

Fish Adult Movement and Larval Dispersal:

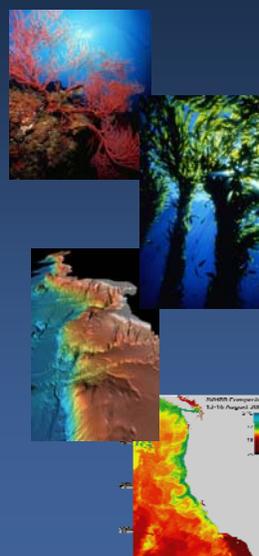
Science to inform marine protected area design

Presented to the MLPA Blue Ribbon Task Force
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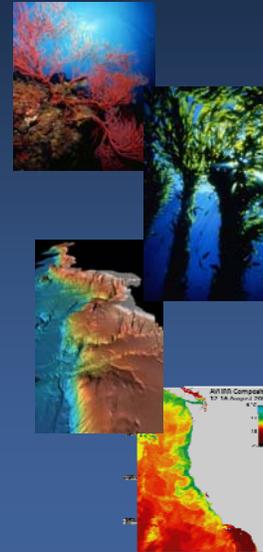
CA Marine Life Protection Act Goals

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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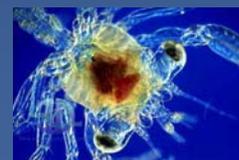
Protecting Populations

size and spacing

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



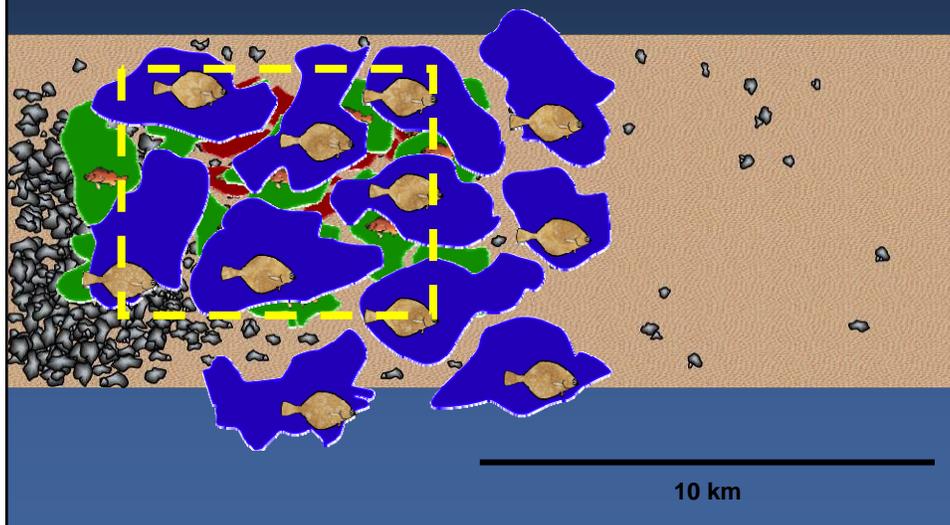
 MPAs must be close enough together that **larvae** can move from one to the next



How Does Movement Determine Marine Protected Area Size and Shape?

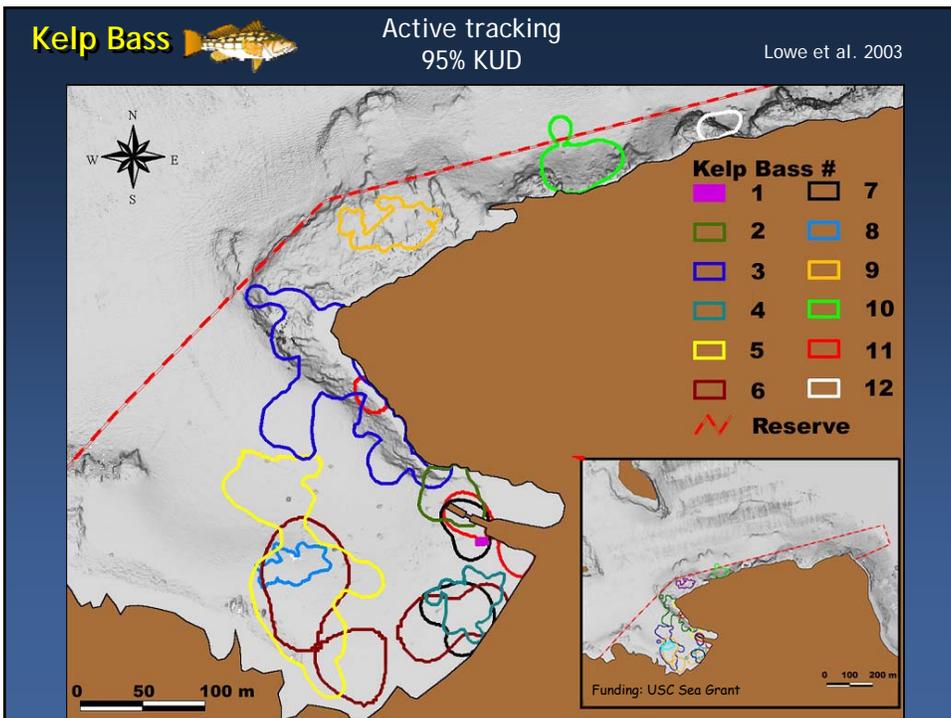
-  Population protection scales with movement and MPA size
-  Movement affects the amount of spillover from an MPA (pros and cons)
-  MPAs need to protect all the habitats that fish (and invertebrates) use over their lifetime

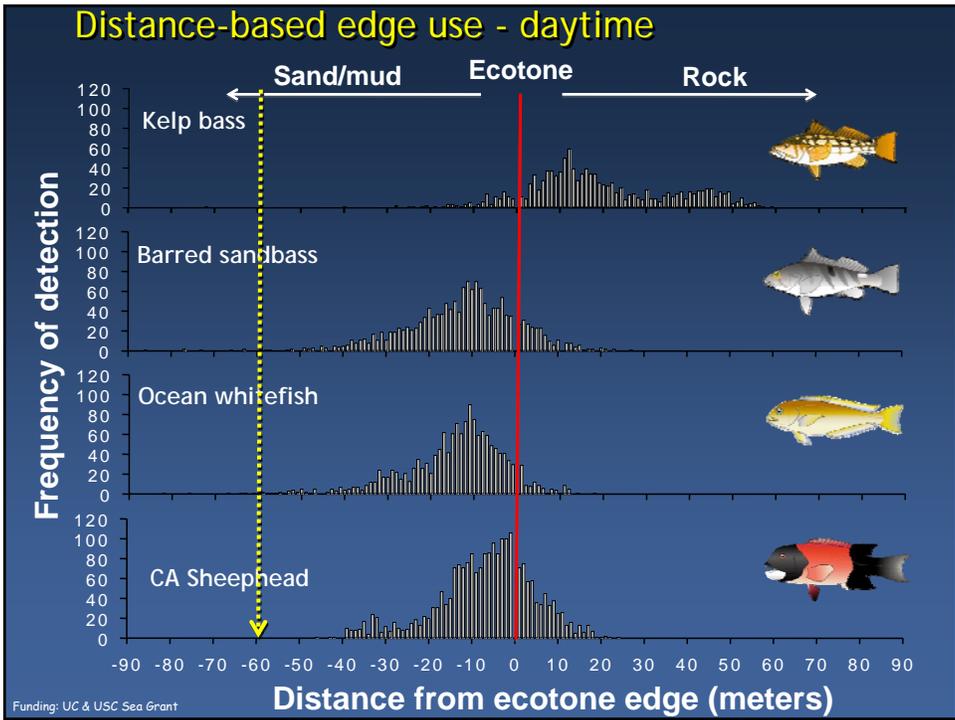
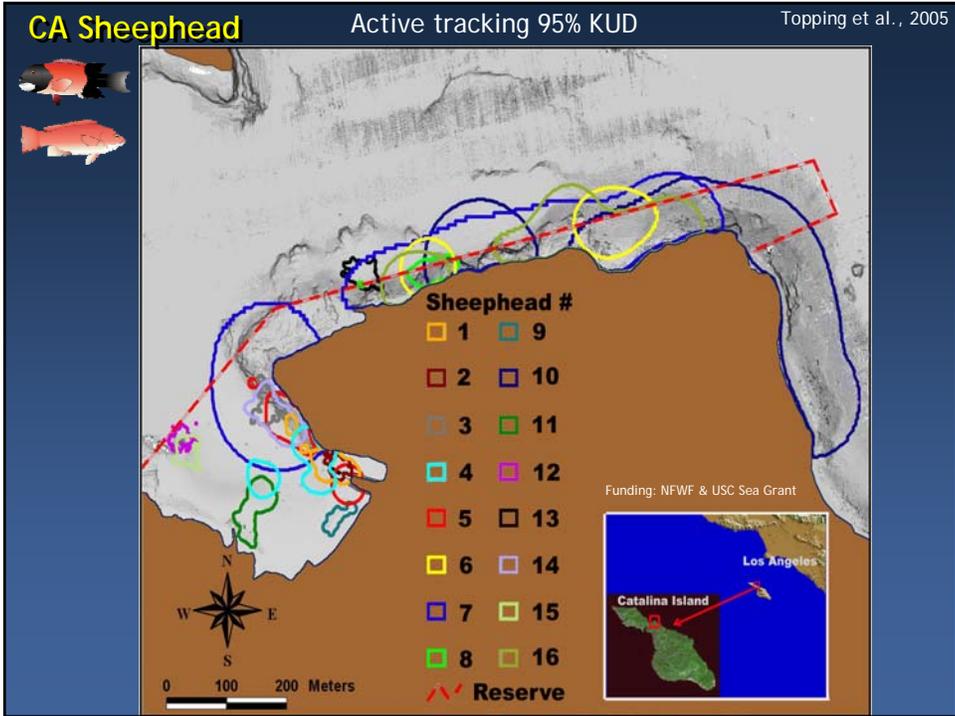
Population Protection Scales With Home Range and MPA Size



How Do We Know About Adult Movements?

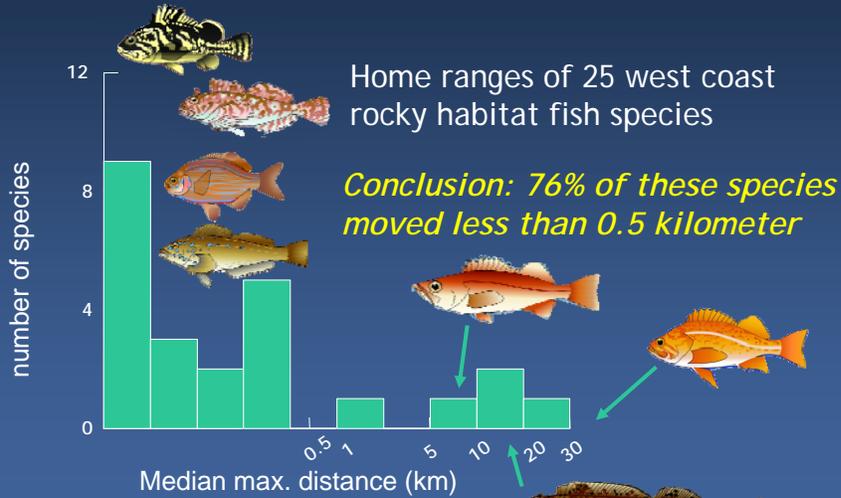
Fishing, Direct Observation, Acoustics, Tagging,
Genetics, Current and Habitat Associations





Adult Movement

Marine Reserve Size



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)

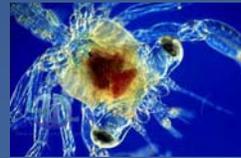
Protecting Populations

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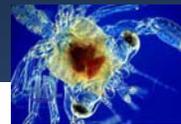
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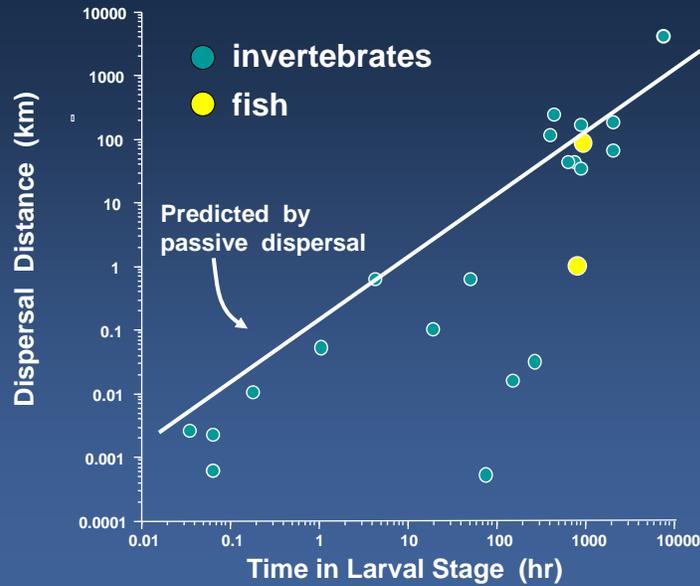
MPAs must be close enough together that larvae can move from one to the next



Reserves Connected by Larval Dispersal



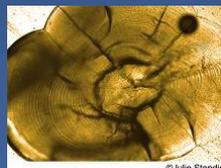
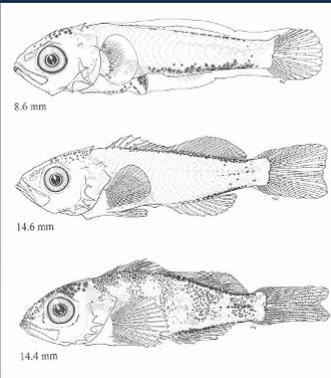
Pelagic duration: a proxy for dispersal potential



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

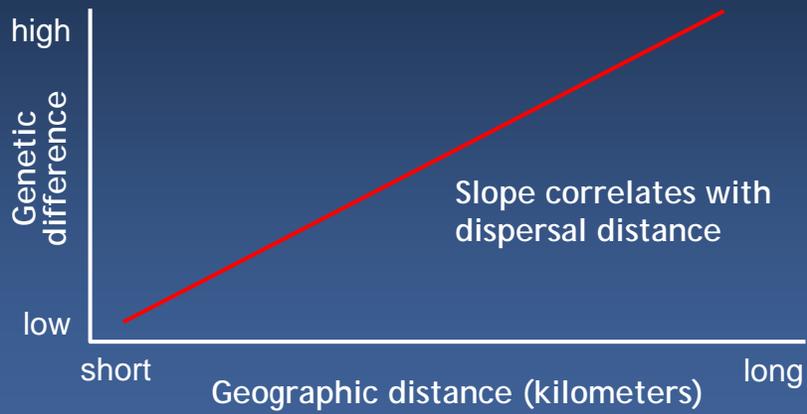


AVERAGE = 94 days

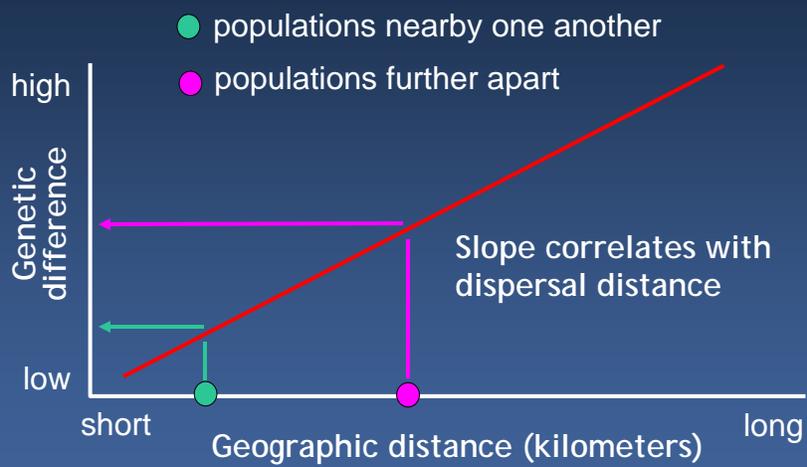
Shanks et al. 2003

Genetic Approaches

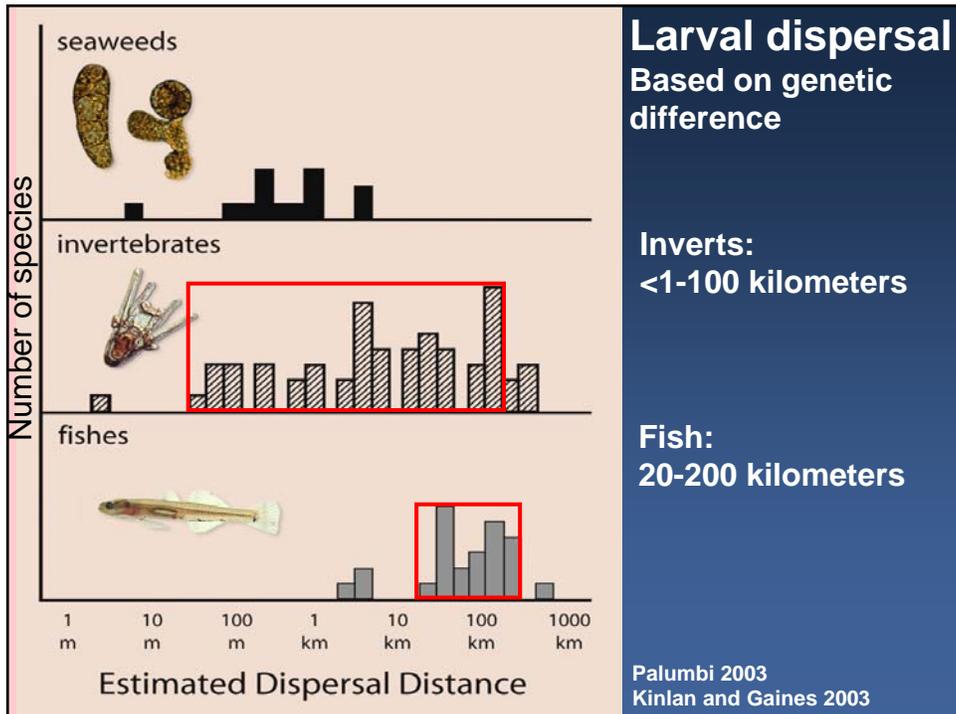
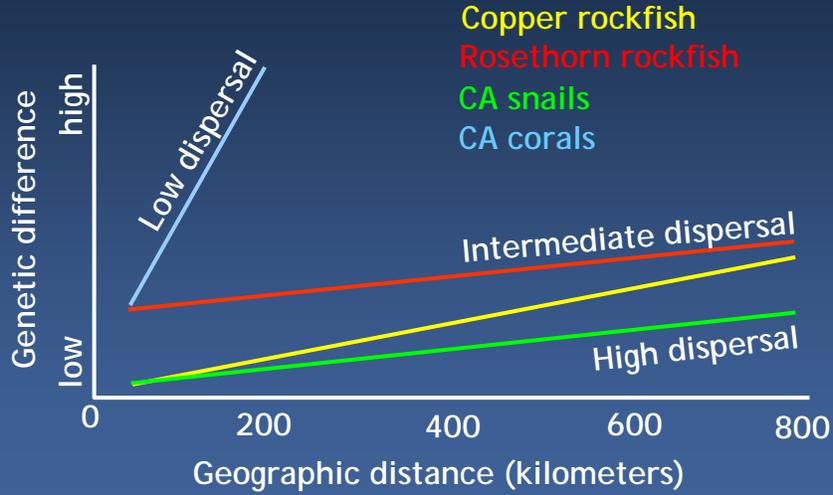
geographic distance \approx genetic difference



Geographic distance \approx genetic difference



Genetic Difference



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