Fish Adult Movement and Larval Dispersal:

Science to inform marine protected area design

Presented to the MLPA South Coast Regional Stakeholder Group
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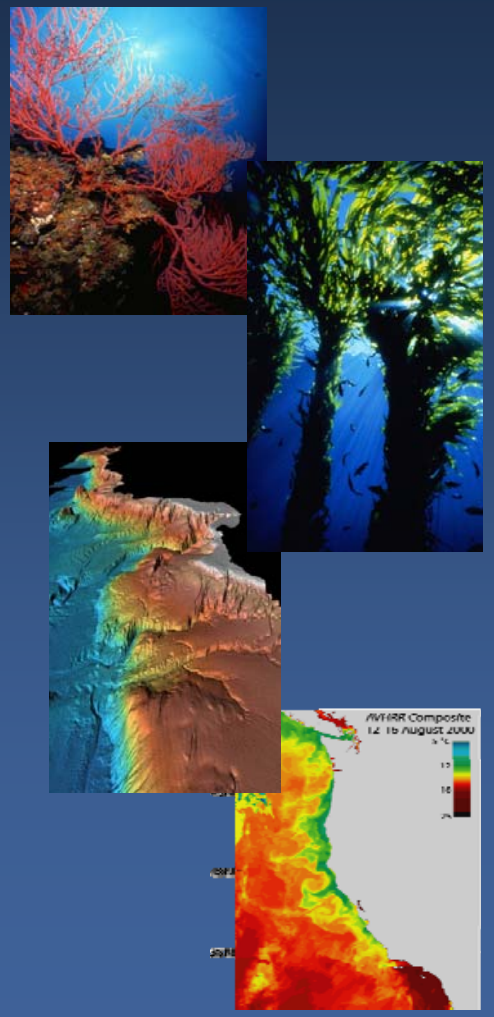
CA Marine Life Protection Act Goals

1. Protect **natural diversity** and **ecosystem functions**.
2. Sustain and restore marine life **populations**.
3. Improve recreational, educational, and study **opportunities**.
4. Protect representative and unique **habitats**.
5. Clear objectives, effective management, adequate enforcement, sound science.
6. Ensure that MPAs are designed and managed as **a network**.



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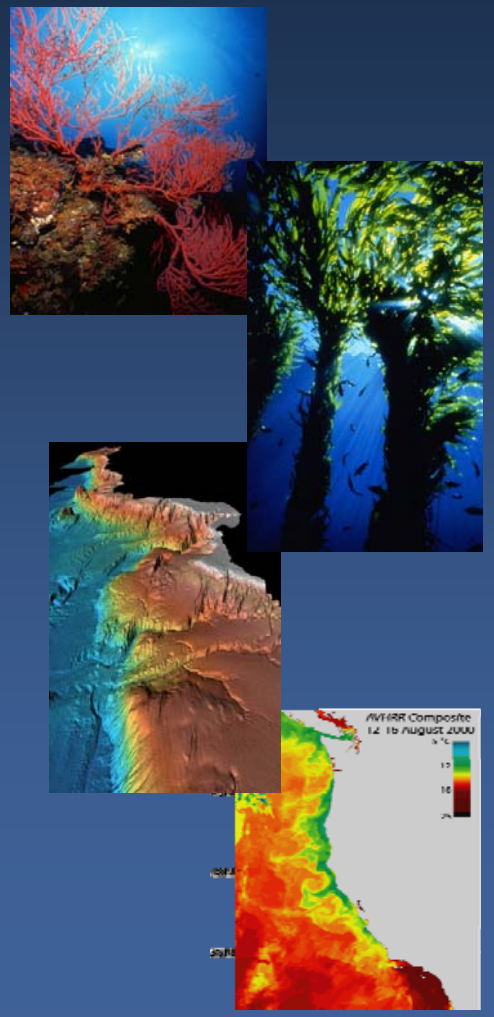
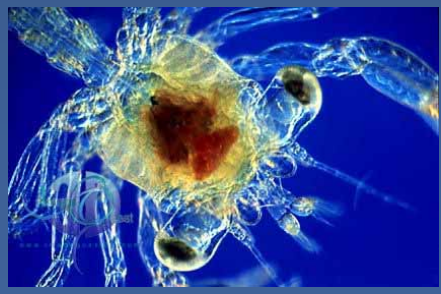


Protecting Populations

size and spacing

- MPAs must be large enough that adults don't move out of them and become vulnerable to fishing

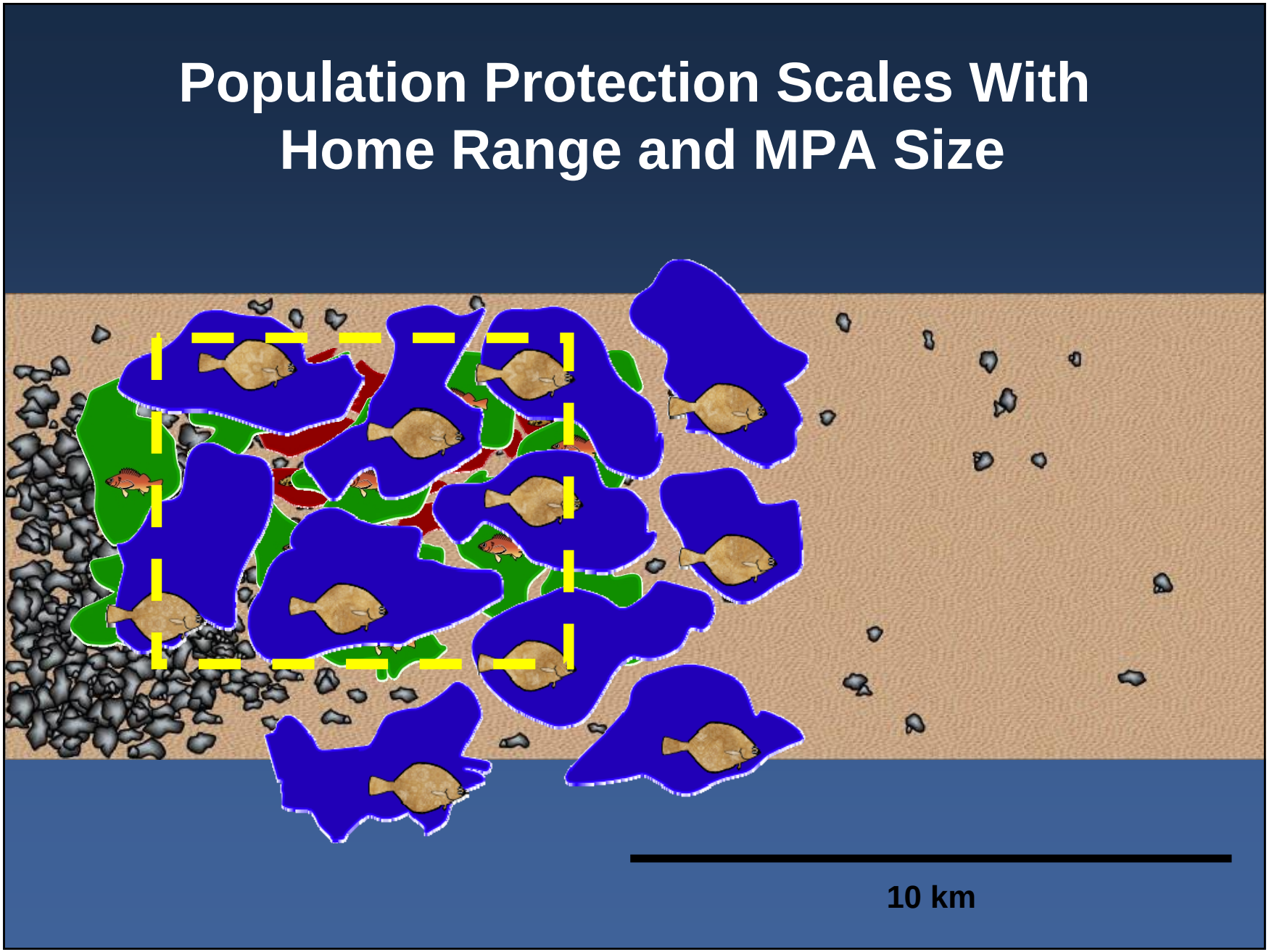
- MPAs must be close enough together that larvae can move from one to the next



How Does Movement Determine Marine Protected Area Size and Shape?

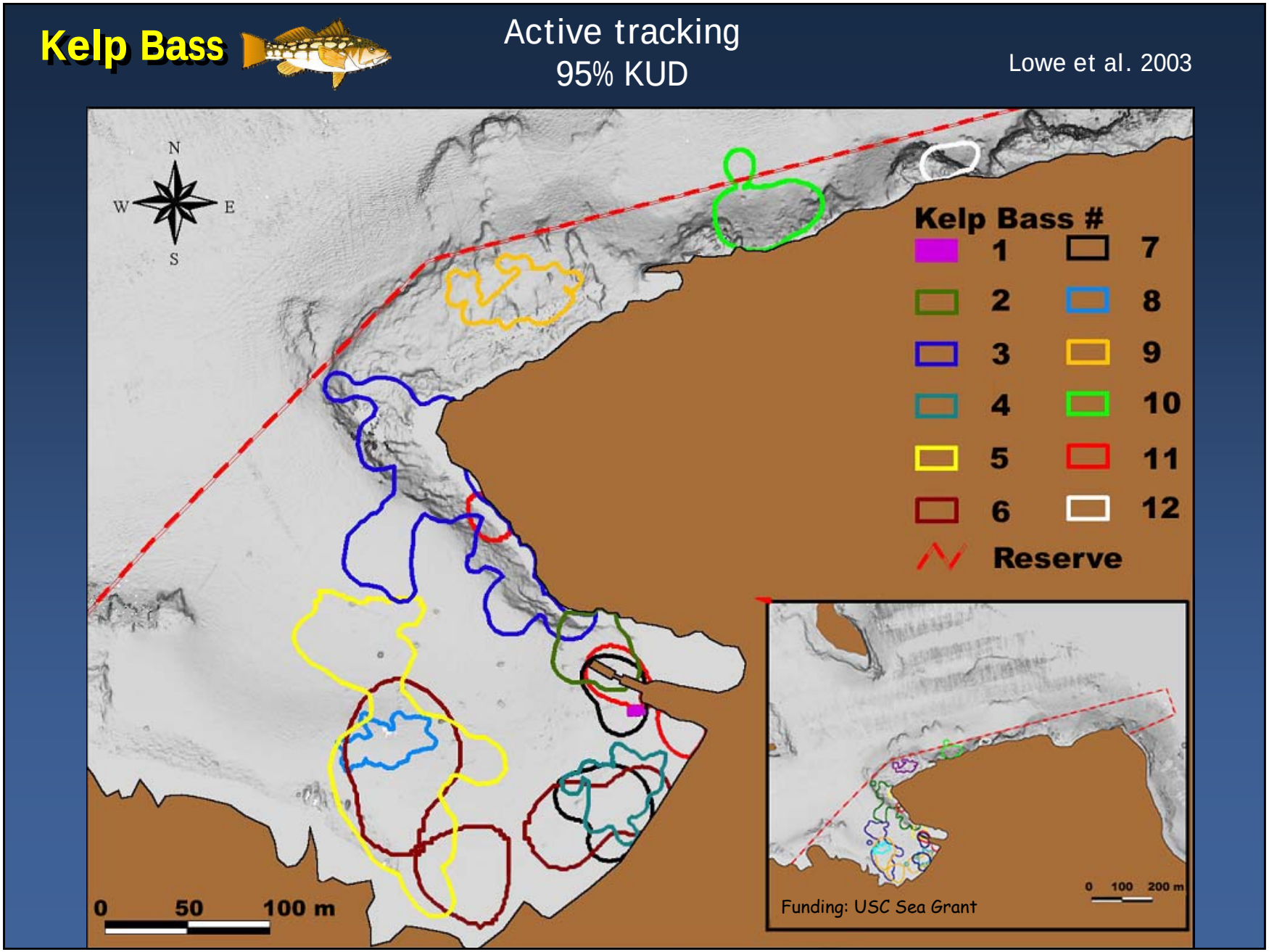
- Population protection scales with movement and MPA size
- Movement affects the amount of spillover from an MPA (pros and cons)
- MPAs need to protect all the habitats that fish (and invertebrates) use over their lifetime

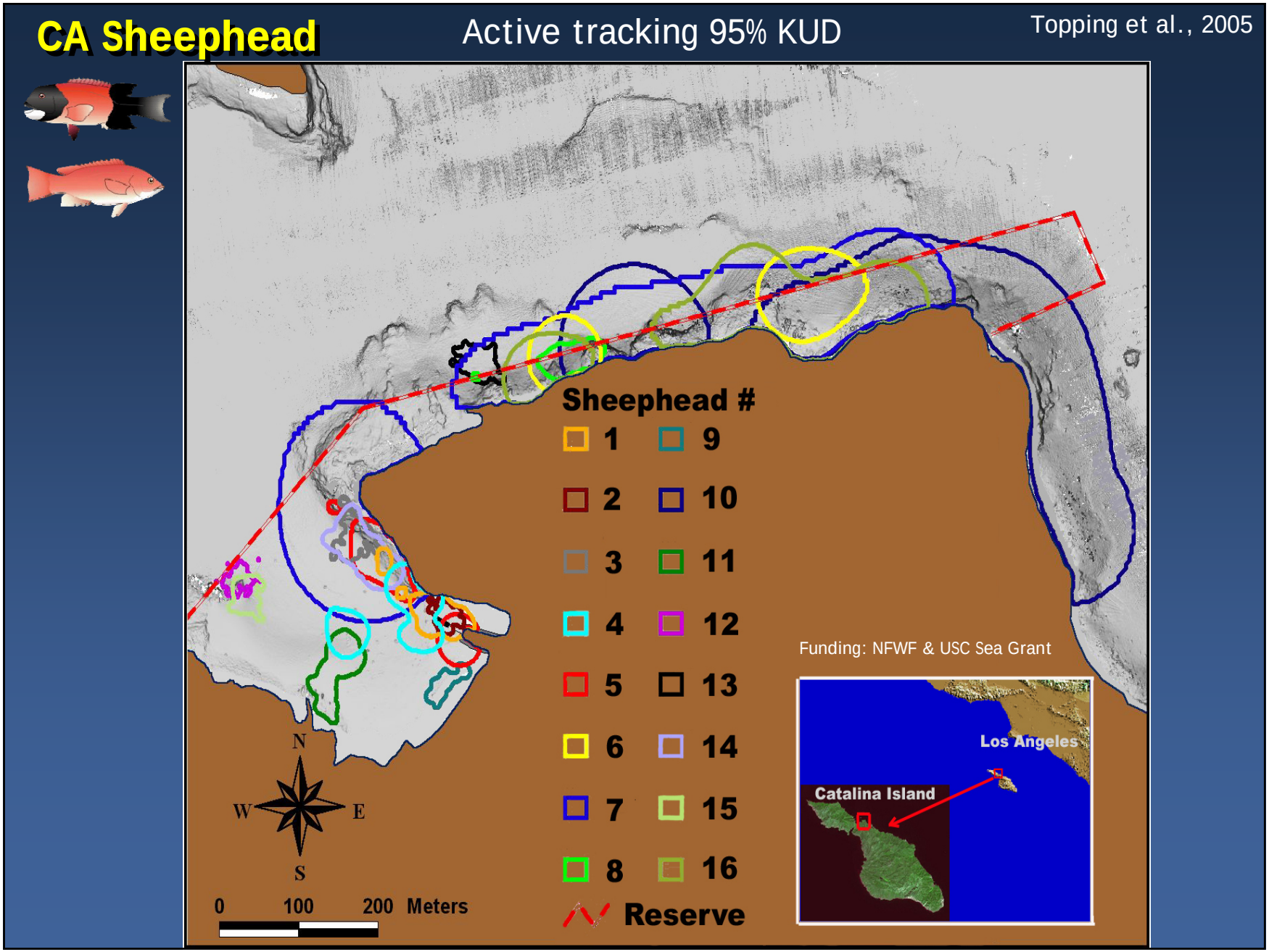
Population Protection Scales With Home Range and MPA Size

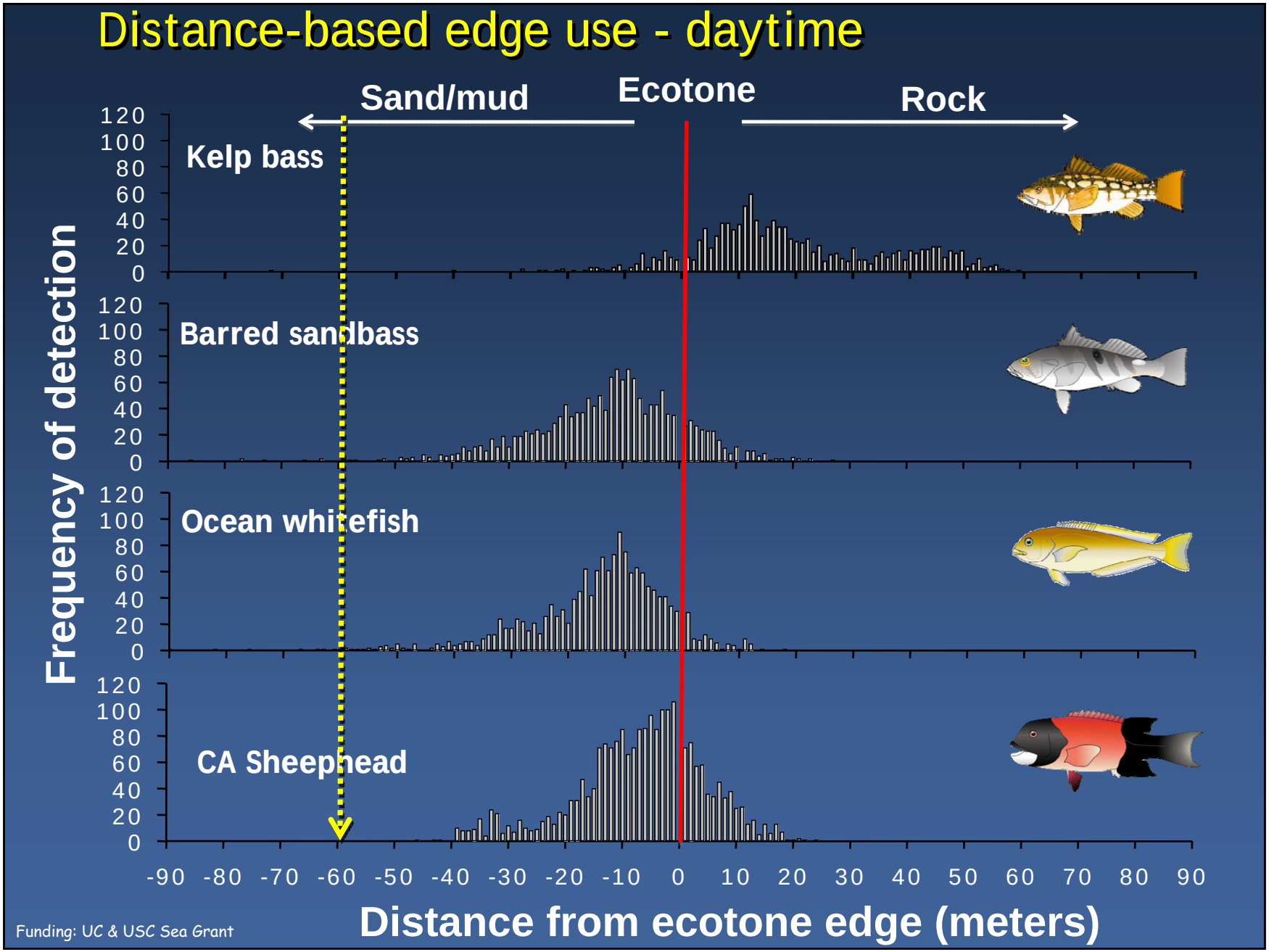


How Do We Know About Adult Movements?

Fishing, Direct Observation, Acoustics, Tagging,
Genetics, Current and Habitat Associations


Kelp Bass
Active tracking
95% KUD
Lowe et al. 2003
N
W
E
S
Kelp Bass #
1
2
3
4
5
6
7
8
9
10
11
12
Reserve
0 50 100 m
0 100 200 m
Funding: USC Sea Grant


CA Sheephead
Active tracking 95% KUD
Topping et al., 2005
Sheephead #
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Reserve
N
W
E
S
0
100
200 Meters
Funding: NFWF & USC Sea Grant
Los Angeles
Catalina Island


Distance-based edge use - daytime
Sand/mud
Ecotone
Rock
Kelp bass
Barred sandbass
Ocean whitefish
CA Sheephead
Frequency of detection
0
20
40
60
80
100
120
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90
Distance from ecotone edge (meters)
Funding: UC & USC Sea Grant

Adult Movement

Marine Reserve Size

Home ranges of 25 west coast rocky habitat fish species

Conclusion: 76% of these species moved less than 0.5 kilometer

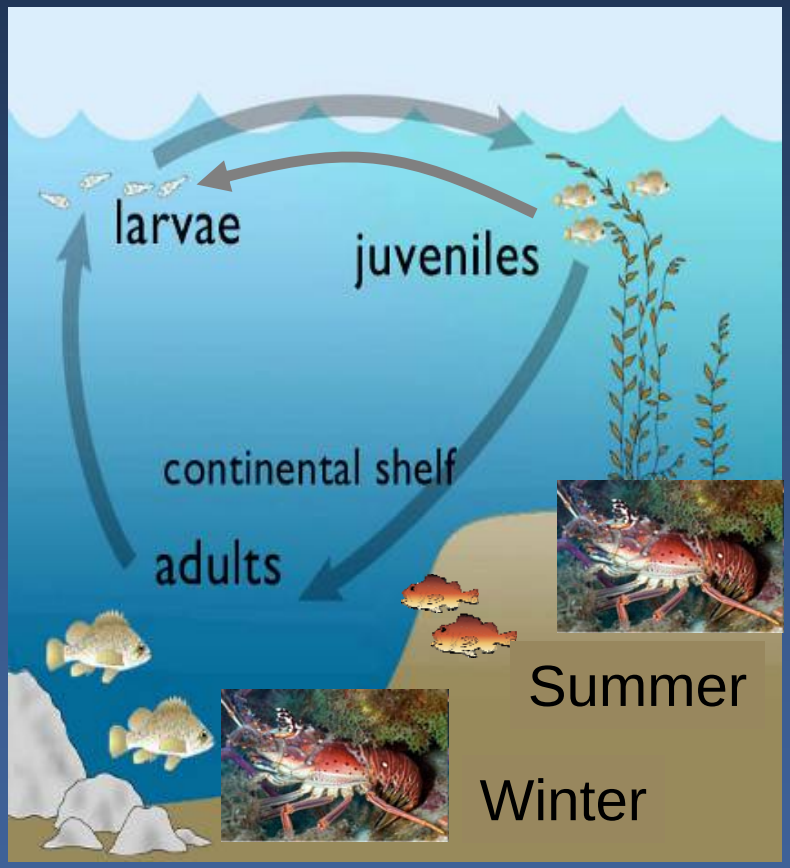
Freiwald, unpublished

Reserve Size and Species Protected

Adult Home Range Size

0 – 1 km	1 – 10 km	10 – 100 km	100 – 1000 km	> 1000 km
Many rockfish	Some rockfish	Some rockfish	Few rockfish	Some schooling fish
Other reef fish	Some surfperch	Other reef fish	Some schooling fish	Tunas
Some surfperch		Some flatfish	Salmon	Many sharks
			More flatfish	

Species Use Different Depths at Different Times



Protect the range of depths species use

Over their lifetime

Seasonally

Master Plan Size Guidelines

- Minimum alongshore span of **5 – 10 kilometers** (3 - 6 miles)
- Preferably **10 – 20 kilometers** (6 - 12 miles)
- Extend from the intertidal zone to deep waters (3 miles offshore)

Protecting Populations

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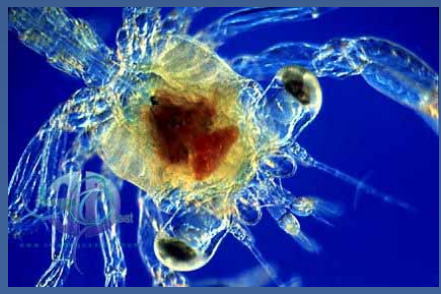
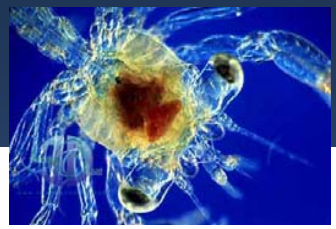
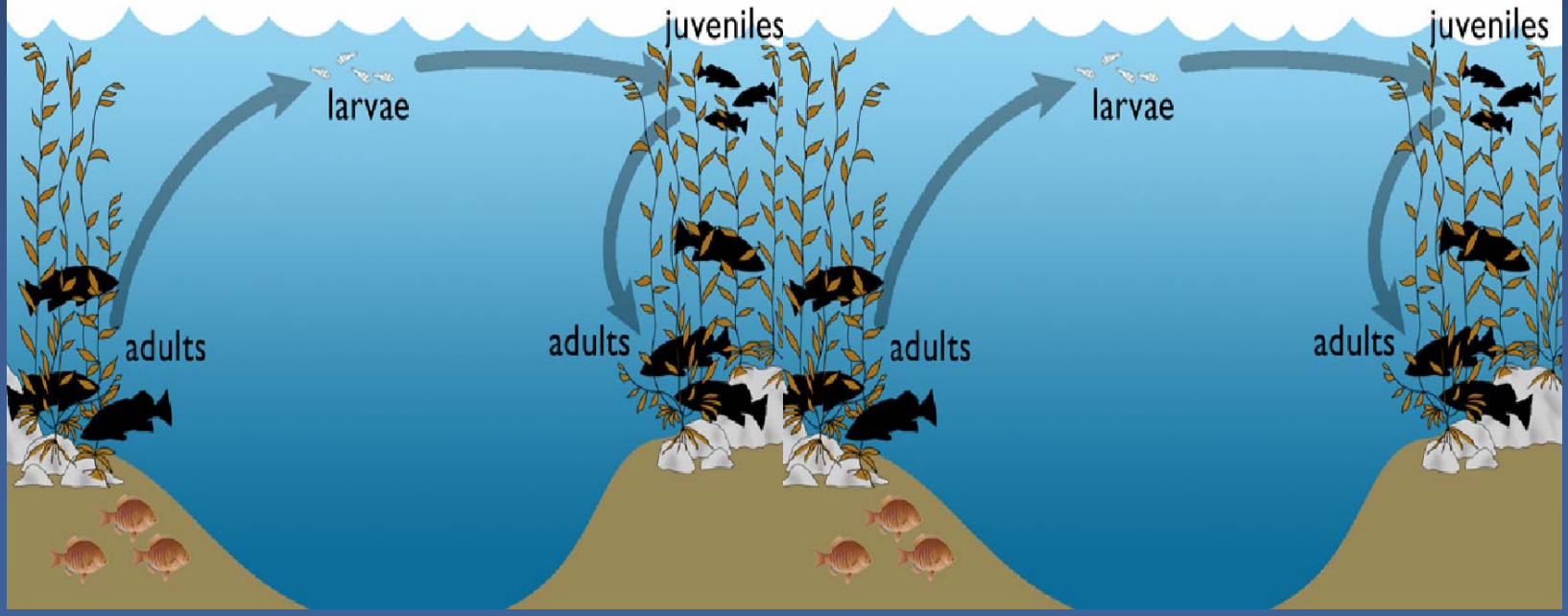
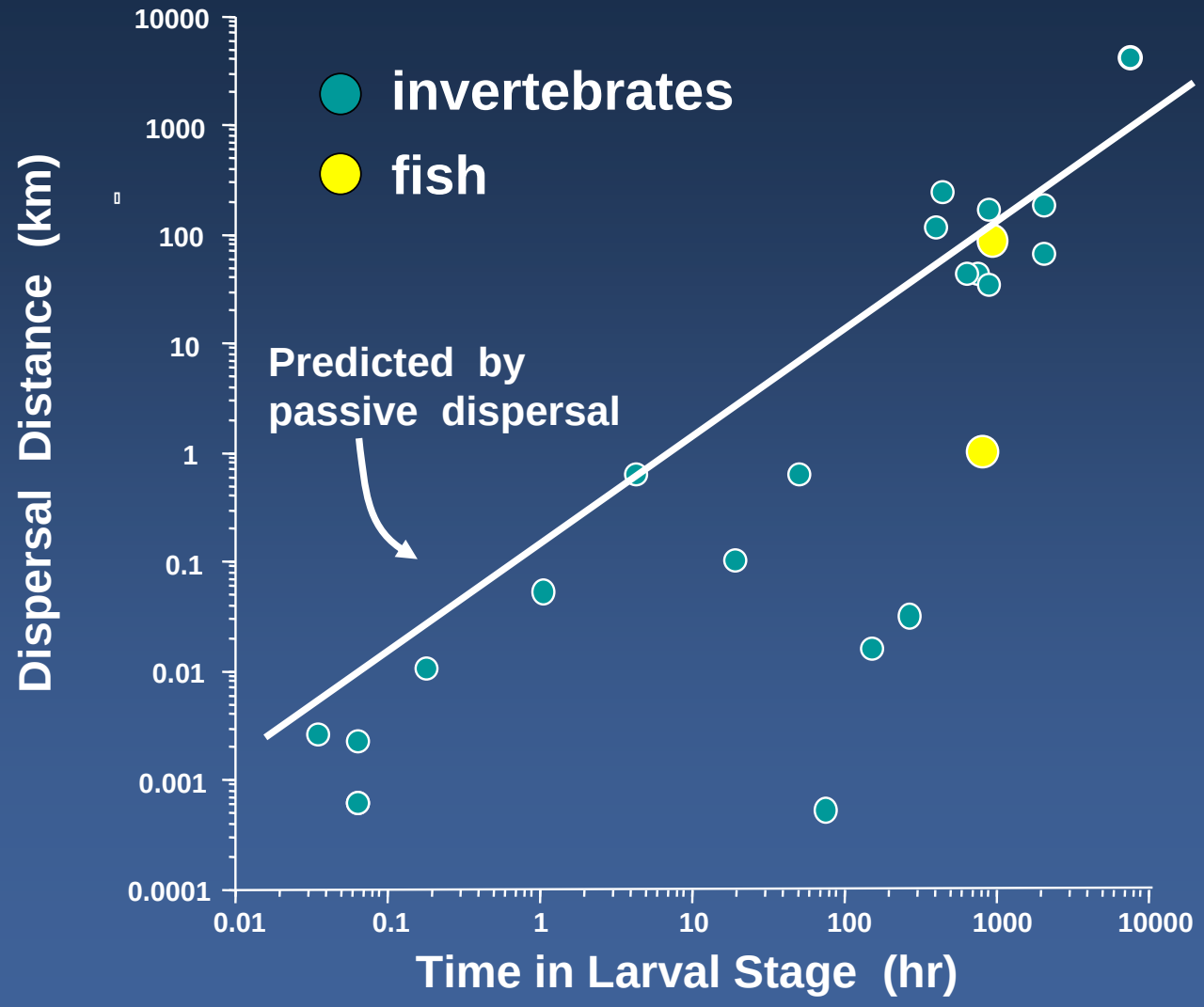


Reserves Connected by Larval Dispersal





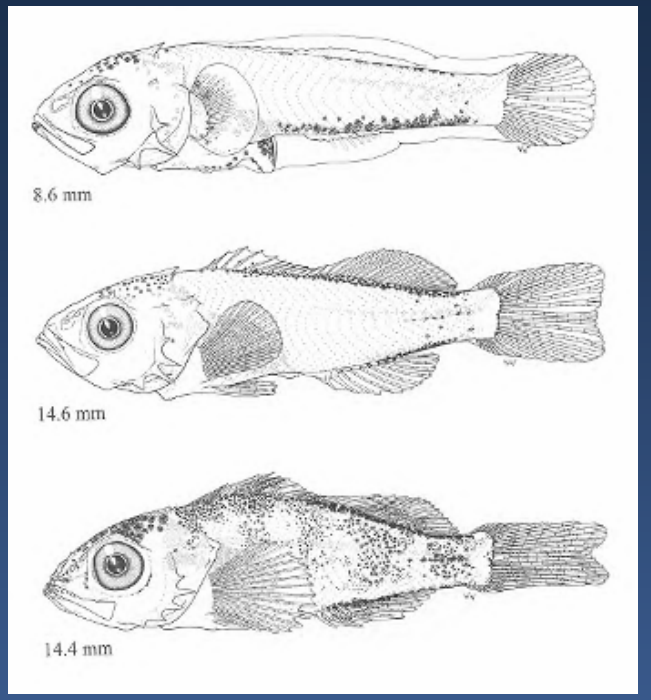
Pelagic duration: a proxy for dispersal potential

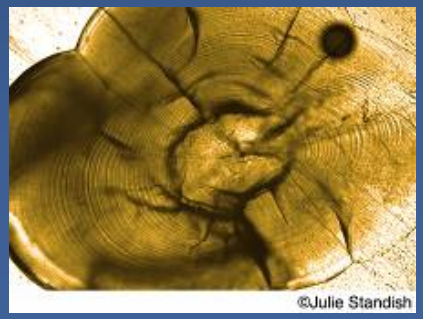


Shanks et al. 2003 Ecological Applications

Time in the Larval Stage (fish)

Western North American Coastal Fish	Time in Larval Stage midpoint (range)
Aurora Rockfish (*Sebastes aurora*)	105 (90-120)
Gopher Rockfish (*S. carnatus*)	75 (60-90)
Yellowtail Rockfish (*S. flavidus*)	85 (60-110)
Black Rockfish (*S. melanops*)	145 (110-180)
Blackgill Rockfish (*S. melanostomus*)	105
Blue Rockfish (*S. mystinus*)	105 (80-130)
Bocaccio (*S. paucispinis*)	160 (150 to 170)
Olive Rockfish (*S. serranoides*)	135 (90-180)
Kelp Bass (*Paralabrax clathratus*)	30 (25-35)
Spotted Sand Bass (*P. maculatofasciatus*)	22 (17-27)
White Seabass (*Atractoscion nobilis*)	32 (29-35)
Halfmoon *(Medialuna californiensis)*	60
Blacksmith *(Chromis punctipinnis)*	35 (32-38)
Garibaldi *(Hypsypops rubicunda)*	20 (18-22)
Rock Wrasse (Halichoeres *semicinctus)*	30 (26-34)
Senorita *(Oxyjulis californica)*	39 (36-43)
California Sheephead *(Semicossyphus pulcher)*	37 (34-52)
Giant Kelpfish *(Heterostichus rostratus)*	37 (14-60)
Blackeye Goby *(Coryphopterus nicholsi)*	70
Bluebanded Goby *(Lythripnus* dalli)	70
California Halibut *(Paralichthys californicus)*	27
Pacific Sanddab (Citharichthys sordidus)	271
Speckled Sanddab *(C. stigmaeus)*	219 (113-219)
Petrale Sole *(Eopsetta jordani)*	180



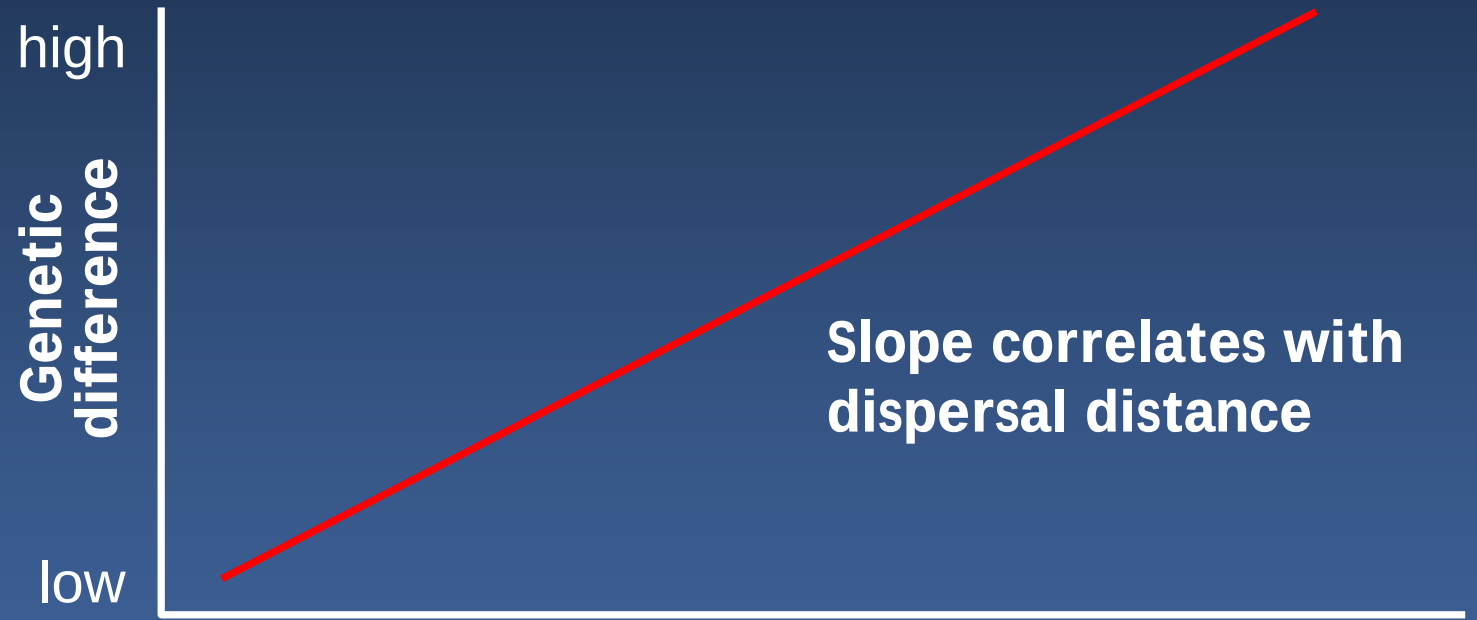


AVERAGE = 94 days

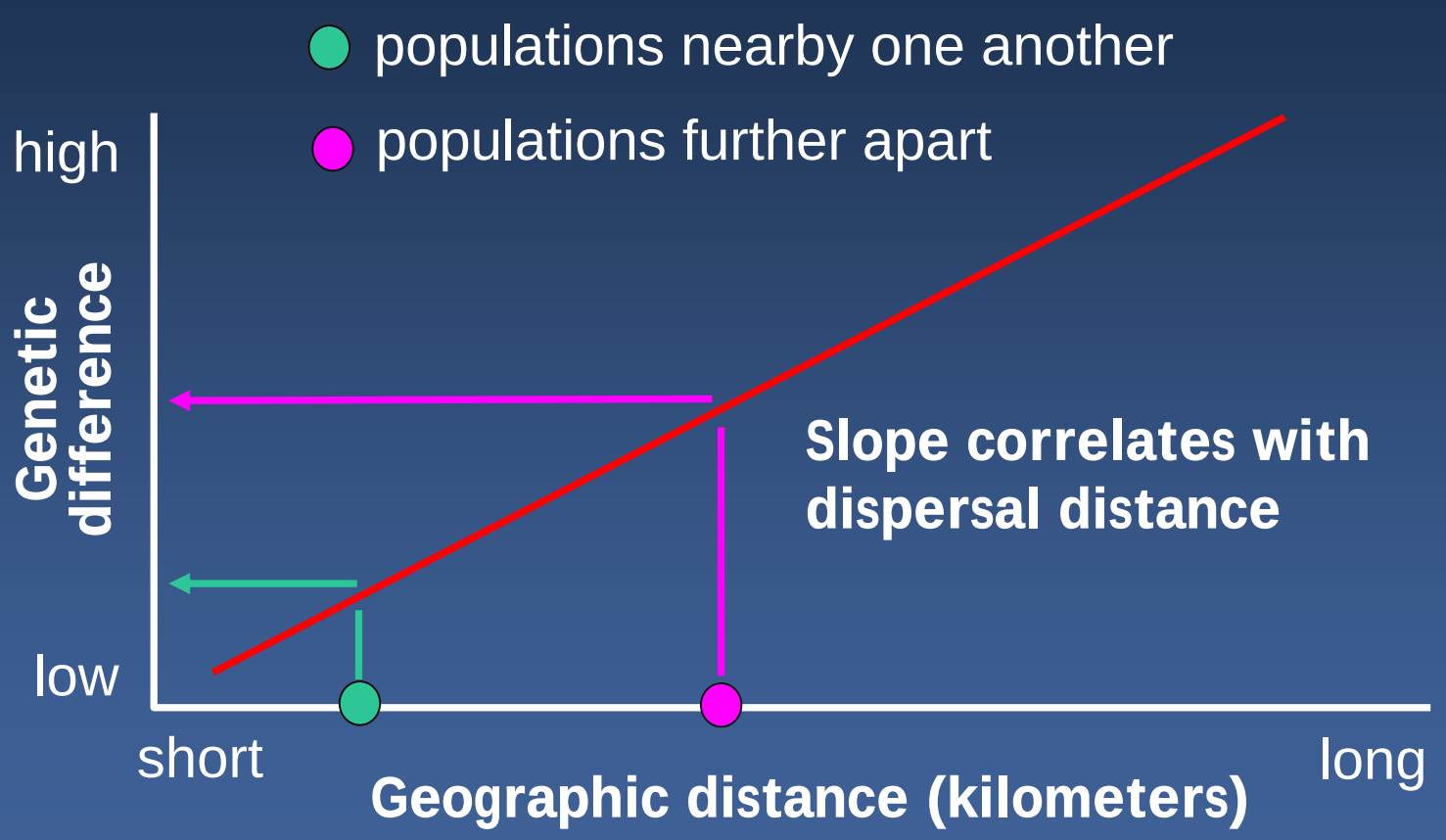
Shanks et al. 2003

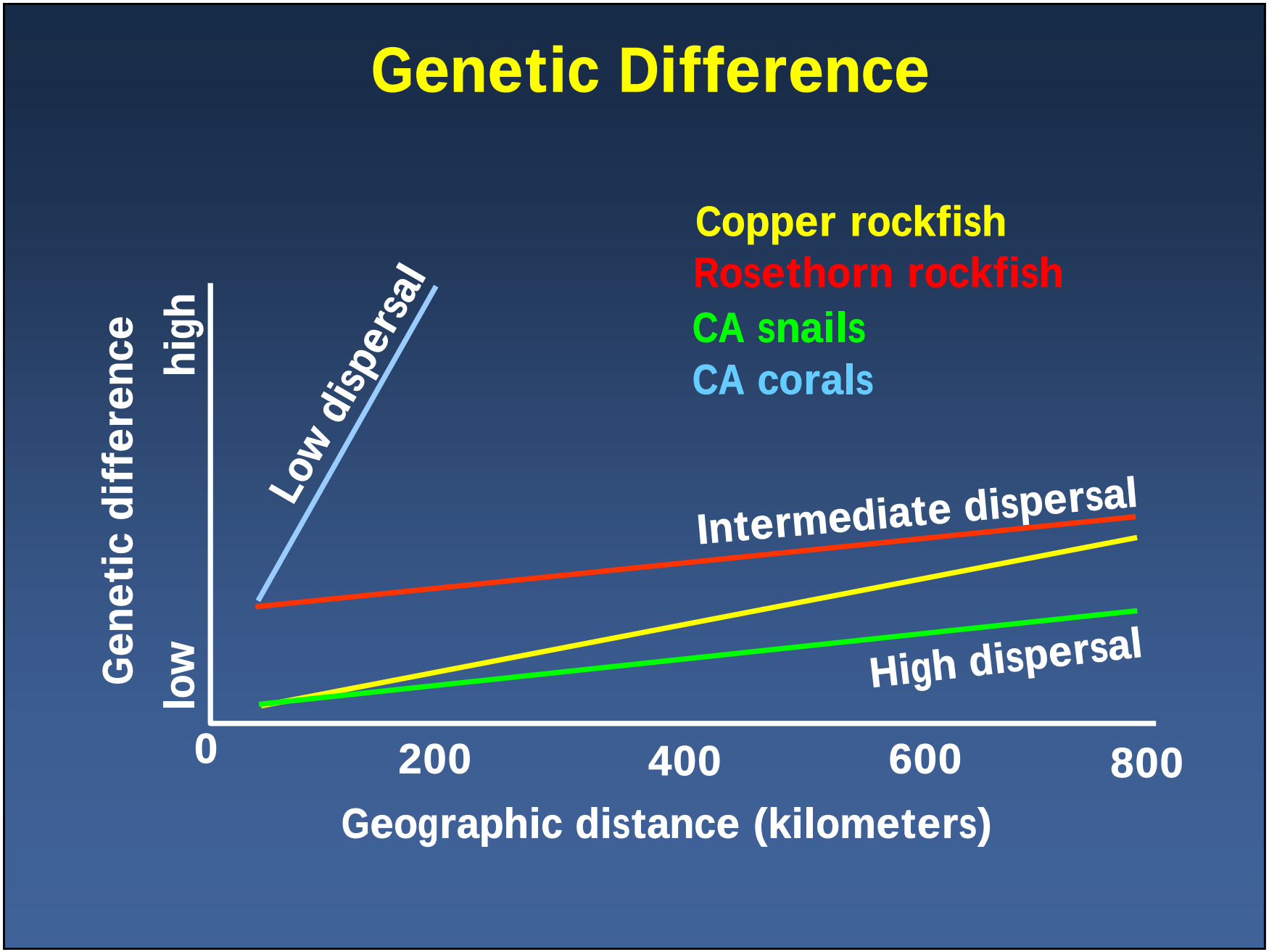
Genetic Approaches

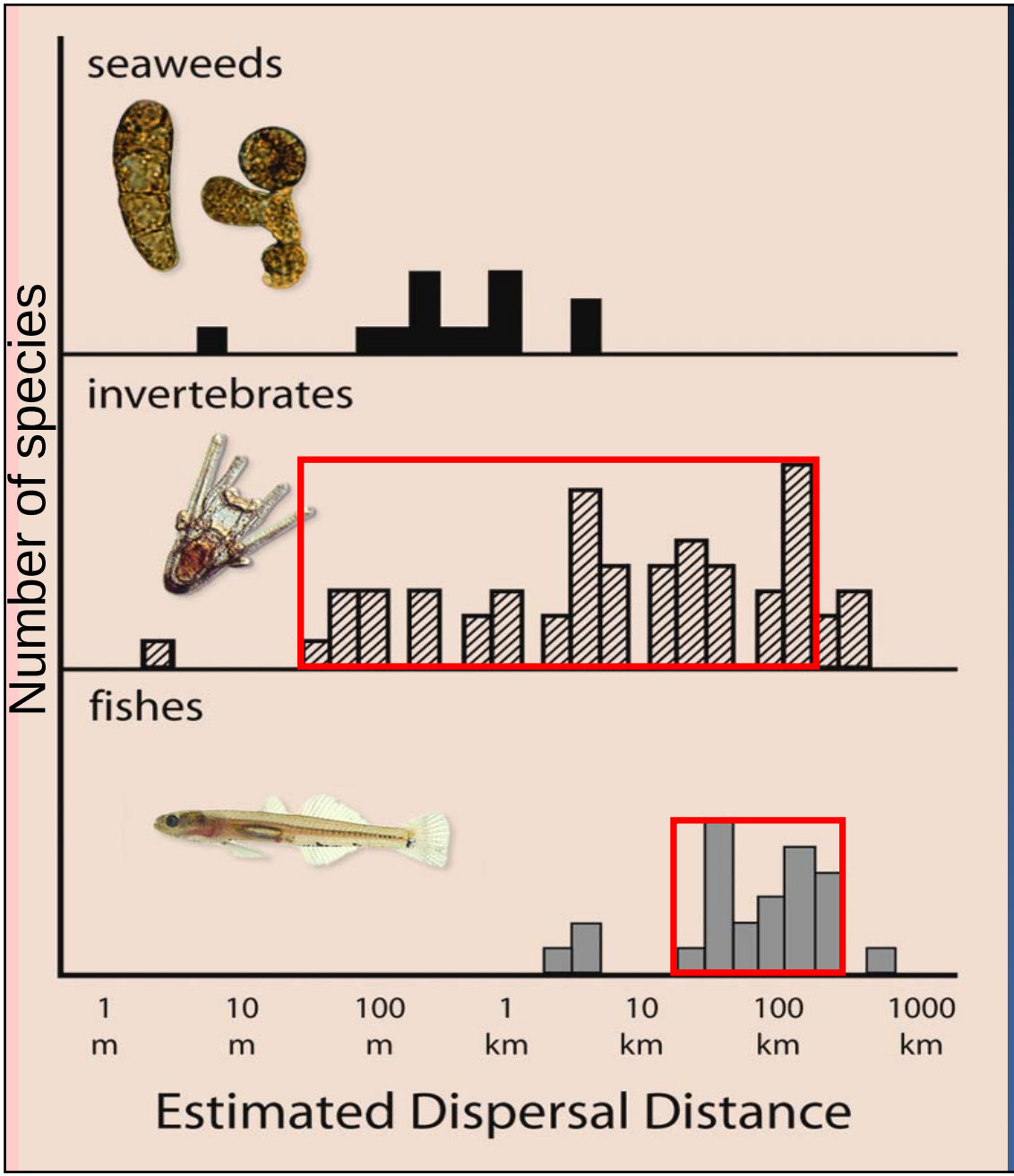
geographic distance ≈ genetic difference



Geographic distance ≈ genetic difference




Genetic Difference
Copper rockfish
Rosethorn rockfish
CA snails
CA corals
Low dispersal
Intermediate dispersal
High dispersal
Genetic difference
high
low
0
200
400
600
800
Geographic distance (kilometers)



Larval dispersal

Based on genetic difference

Inverts:
<1-100 kilometers

Fish:
20-200 kilometers

Palumbi 2003
Kinlan and Gaines 2003

Roles of Multiple, Connected MPAs

- Increase area over which larval export from MPAs is realized
- Reduce negative and increase beneficial impacts to local fisheries along the coast
- Enhance connectivity and replenishment among MPAs
- Reduce dependency of populations inside MPAs on replenishment by populations outside MPAs
- Buffer against local catastrophes (e.g., oil spill, storms)
- Encompass diversity of habitats and associated species

Summary

- MPA size and adult movement interact to determine how well a MPA protects a population and ecosystem
- MPA spacing and larval dispersal interact to determine how well MPAs protect a population and ecosystem
- MPA size and spacing are interrelated