Science-Based Design for Effective Marine Reserves: Lessons from the California Marine Life Protection Act Initiative—presentation by Rick Starr, University of California Sea Grant, and Mark Carr, University of California, Santa Cruz

The design of marine reserves needs to match the goals and objectives for management or conservation of the area. The CA Marine Life Protection Act of 1990 has 6 goals, 4 of which are directly addressed with marine protected area (MPA) design:

1. Protect natural diversity and ecosystem functions
2. Sustain and restore marine life populations
3. Protect representative and unique habitats
4. Ensure that MPAs are designed and managed as a network

The Marine Life Protection Act Science Advisory Team (SAT), composed of scientific advisors appointed by California Department of Fish and Game, provided the scientific support for the Marine Life Protection Act Initiative and developed the information found here.

Key habitats were identified using:

- Bottom type and depth
- Biogenic habitat
- Oceanographic features

Species were identified according to their affiliation with the key habitats (Figure 1):

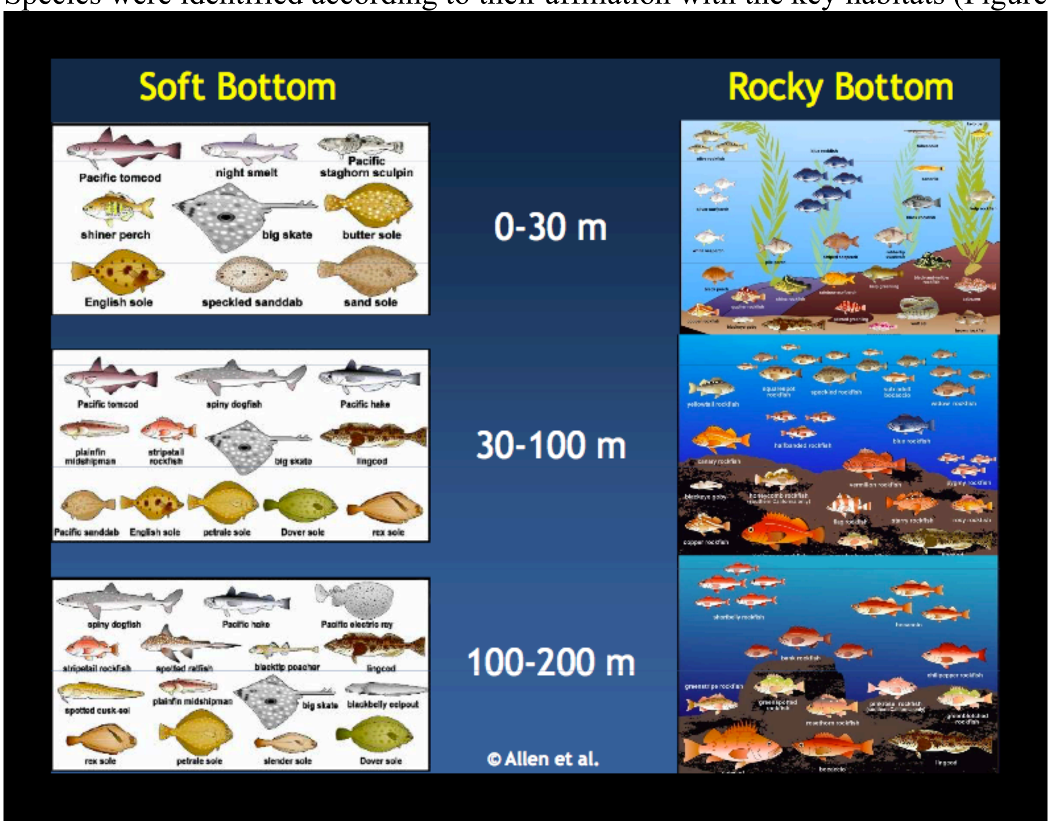

Figure 1. Fish species commonly associated with hard and soft bottom habitats in nearshore California.

Size of reserves should be based on range of adult movement.
In order to effectively protect individuals of a species, marine protected areas or marine reserves should be large enough to assure that at least some individuals will stay within them for most of their natural lifespan. In California, reserve size was set according to the median maximum or 75th percentile of the maximum range of adult movement for different species, primarily because adults are the targeted size class of fisheries. Data for this analysis came primarily from published studies that used information on movement from tagged fish (Figure 2).

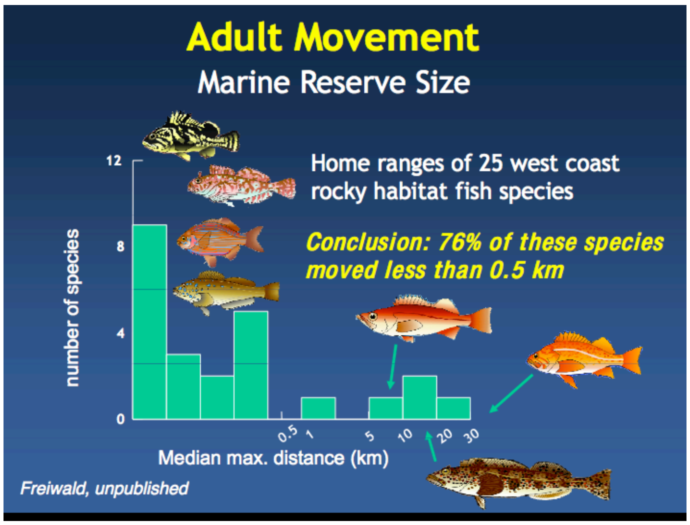

Figure 2. Chart showing the median of the maximum movement distance for each of 25 species of nearshore California fishes.

Once movement and home ranges have been identified for a variety of species, a chart of what species can be protected for different sized reserves can be rendered (Figure 3):

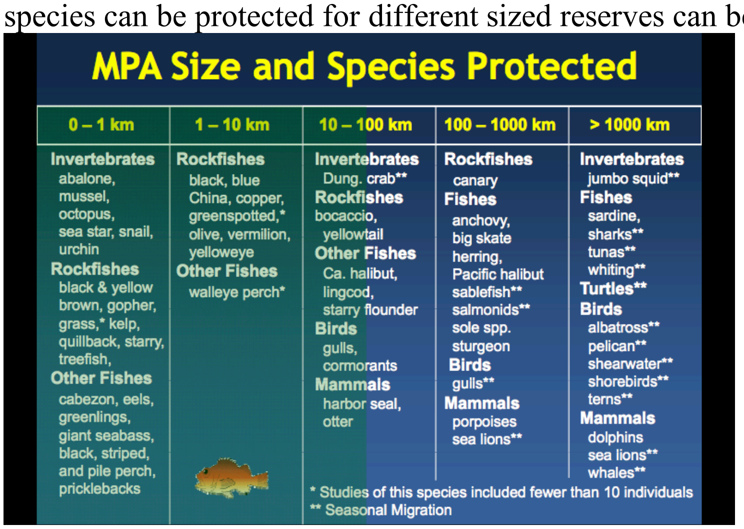

Figure 3. Species that are likely to benefit from reserves of increasing size, based on California species lists. Each species is categorized by its home range distance according to the typical movements of that species (population density, or the number of individuals that would benefit, is not included).

From this process, the California MLPA size guidelines to meet stated goals and objectives were determined to be:

- Minimum alongshore span of 5-10 km (3-6 miles)
- Preferably 10-20 km (6-12 miles)
- Extend from the intertidal zone to the offshore boundary of state waters (3 miles offshore)

Most of the species listed in these figures and tables are found in Oregon state waters.

Marine reserve spacing should be based on larval dispersal

MPAs should be spaced far enough apart to maximize the length of coastline replenished by larvae produced within MPAs, but close enough together that *larvae* have the potential to be exported from one to the next (Figure 4):

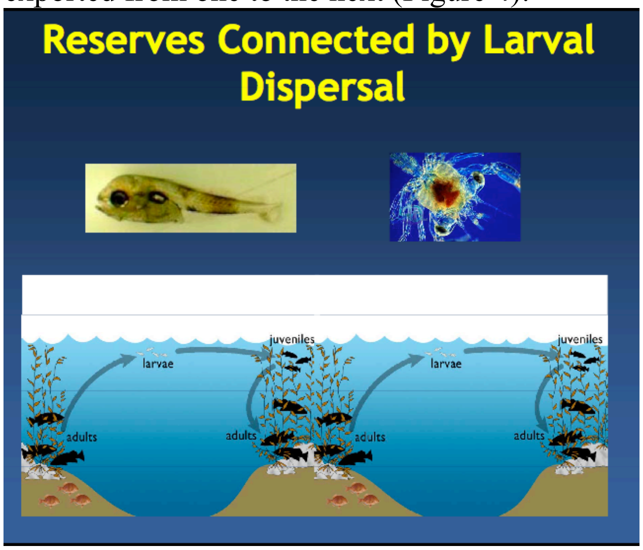

Figure 4. Conceptual model of how local fish populations contribute to the replenishment of one another, connected by the transport of larvae by currents.

Dispersal distance can be estimated by the length of time larvae spend in the pelagic stage. As shown in Figure 5, the longer larvae spend in the pelagic stage, the farther they go:

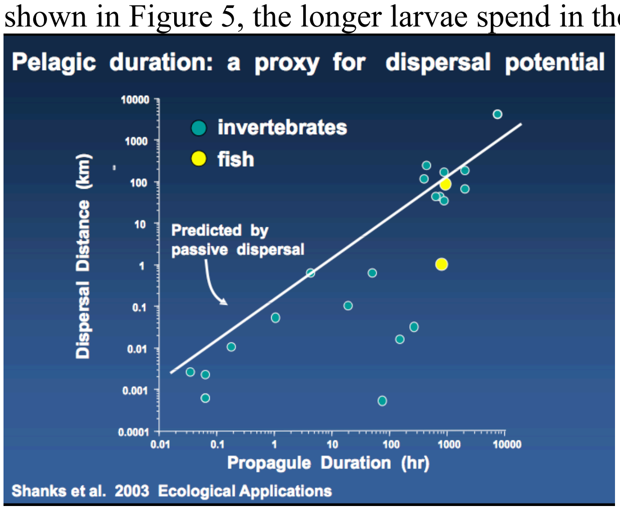

Figure 5. This plot shows a significant positive correlation between larvae (propagule) duration in the pelagic stage and dispersal distance (km).

An additional method used to confirm dispersal distance is genetic differences. Genetic tests can be performed to see how closely related two organisms or populations are. The slope of the relationship between geographic distance and genetic difference can estimate the distance that larvae of a species are dispersed (i.e. transported by currents). The lower the slope, the longer the average dispersal distance (Figure 6).

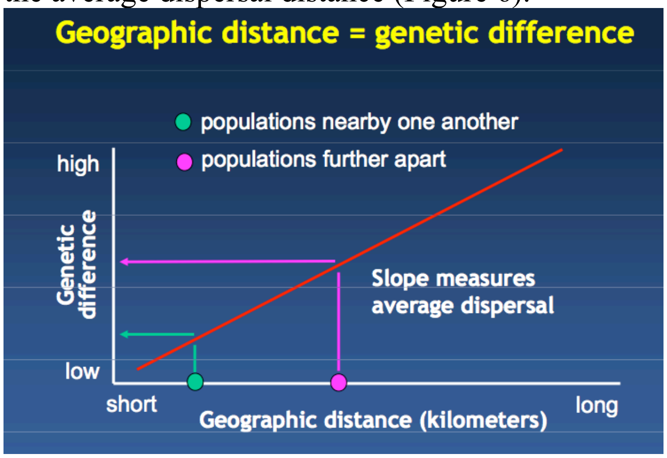

Figure 6. Conceptual graph of how genetic difference relates to geographic distance. For a given average dispersal distance (indicated by the slope of the line), populations further apart show greater genetic difference than close by populations.

Based in this genetic data, generalizations of larval dispersal can be made for invertebrates and fish (Figure 7). The estimates of larval dispersal from genetic studies are similar to the estimates from the time spent in the pelagic stage. This similarity reinforces the estimates.

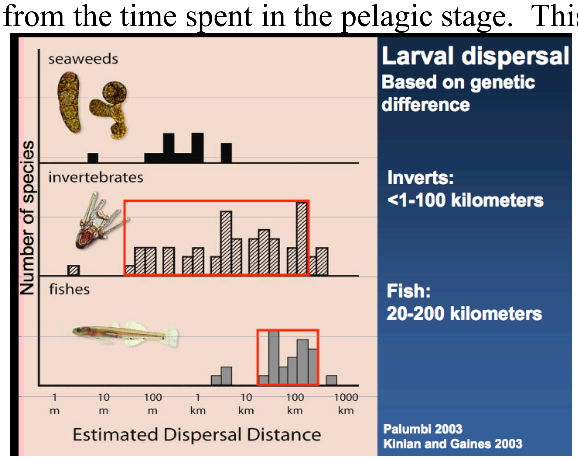

Figure 7. Estimates of larval dispersal distances for invertebrates and fish species based on genetic evidence

By combining size information and spacing information, guidelines for size and spacing were developed. To aid the process, the SAT developed minimum and preferred guidelines.

Size guidelines:

- 5-10 km, minimum
- 10-20 km, preferred
- Intertidal to deep waters

Spacing guidelines:

- 50-100 km apart

Size and spacing are inter-related

- Smaller MPAs should be closer together
- Larger MPAs may be spaced farther apart

Finally, the CA MLPA Scientific Advisory Team explored the issue of how much habitat should be present within a protected area to qualify as sufficient to contribute to a network and be considered as a replicate of that habitat. Most areas considered for MPAs included multiple habitat types; this is desirable, because it increases the diversity of species that would be within a protected area. Guidelines for minimum habitat area needed to protect biodiversity were developed based on species-area relationships (Figure 8). The graphs show the accumulation of possible species in a habitat as the size of the habitat area increases.

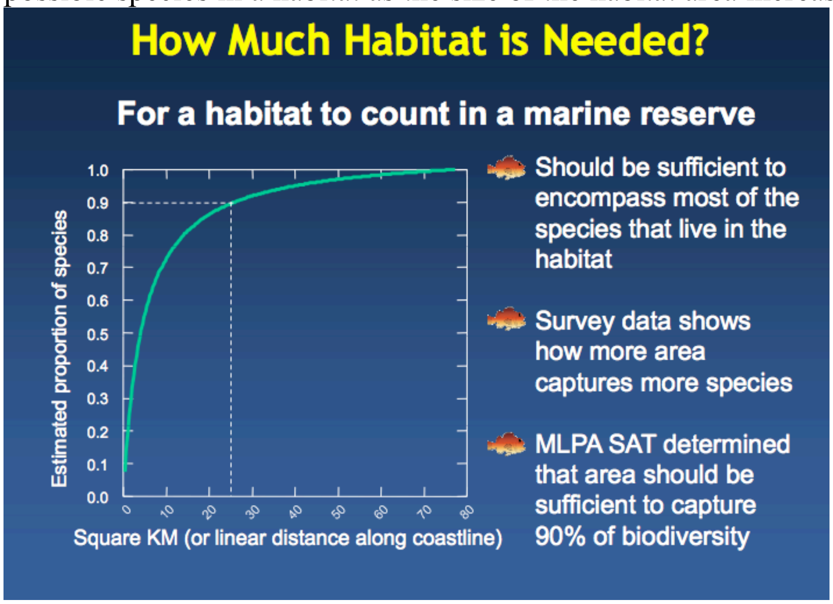

Figure 8. Guidelines for minimum habitat area needed to protect biodiversity developed by the CA MLPA Scientific Advisory Team

The presentation ended with emphasis on how these analyses were used as guidelines for the stakeholders to make decisions. These science-based results were used as guidelines, but stakeholders drew actual lines of the MPAs.