Dispersal of fish larvae and connectivity of populations

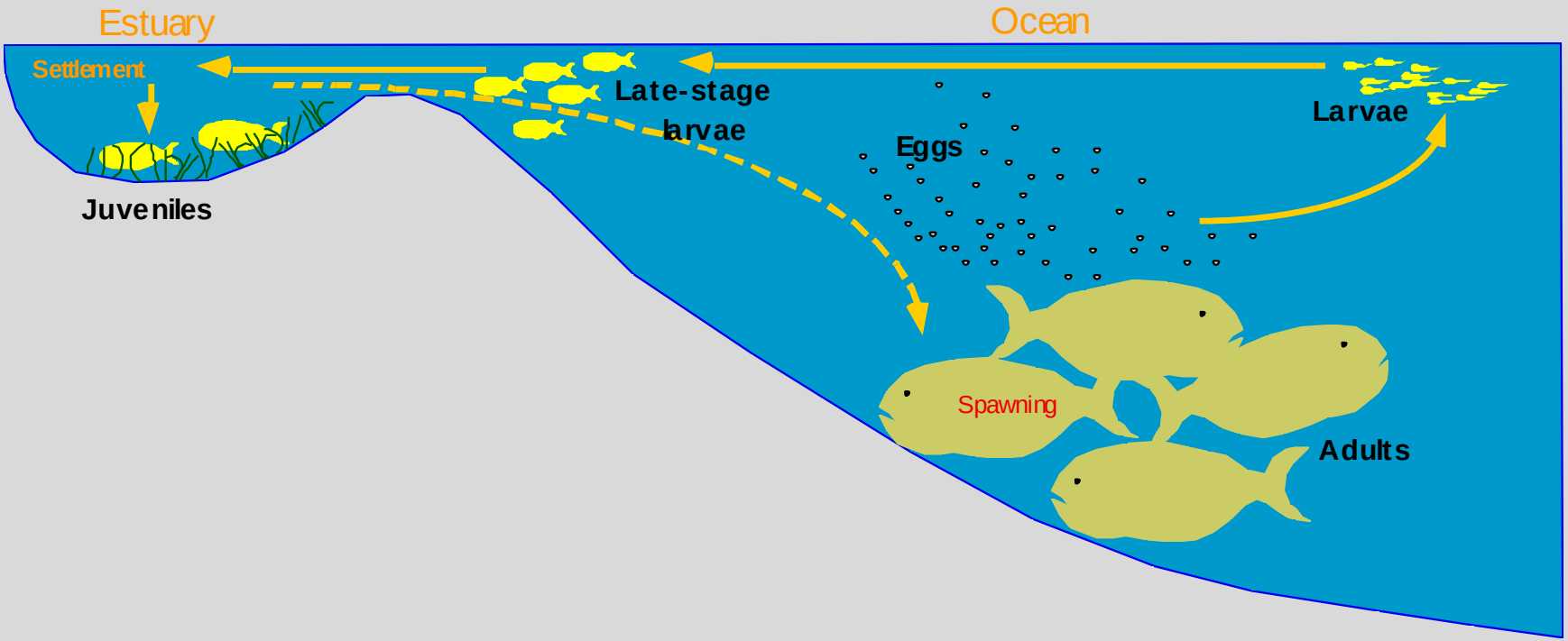
Tom Trnski, Head of Natural Sciences

29 July 2014

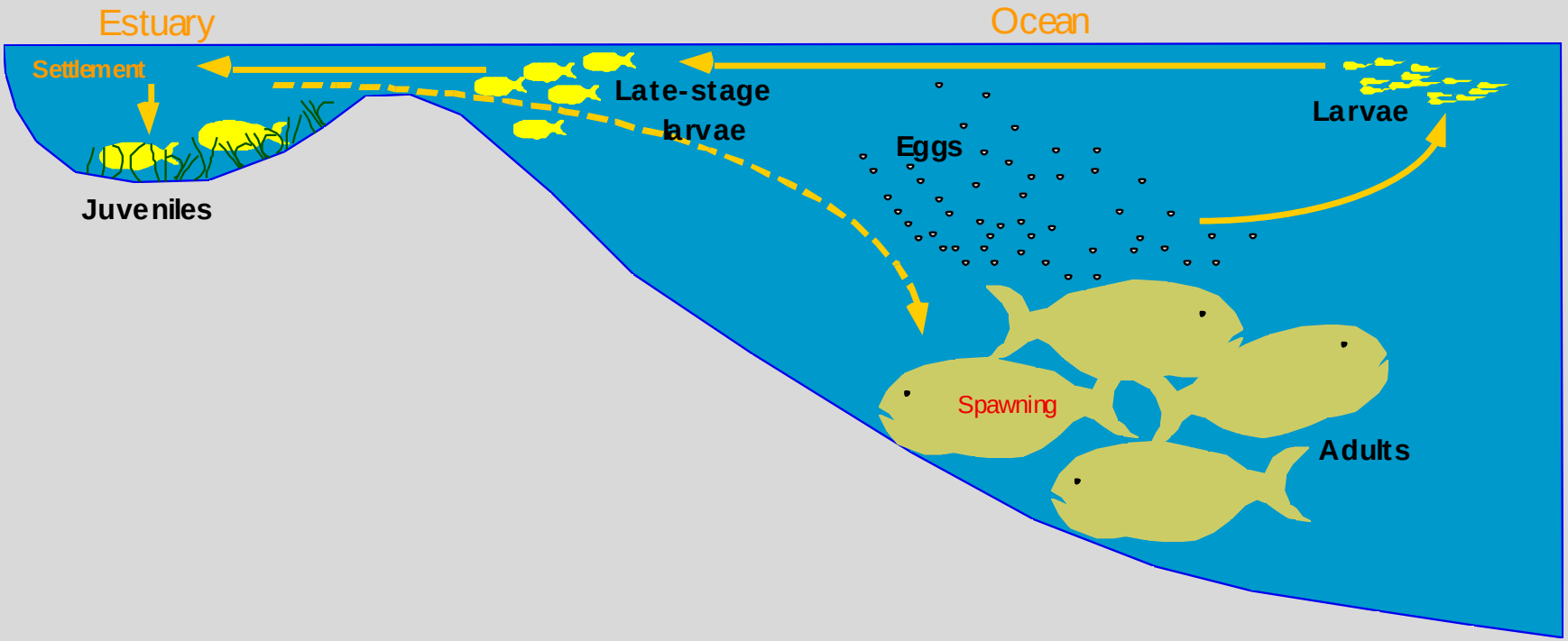

Image: wix.com

Image: Shutterstock / kerenby

Marine life history

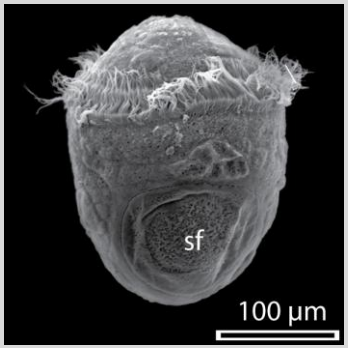


Marine life history



Dispersal phase is during egg and larval stage

Types of larvae



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FAUNA MALESIANA HANDBOOKS

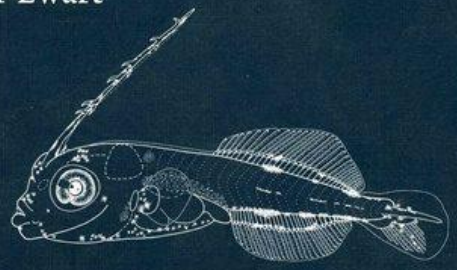
The larvae of Indo-Pacific coastal fishes

An identification guide to marine fish larvae

Edited by

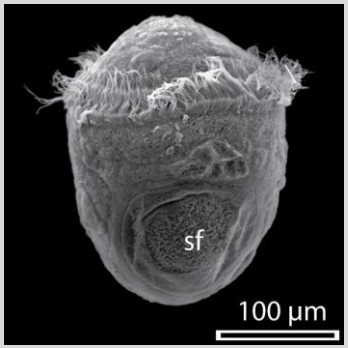
Jeffrey M. Leis

Brooke M. Carson-Ewart



BRILL

Dispersal distance



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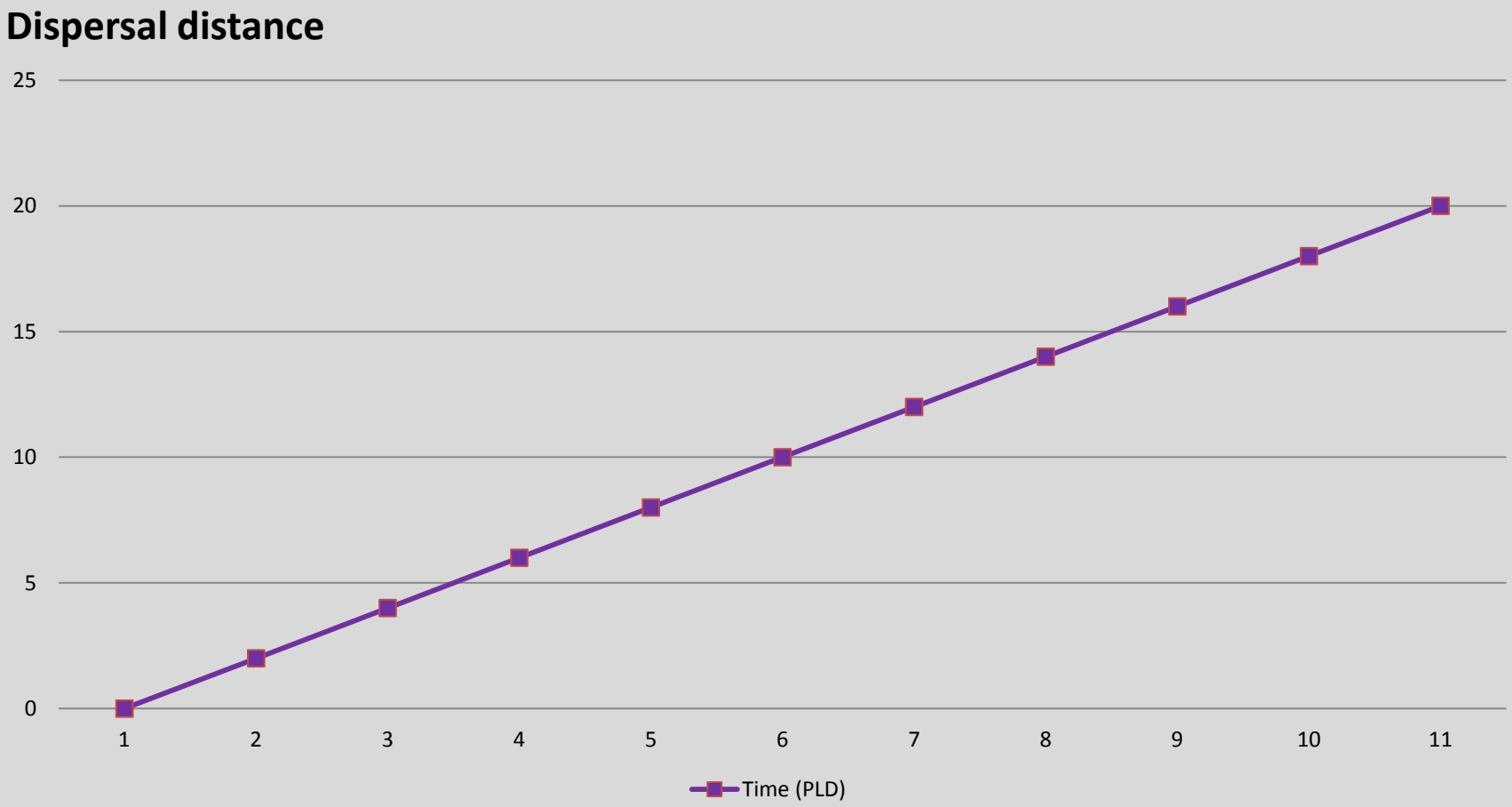
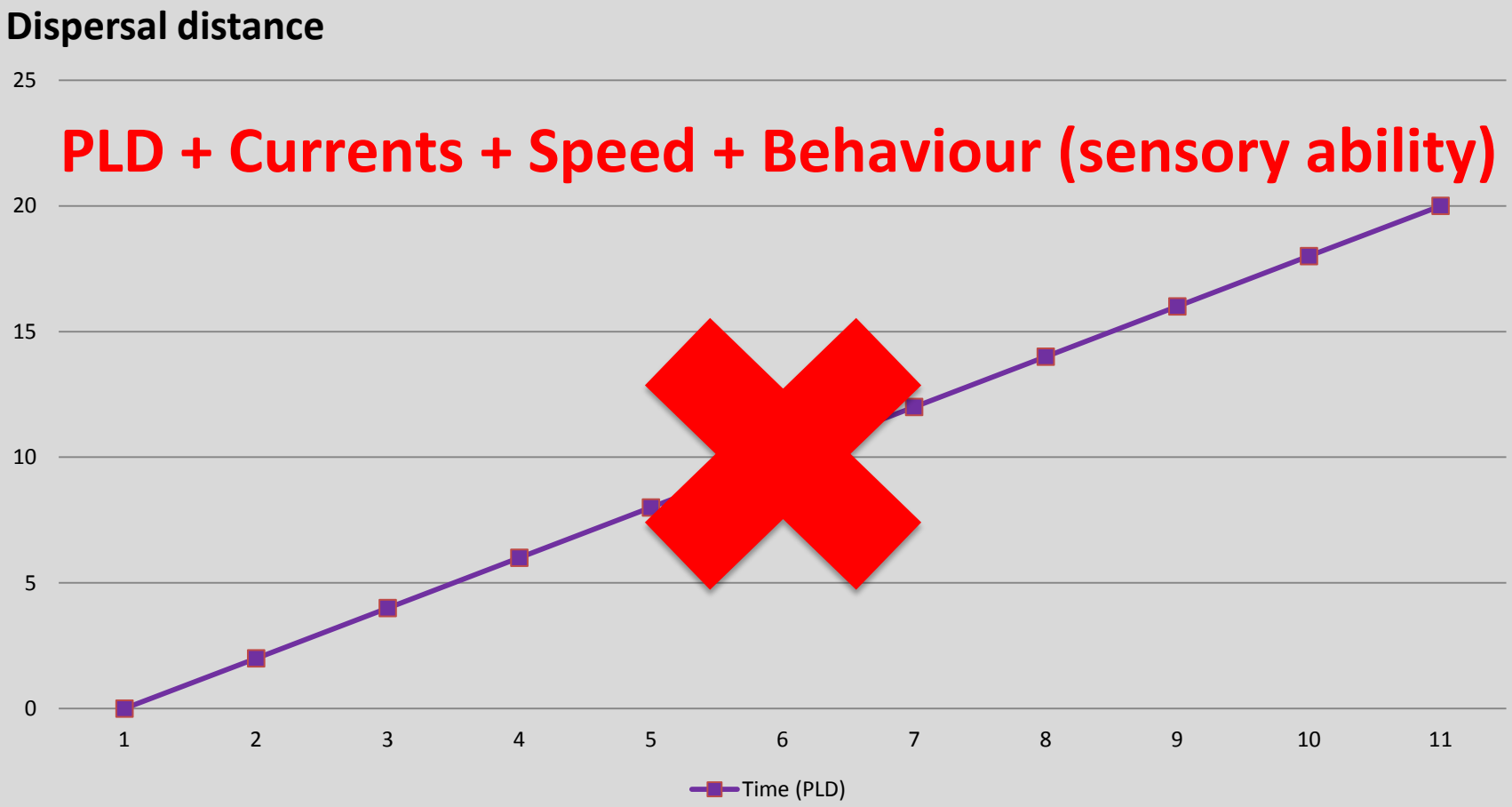
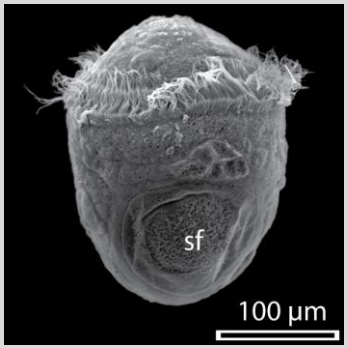


Dispersal distance



Swimming ability



- Limited swimming speed
- Vertical migrations – affects entrainment or broadcast dispersal

Swimming ability

Late larvae can sustain swimming for days at several BL/s

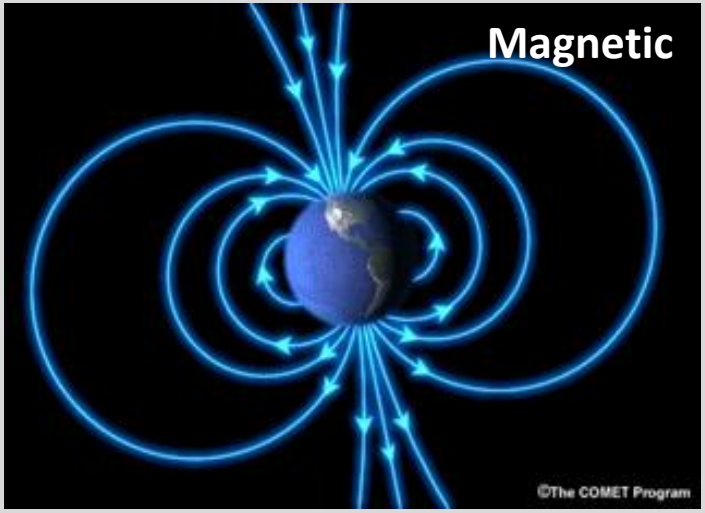
Species	Speed	24 hour distance
Snapper	8-14 cm/s	6.9-12.1 km
Lobster	8-10 cm/s	6.9-8.6 km
Mussel	<1 cm/s	< 860 m

Larval sensory systems

10 m
Early

100 m
Mid

100 km
Late?

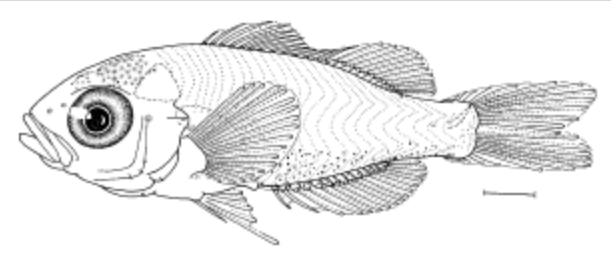


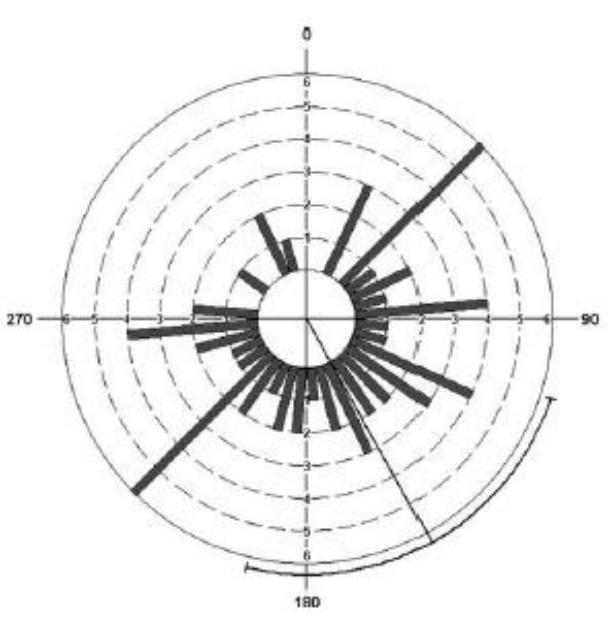
1000 m
Mid-Late

Larval responses to environment

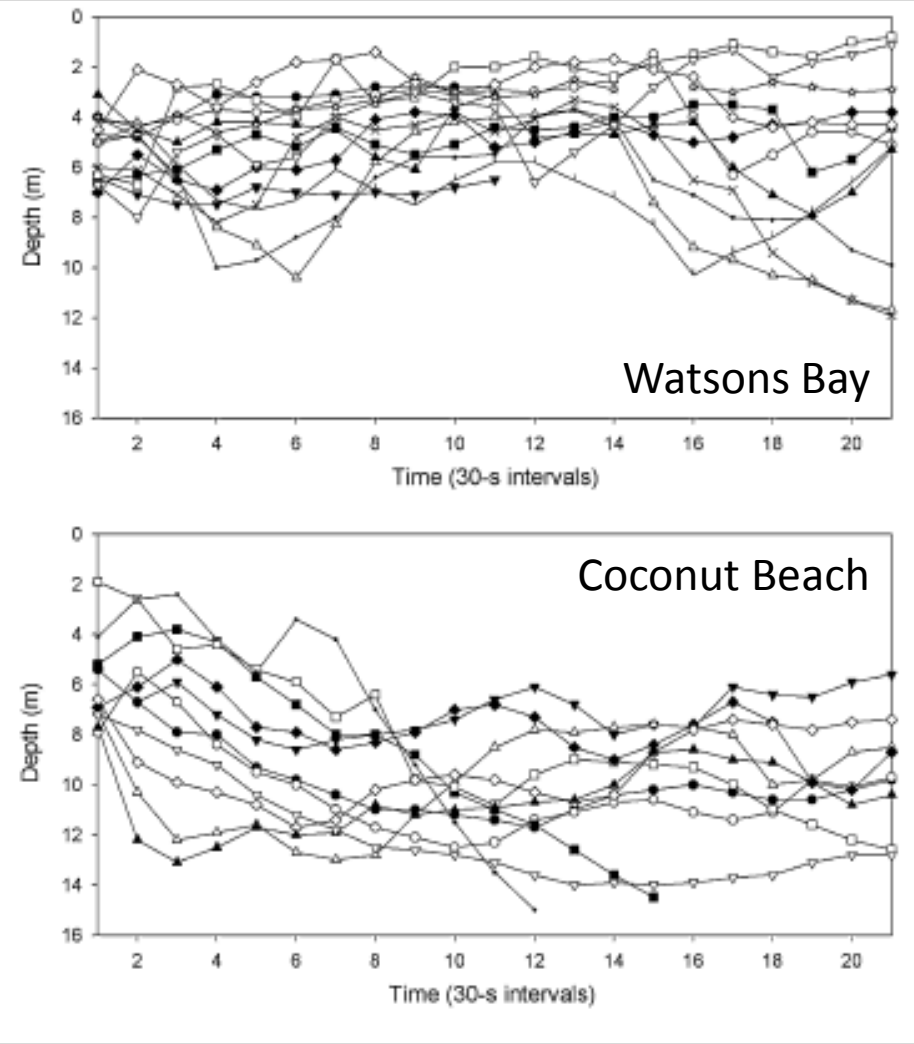
Sensory cue	Species	Response	Reference
Chemical	Cardinalfish (settlement stage)	Select coral reef lagoon water over ocean water	Atema *et al* 2002 MEPS 241
Chemical	Anenomefish (settlement stage)	Select water with mangrove leaves or anenome water over ocean water	Dixson et al 2008 Proc. Roy Soc B 275
Mixed	Snapper	60-95% of adults originated from local estuary (within 60 km)	Gillanders 2002 MEPS 240 Hamer et al 2005 Can J Fish Aq Sci 62
Chemical	Snapper (settlement stage)	Prefer water from seagrass and date mussel beds than artificial or ocean water	Radford *et al* 2012 Mar Freshw Res 63
Sound	Coastal crabs	Orient to reef sounds during ¼ and ¾ moon on neap tides	Jeffs *et al* 2003 Mar Freshw Res 54
Chemical	Green lipped mussel	Algal chemicals enhance settlement	Alfaro et al 2006 Aquaculture Int 14

Depth and direction

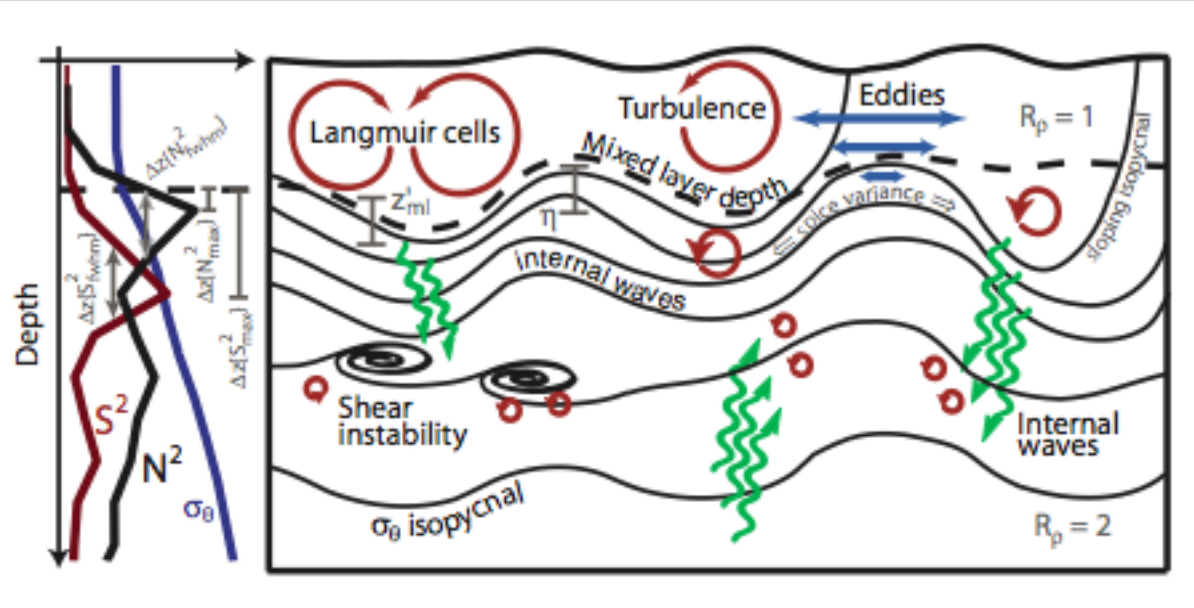


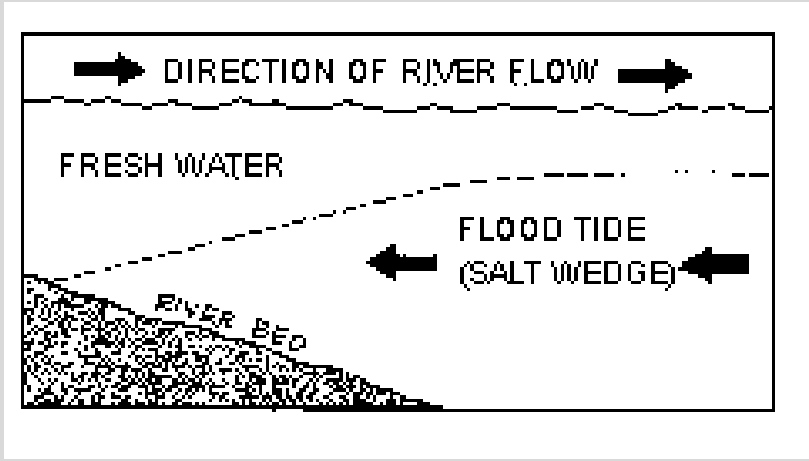


Leis et al 2007 Mar Biol

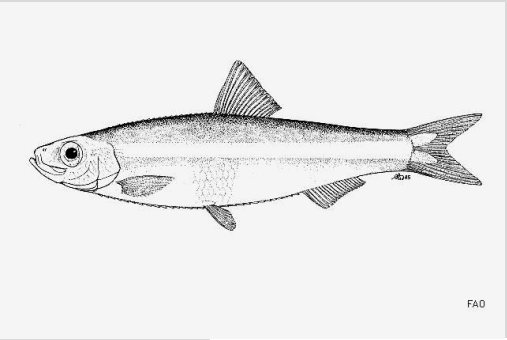


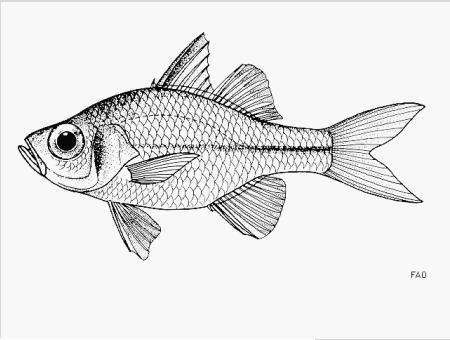
Physical interaction

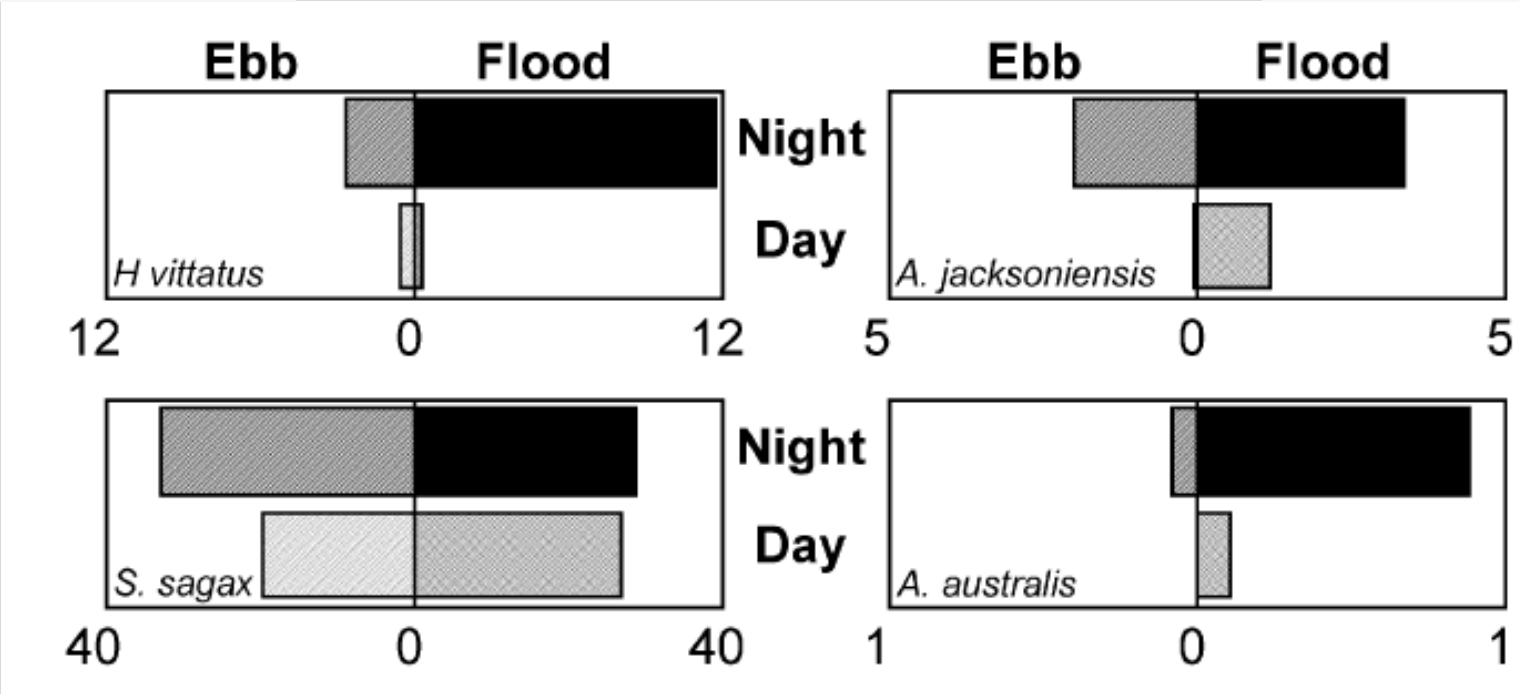


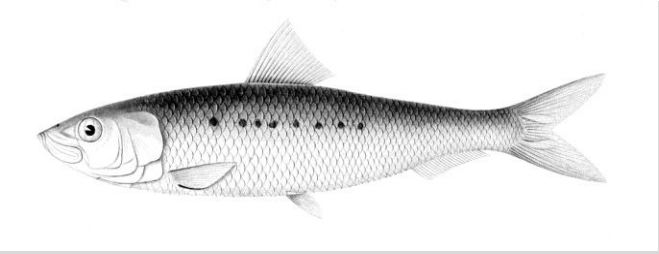


Flow selection





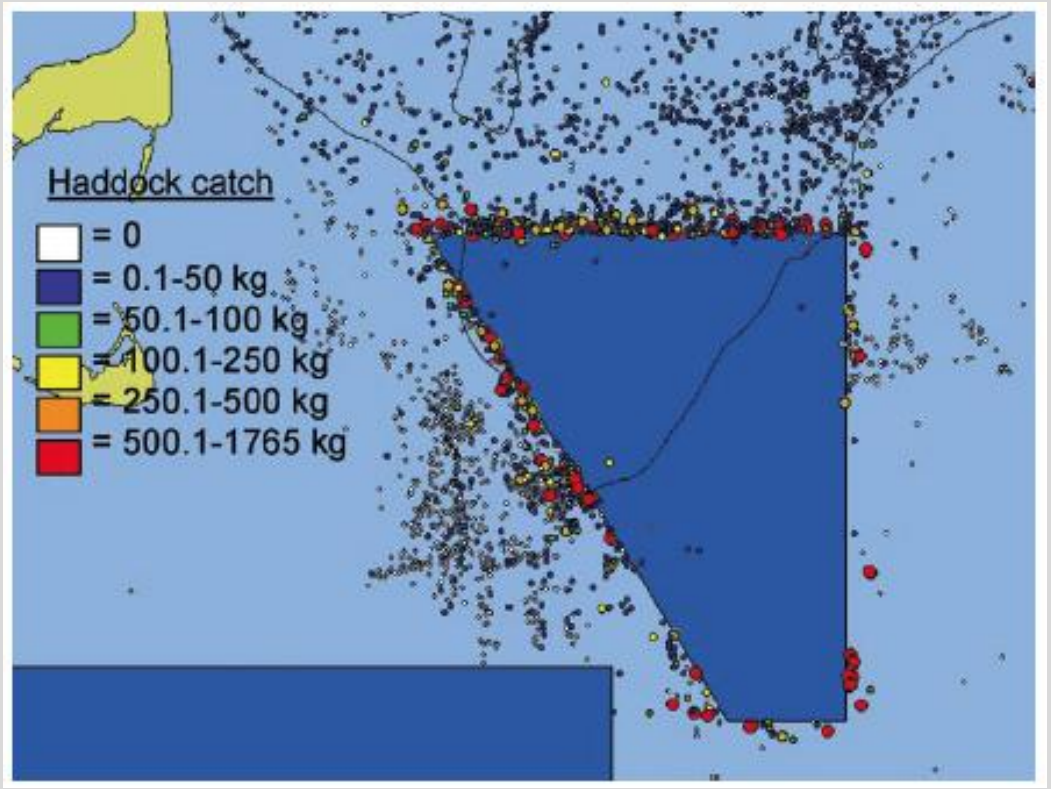




Trnski 2001 Marine Freshw Res 52

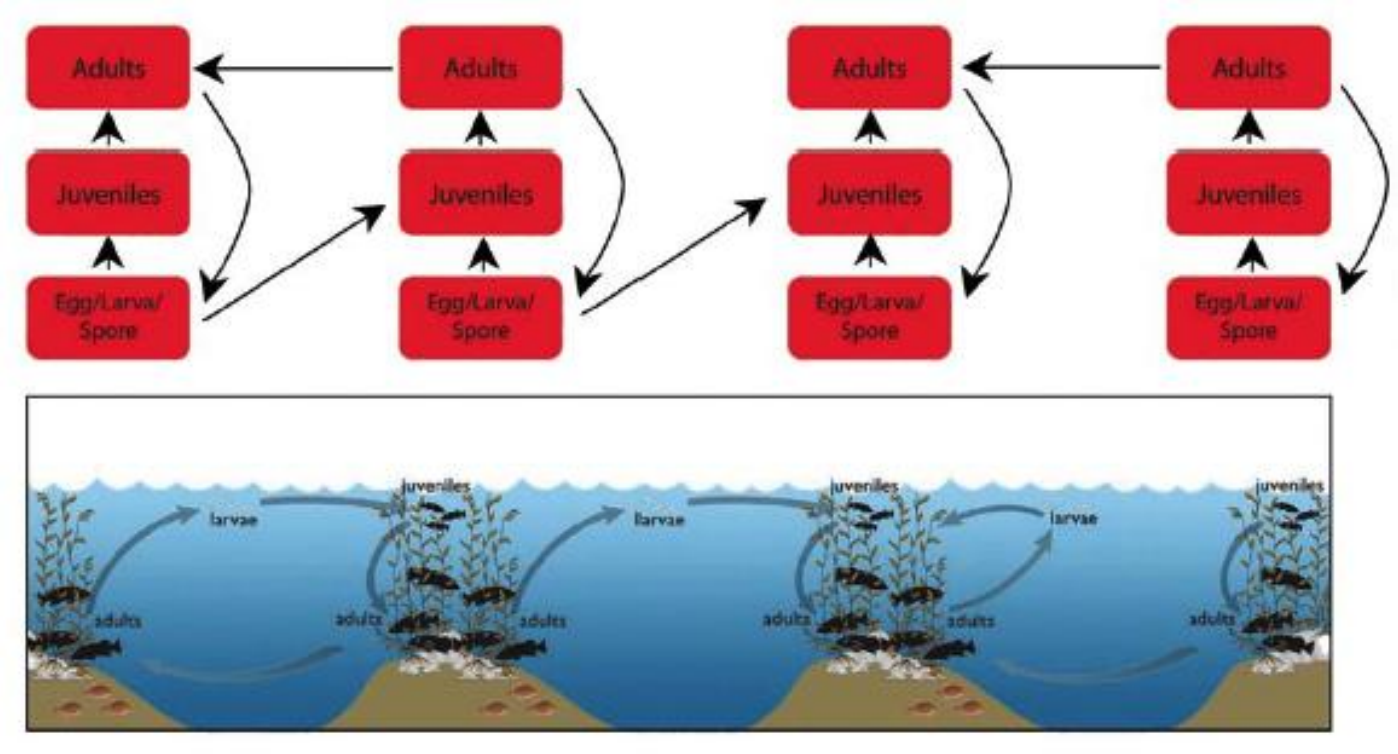
Marine dispersal

- Increasing density inside the reserve spills out to adjacent areas. Fishers “fish-the-line”.



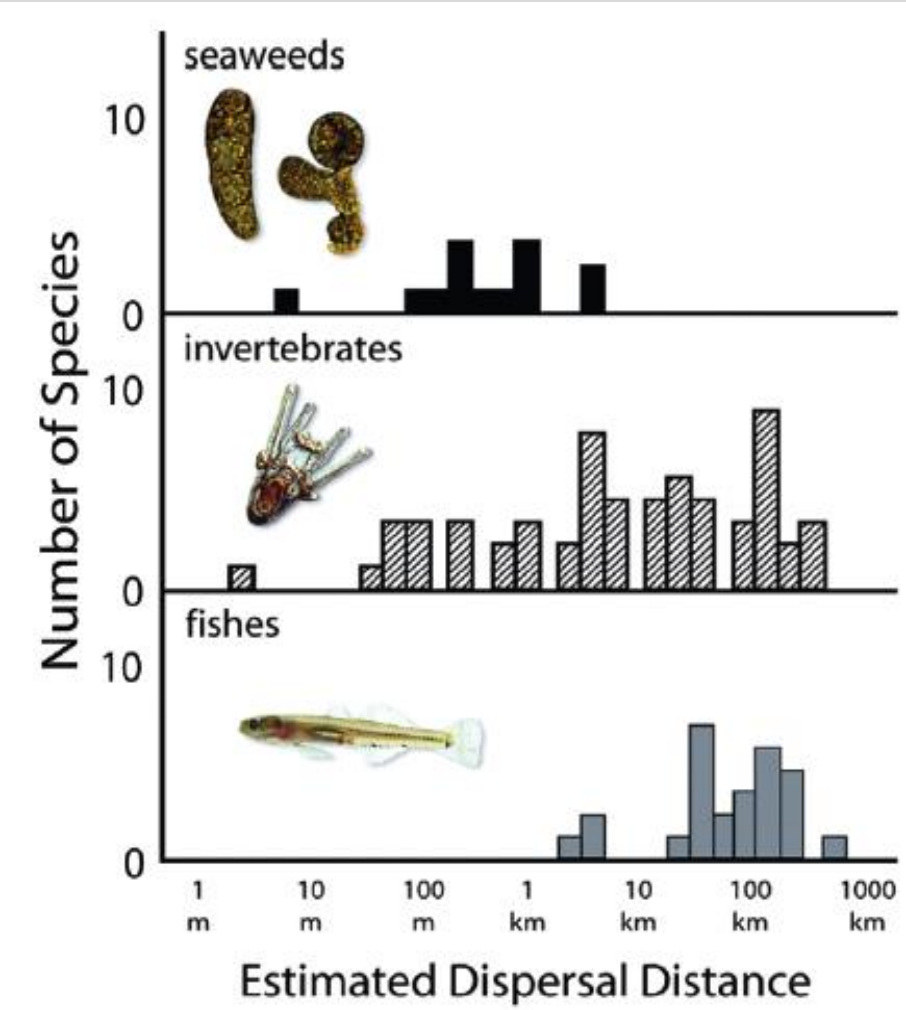
Fogarty & Botsford 2012 Oceanography 20: 112-123

Dispersal and Connectivity

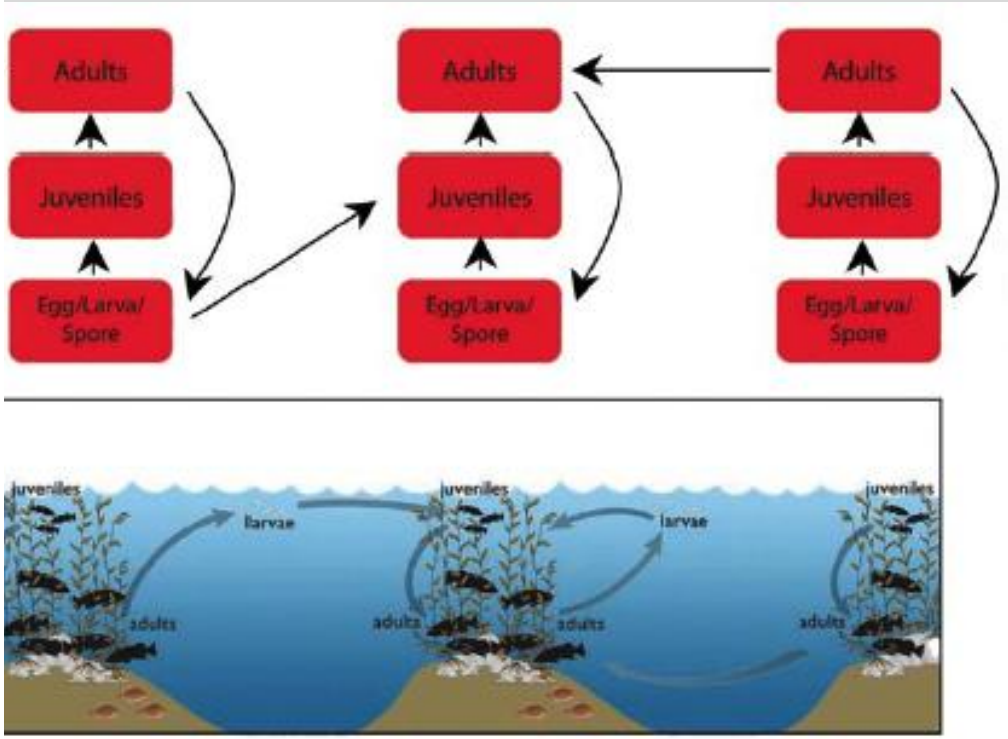


Gaines *et al* 2012 Oceanography 20: 90-99

Dispersal and Connectivity



Open vs Closed populations



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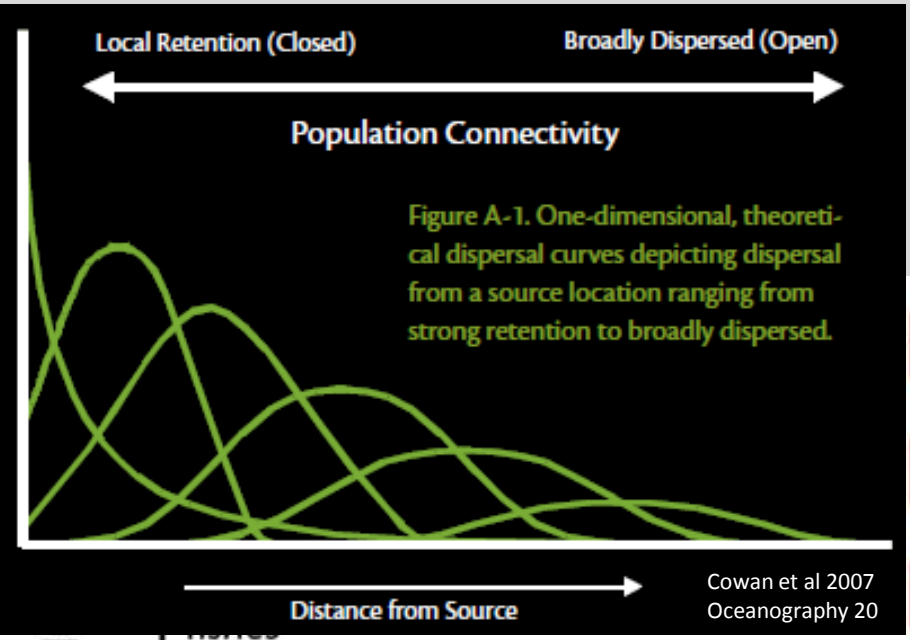
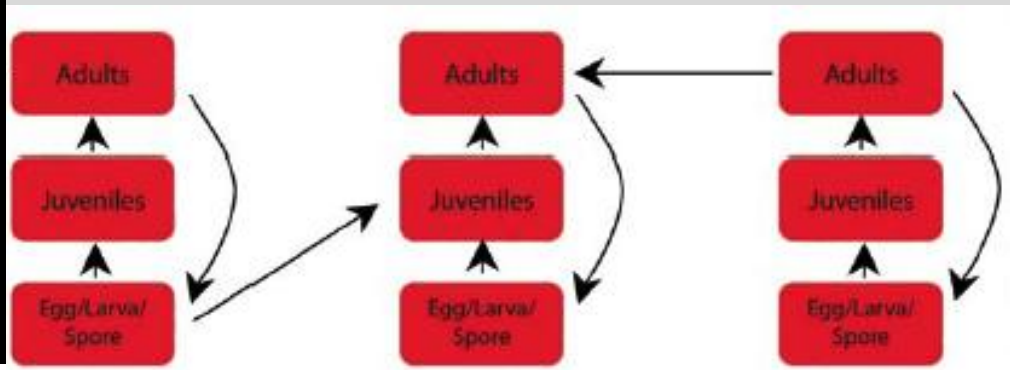
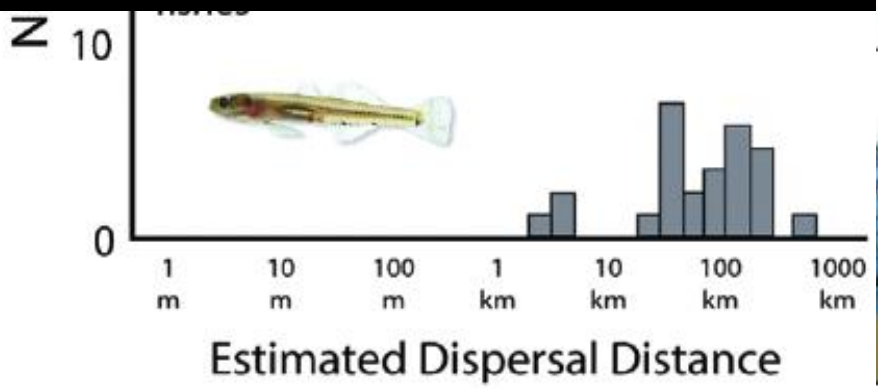
Dispersal and Connectivity

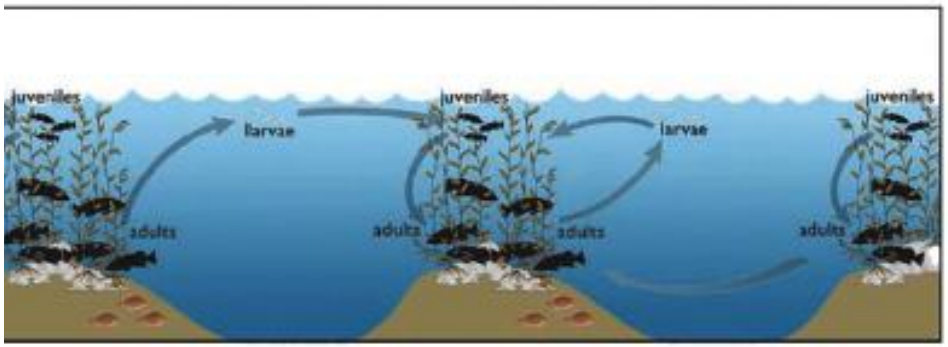


Cowan et al 2007
Oceanography 20

Open vs Closed populations







Gaines *et al* 2012 Oceanography 20: 90-99

Self recruitment

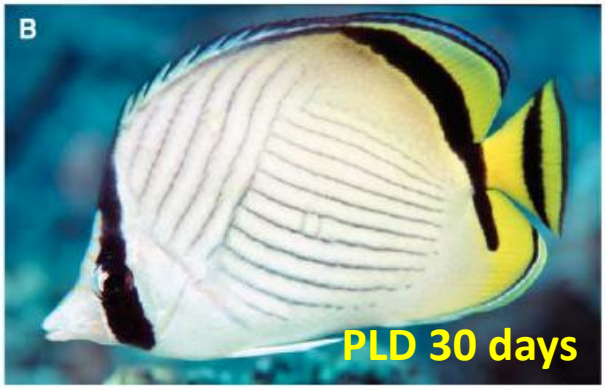
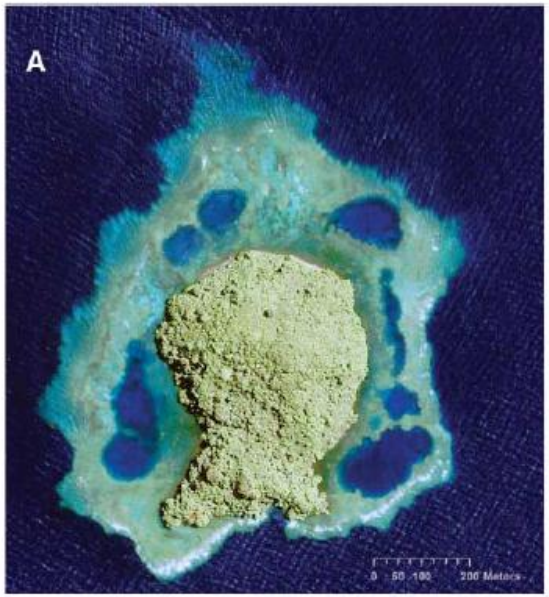


Fig. 1. Study species. An adult (**A**) *A. percula* (photo by S. R. Thorrold) and (**B**) *C. vagabundus* (photo by R. Patzner).



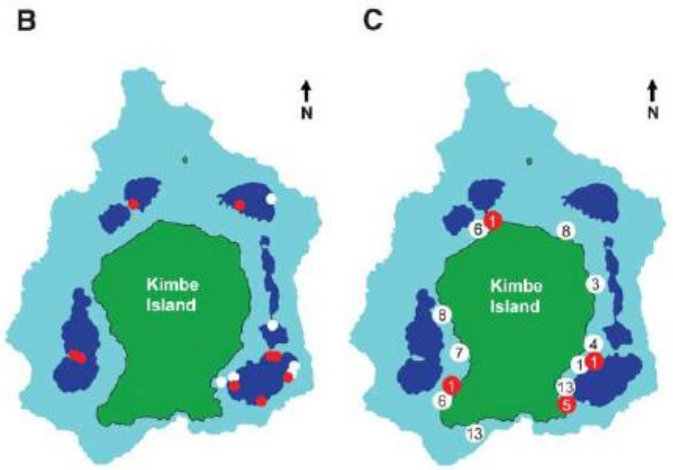
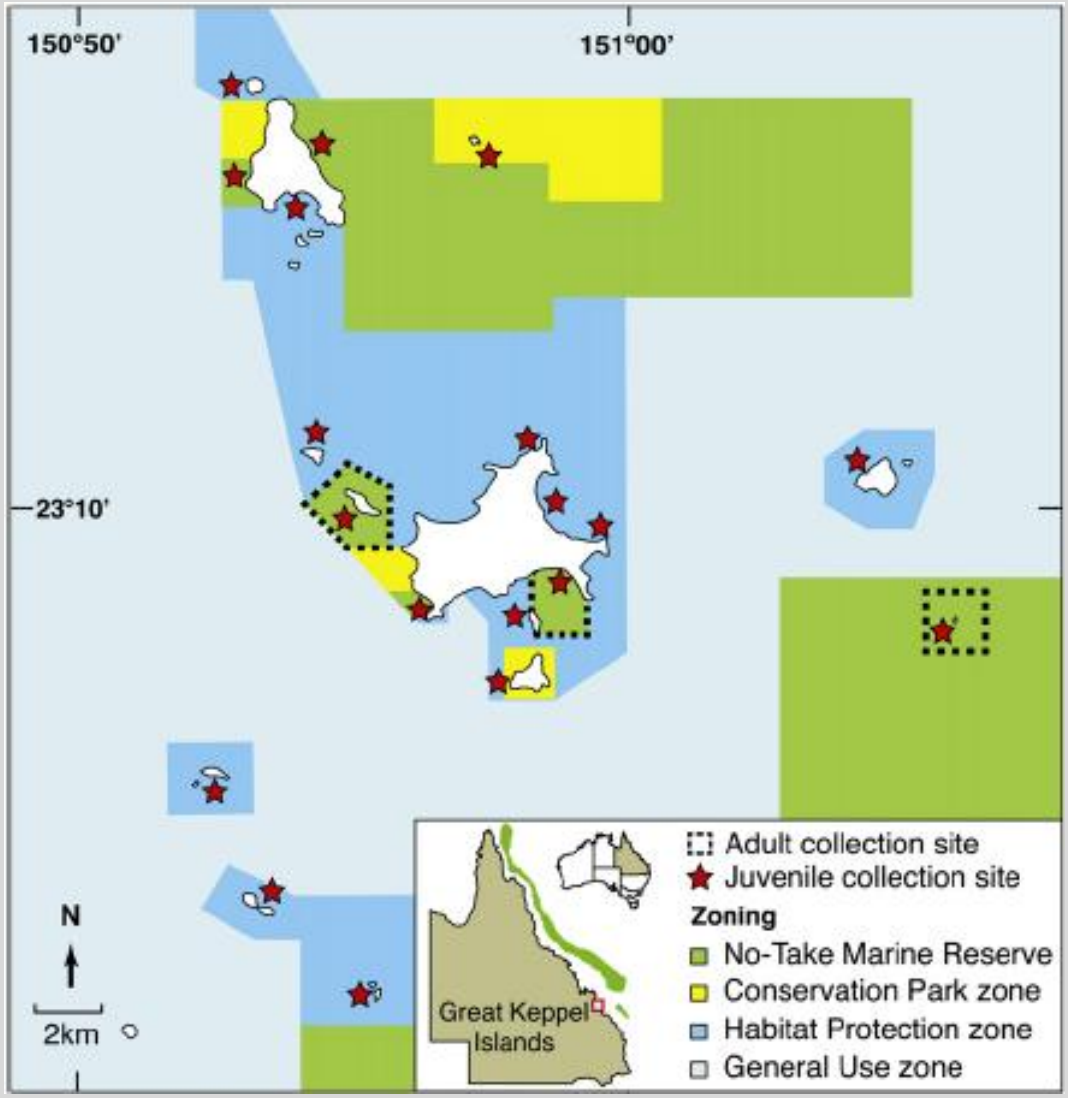


Fig. 2. (**A**) Satellite image of the Kimbe Island MPA (taken by the IKONOS-2 satellite at a resolution of 1 m). (**B** and **C**) Schematic diagrams of Kimbe Island showing the locations of tagged (red circles) and untagged (white circles) juveniles collected in February 2005. The locations of juvenile (B) *A. percula* ($n = 15$) and (C) *C. vagabundus* ($n = 77$) are shown. In (C), the number in each cirde corresponds to the number of juveniles collected from that location.

Almany *et al* 2007 Science 316

- Nearest reefs 10 km away
- Matching juveniles with maternal parent
- Self recruitment 60% for both species

Benefits outside of reserves



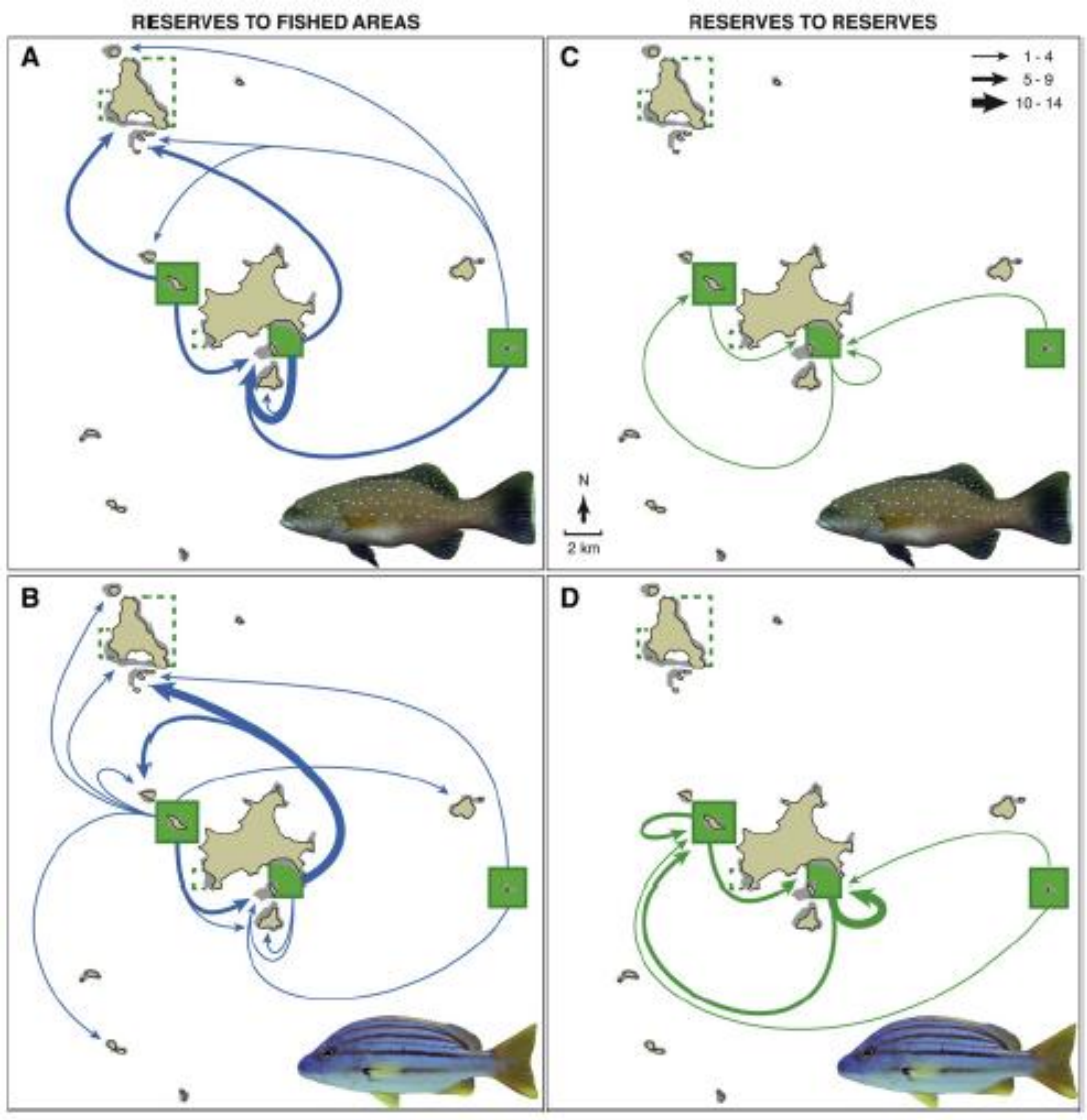
Larval Export from Marine Reserves and the Recruitment Benefit for Fish and Fisheries

Harrison *et al* 2012 Current Biology 22: 1023-1028

Adults inside reserves have:

- Twice the biomass
- Larger size
- Greater per capita fecundity

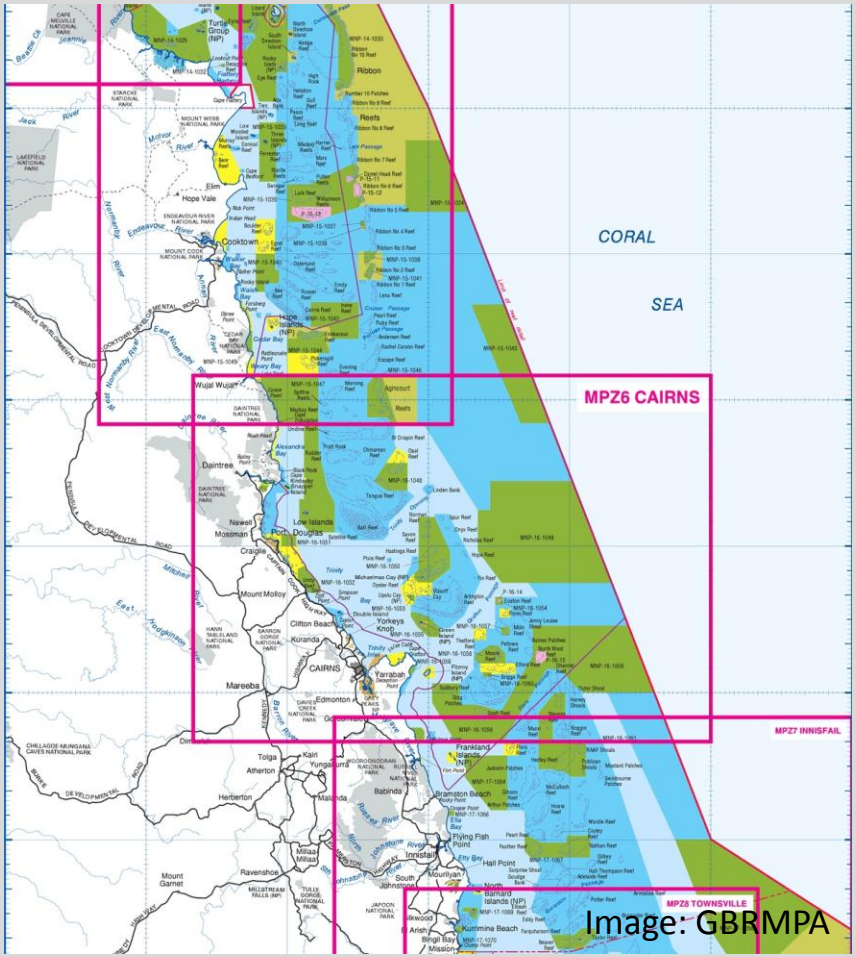
Benefits outside of reserves



Harrison *et al* 2012 Current Biology 22: 1023-1028

- Both species self-replenished and also provided new recruits outside of the reserves.
- Coral trout exported 83% of offspring to fished reefs.
- Striped snapper exported 55% of offspring to fished reefs.
- Reserves provide half the total juveniles to the area, yet only represent 28% of the area.

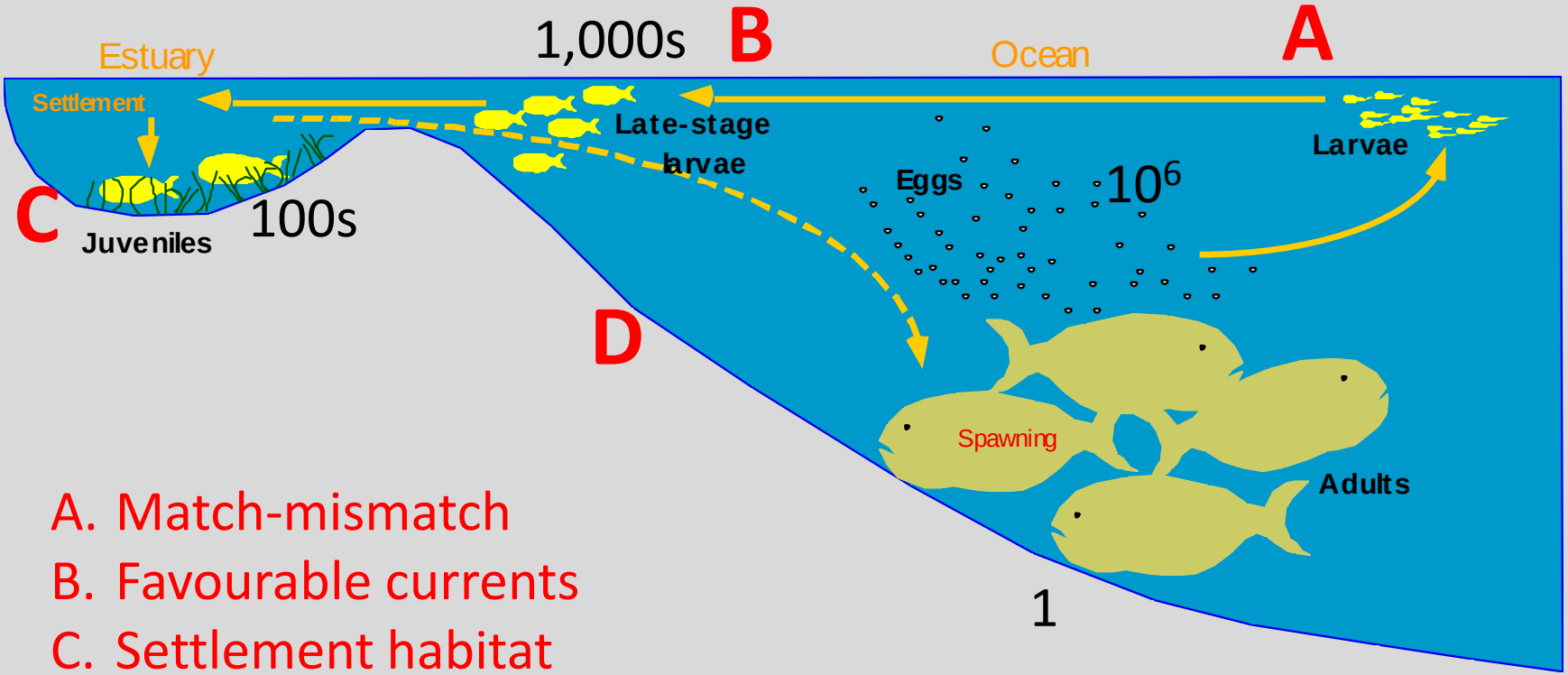
Great Barrier Reef Marine Park



- A mosaic of usage zones
- 33% is no-take

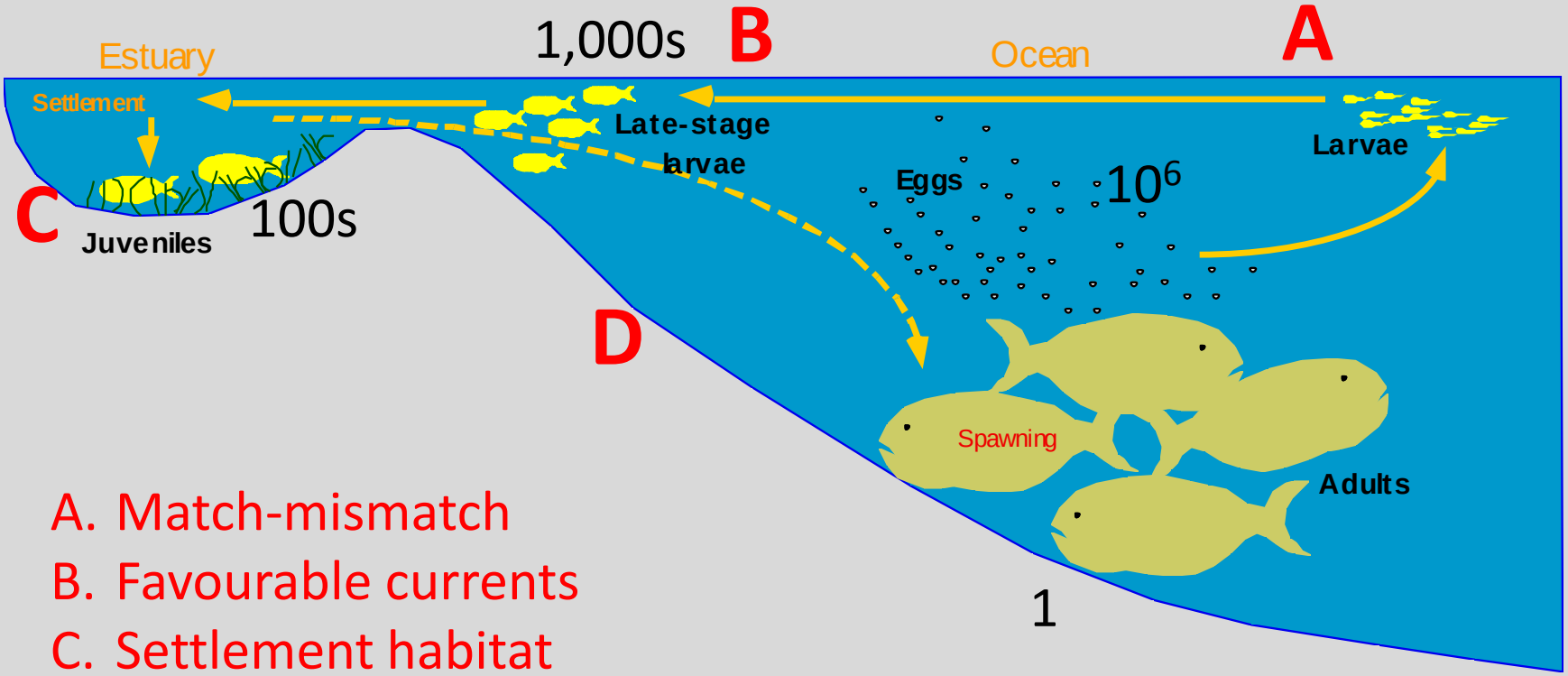
- Fishers objected strongly to loss of access
- Community support overwhelming and predicted fish reduction didn’t occur

Population demography



A. Match-mismatch
B. Favourable currents
C. Settlement habitat
D. Fishing pressure

Population demography



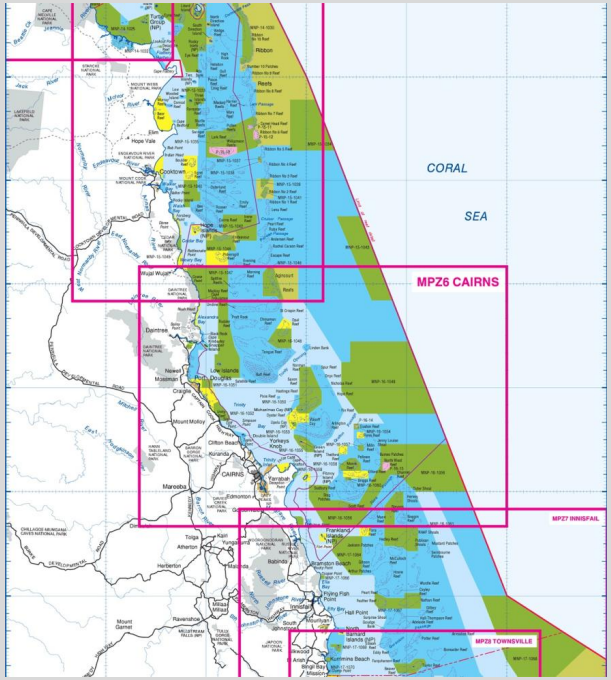
A. Match-mismatch
B. Favourable currents
C. Settlement habitat
D. Fishing pressure

Decoupled relationship between adults and recruitment

Management implications

- Old, big, fat females produce more eggs per unit of body weight, and the resulting larvae and juveniles are fitter.
- Presence of conspecifics may be required for successful settlement
- Trophic cascades – eg jellyfish dominated
- Physical conditions for larvae are favourable only in some years and some seasons

Management implications



- Number, size and location of no-take reserves will determine their success at replenishing marine populations and maintaining biodiversity
- Pelagic and demersal habitats need to be healthy for entire range of life cycle