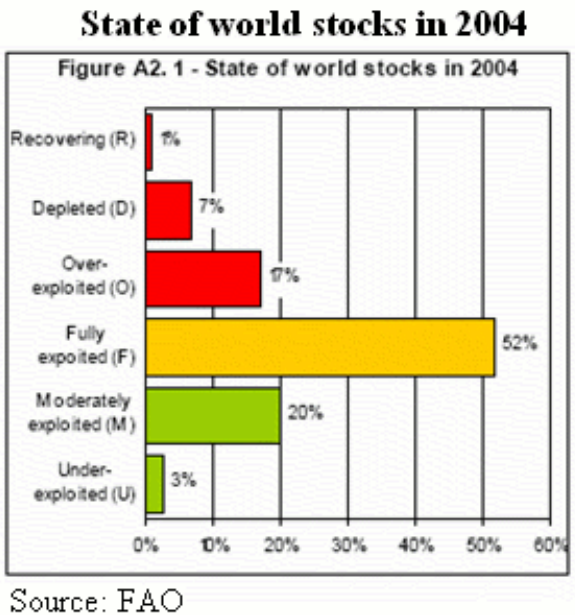
MHI onaga (E. coruscans) mean weight and perc





Fisheries declines?





Source: FAO