Appendix A: Bibliographies of reserve response papers

This list is not meant to be comprehensive, and does not include modeling papers designed to evaluate the fisheries effects of reserves. A list of species reference papers can be obtained from the authors (Selina.Heppell@oregonstate.edu) and through the ODFW website on the Nearshore Strategy.

Marine Reserve papers that include a focus on temperate (cold water) ecosystems

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Botsford, L., Micheli, F., Hastings, A. 2003. Principles for the design of marine reserves. Ecological Applications. 13(1): S25-S31.

Branch, G. M., and F. Odendaal. 2003. The effects of marine protected areas on the population dynamics of a South African limpet, *Cymbula oculus*, relative to the influence of wave action. *Biological Conservation* 114:255-269

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Davidson, R. J., E. Villouta, R. G. Cole, and R. G. F. Barrier. 2002. Effects of marine reserve protection on spiny lobster (*Jasus edwardsii*) abundance and size at Tonga Island Marine Reserve, New Zealand. *Aquatic Conservation-Marine and Freshwater Ecosystems* 12:213-227.

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Edgar, G. J., and N. S. Barrett. 1999. Effects of the declaration of marine reserves on Tasmanian reef fishes, invertebrates and plants. *Journal of Experimental Marine Biology and Ecology* 242:107-144.

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Kaplan, D., Botsford, L., Jorgensen, S. 2006. Dispersal per recruit: an efficient method for assessing sustainability in marine reserve networks. Ecological applications. 16(6): 2248-2263.

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Langlois, T. J., M. J. Anderson, and R. C. Babcock. 2005. Reef-associated predators influence adjacent soft-sediment communities. *Ecology* 86:1508-1519

Langlois, T., M. Anderson and R. Babcock. 2006. Inconsistent effects of reefs on different size classes of macrofauna in adjacent sand habitats. *Journal of Experimental Marine Biology and Ecology* 334: 269-282

Lloret, J., and S. Planes. 2003. Condition, feeding and reproductive potential of white seabream *Diplodus sargus* as indicators of habitat quality and the effect of reserve protection in the northwestern Mediterranean. *Marine Ecology Progress Series* 248:197-208

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Macpherson, E., A. Garcia-Rubies, and A. Gordoa. 2000. Direct estimation of natural mortality rates for littoral marine fishes using populational data from a marine reserve. *Marine Biology* 137:1067-1076

Manriquez, P. H., and J. C. Castilla. 2001. Significance of marine protected areas in central Chile as seeding grounds for the gastropod *Concholepas concholepas*. *Marine Ecology Progress Series* 215:201-211

Mayfield, S., G. M. Branch, and A. C. Cockcroft. 2005. Role and efficacy of marine protected areas for the South African rock lobster, *Jasus lalandii*. *Marine and Freshwater Research* 56:913-924

Micheli, F., L. Benedetti-Cecchi, S. Gambaccini, I. Bertocci, C. Borsini, G. C. Osio, and F. Roman. 2005. Cascading human impacts, marine protected areas, and the structure of Mediterranean reef assemblages. *Ecological Monographs* 75:81-102

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Ojeda-Martinez, C., J. Bayle-Sempere, P. Sánchez-Jerez, A. Forcada and C. Valle. 2007. Detecting conservation benefits in spatially protected fish populations with meta-analysis of long-term monitoring data. *Marine Biology* 151: 1153-1161

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Wagner, L., Ross, J., Possingham, H. 2007. Catastrophe management and inter-reserve distance for marine reserve networks. Ecological modelling. 201: 82–88.

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Tropical Reserve response papers

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Abesamis, Rene A.; Russ, G. R., and Alcala, A. C. 2006. Gradients of abundance of fish across no-take marine reserve boundaries: evidence from Philippine coral reefs. Aquatic Conservation: Marine and Freshwater Ecosystems. 16: 349–371

Aguilar-Perera, A. 2007. Disappearance of a Nassau grouper spawning aggregation off the southern Mexican Caribbean coast. Marine Ecology Progress Series. 327: 289-296.

Alcala, A., Russ, G. 2006. No-take marine reserves and reef fisheries management in the Philippines: a new people power revolution. Ambio. 35: 245-254.

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Crawford. 2006. Factors influencing progress in establishing community based mpas in Indonesia.

Giacalone, V., D'Anna, G., Pipitone, C., Badalamenti, F. 2006. Movements and residence time of spiny lobsters, Palinurus elephas released in a marine protected area: an investigation by ultrasonic telemetry. Journal of the Marine Biological Association of the United Kingdom. 86: 1101-1106.

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Hawkins, J. 2006. Effects of habitat characteristics and sedimentation on performance of marine reserves in St. Lucia. Biological Conservation. 127: 487-499.

Hereu, B., et al. 2006. Temporal patterns of spawning of the dusky grouper *Epinephelus marginatus* in relation to environmental factors. Marine Ecology Progress Series. 325: 187-194.

Mumby, P. 2006. Connectivity of reef fish between mangroves and coral reefs: Algorithms for the design of marine reserves at seascape scales. Biological Conservation. 128: 215-222.

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Mumby 2006. Impact of exploiting grazers (Scaridae) on the dynamics of Caribbean coral reefs. Ecological Applications. 16(2): 747-769.

Newman, M., Paredes, G., Sala, E., Jackson, J. 2006. Letter: Structure of Caribbean coral reef communities across a large gradient of fish biomass. Ecology Letters. 9: 1216-1227.

Pillans, S., Ortiz, J., Pillans, R., Possingham, H. 2007. The impact of marine reserves on nekton diversity and community composition in subtropical eastern Australia. Biological Conservation. 136: 455-469. SUBTROPICAL

Purcell, J., Cowen, R., Hughes, C., Williams, D. 2006. Weak genetic structure indicates strong dispersal limits: a tale of two coral reef fish. Proceedings of the Royal Society Biological Sciences Series B. 273: 483-1490.

Smith, M., Zhang, J., Coleman, F. 2006. Effectiveness of marine reserves for large-scale fisheries management. Canadian Journal of Fisheries and Aquatic Sciences. 63: 153-164.

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Appendix B: Size and Spacing Meeting Information

Meeting Agenda

Final Agenda (updated 04/10/08)

April 9 (Wednesday) EVENING SOCIAL starts at 7pm in the Dining Hall

Day 1 Thursday, April 10
Breakfast in the Dining Hall and coffee provided

8:30 am Welcome, Introductions and Overview of our task at hand

Welcome to OIMB	Craig Young, OIMB
OPAC process: how we got here	Greg McMurray, OPAC
STAC roles and current requests from Marine Reserves Working Group	Selina Heppell, OSU
Review of draft goals and objectives approved by OPAC Work Plan for this meeting	Jack Barth, OSU

Questions, discussion

BREAK to load presentations

9:30 am Short presentations – please limit to 20 minutes

Review of the "rules of thumb" developed for reserve siting in CA	Rick Starr, Moss Landing Marine Lab and Mark Carr, UCSC
Review of theoretical approaches	Will White, UCDavis
Review of data on invertebrates and larval dispersal	Alan Shanks and Craig Young, U Oregon
Review of available data and maps	
Physical oceanography: chemistry, currents and dispersion models	Mike Kosro and Hal Batchelder, OSU
Fine-scale habitat mapping and species associations	Dave Fox, ODFW
Habitat Maps	Chris Goldfinger, OSU

LUNCH at OIMB
2pm – Work Session begins

Issue #1: Size and configuration?

- Review of existing synthesis documents on relationship between reserve size and biological response – what responses can be expected for reserves of different size?
- Review available data on home range, movement of adults and juveniles of local species
- Review habitat types and maps, discuss need to extend shore-based reserves to deeper water
- Discuss approaches, recommendations that can be made with existing data, certainty of those recommendations, and what additional synthesis or research could be done over the short- and longer-term

BREAK

Issue #2: Spacing?

- Review data and theory on network concepts, connectivity
- Review dispersal information, habitat distribution, and physical oceanography of the Oregon coast
- Discuss approaches, recommendations that can be made with existing data, certainty of those recommendations, and what additional synthesis or research could be done over the short- and longer-term

Additional discussion as needed. Break around 5:30.

DINNER at OIMB 6:30 pm

Day 2 Friday, April 11
Breakfast in the Dining Hall and coffee provided

8:30 am Synthesis: Matching Oregon's objectives to what we know

- What can be recommended, based on available information?
- Is there short-term (< 1 year) data gathering or synthesis that could contribute?
- How do size and spacing recommendations vary according to goals and objectives?
- Develop consensus statements for report to OPAC

BREAK

Continue Synthesis Discussion and outline report to OPAC
Next Steps

Conclusion of the Workshop – noon on April 11.

Workshop request memo from OPAC to STAC

MEMO

DATE: April 4, 2008

TO: STAC

FROM: OPAC Marine Reserves Working Group

SUBJECT: Request for information on size, spacing and other attributes of marine reserves in Oregon's Territorial Sea.

The MRWG is requesting the STAC to recommend guidelines for the marine reserve nomination process based on available biological and ecological data at your next planned workshop. In recognition of the limited time available before the nomination process for marine reserves, the MRWG requests the STAC provide their best guidance on the following questions:

- How do we identify "special places" in nearshore Oregon, such as biodiversity hotspots, unique habitat features etc. using available habitat maps and biological information.

- What guidelines should we use for minimum size and spacing for reserves (i.e. networks or systems) to meet our stated goals and objectives, and what is the relationship between reserve properties (size, configuration, habitat-types, depths) and the likelihood of meeting those objectives?

- What research data is available and what is known and not known with respect to physical, biological and ecological information that contributes to these recommendations?

- Can you provide us with other supporting information which the STAC considers relevant for the placement of marine reserves, development of coastwide reserve planning guidelines, or evaluation of publicly nominated sites?

List of Meeting Participants and Contact Information

Participants

	Name	e-MAIL ADDRESS	Affiliation
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34	Emily Saarman	emily@biology.ucsc.edu	PISCO
35	Kayla Thomas	thomas.kayla@gmail.com	OSU

Appendix C: List of Oregon nearshore species (mostly fishes) and their habitats

Prepared by C. Don, Oregon Department of Fish and Wildlife; species list based on ODFW Nearshore Strategy, http://www.dfw.state.or.us/MRP/nearshore/index.asp

				Habitat Type(s)									
	Common Name	**Scientific Name**	**Life History Stage**	**Hard Bottom Subtidal (no kelp)**	**Hard Bottom Subtidal (with kelp)**	**Soft Bottom Subtidal**	**Pelagic**	**Estua-rine**	**Rocky Inter-tidal**	**Soft Bottom Inter-tidal**	**Habitat Un-known**	**Predom-inately Nearshore, Offshore, or Mixed?**	**Habitat Notes**
1	**Big skate**	*Raja binoculata*	Adults			x						mixed	
			Juveniles			x						nearshore	
			Lg Juveniles	na	na	na	na	na	na	na	na	na	
			Larvae	na	na	na	na	na	na	na	na	na	
2	**Black rockfish**	*Sebastes melanops*	Adults	x	x		x	x				nearshore	High-relief rocky reefs. Boulder fields. Midwater.
			Juveniles	x	x	x	x	x	x			nearshore	Nearshore sand-rock interface. High rock. Seagrass beds. Midwater. Tidepools.
			Lg Juveniles	x	x	x	x	x	x			nearshore	
			Larvae				x					mixed	
3	**Black-and-yellow rockfish**	*Sebastes chrysomelas*	Adults	x	x	x						nearshore†	† Species does not occur throughout Oregon (Cape Blanco northern extent of range). Spawning not known to occur in Oregon waters.
			Juveniles	x	x	x*			x			nearshore†	* Not known to occur over soft bottom habitats in Oregon waters.
			Lg Juveniles	x	x	x						nearshore†	
			Larvae		x*		x*					*	* Not known to occur in Oregon waters.
4	**Blue rockfish**	*Sebastes mystinus*	Adults	x	x							mixed	
			Juveniles	x	x		x		x			nearshore	
			Lg Juveniles	x	x	x						nearshore	
			Larvae				x					nearshore	
5	**Bocaccio**	*Sebastes paucispinis*	Adults	x	x	x						offshore	
			Juveniles	x	x	x	x	x				nearshore	
			Lg Juveniles	x	x	x						mixed	
			Larvae				x	x				mixed	

				Habitat Type(s)									
	Common Name	**Scientific Name**	**Life History Stage**	**Hard Bottom Subtidal (no kelp)**	**Hard Bottom Subtidal (with kelp)**	**Soft Bottom Subtidal**	**Pelagic**	**Estua-rine**	**Rocky Inter-tidal**	**Soft Bottom Inter-tidal**	**Habitat Un-known**	**Predom-inately Nearshore, Offshore, or Mixed?**	**Habitat Notes**
6	**Brown rockfish**	*Sebastes auriculatus*	Adults	**x**	**x**			**x**				mixed	
			Juveniles	**x**	**x**			**x**				nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae					**x**					
7	**Bull kelp**	*Nereocystis luetkeana*	Adults		**x**							nearshore	
			Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
8	**Cabezon**	*Scorpaenichthys marmoratus*	Adults	**x**				**x**				nearshore	
			Juveniles	**x**	**x**		**x**	**x**	**x**			mixed	
			Lg Juveniles	**x**				**x**				nearshore	
			Larvae				**x**	**x**				mixed	
9	**California mussel**	*Mytilus californianus*	Adults	**x**					**x**			nearshore	Rock. Exposed. Attached. Located in high wave energy areas.
			Juveniles	**x**					**x**			nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**						
10	**California sea lion**	*Zalophus californianus*	Adults	**x**	**x**		**x**	**x**	**x**	**x**		nearshore	Only males found in Oregon. Haul-out on land and man made structures. California sea lions do not breed in Oregon.
			Juveniles	**x***	**x***		**x***		**x***	**x***		*	* Do not occur in Oregon (pups stay with females).
			Lg Juveniles	**x**	**x**		**x**		**x**	**x**			
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
11	**Canary rockfish**	*Sebastes pinniger*	Adults	**x**								offshore	
			Juveniles	**x**	**x**	**x**	**x**		**x**			mixed	Sand, mud, and gravel. Low rock and cobble.
			Lg Juveniles	**x**								mixed	
			Larvae				**x**					mixed	

	Common Name	Scientific Name	Life History Stage	Habitat Type(s) Hard Bottom Subtidal (no kelp)	Hard Bottom Subtidal (with kelp)	Soft Bottom Subtidal	Pelagic	Estua-rine	Rocky Inter-tidal	Soft Bottom Inter-tidal	Habitat Un-known	Predom-inately Nearshore, Offshore, or Mixed?	Habitat Notes
12	**China rockfish**	*Sebastes nebulosus*	Adults	**x**								nearshore	Rock and cobble.
			Juveniles	**x**			**x**					nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**					nearshore	
13	**Copper rockfish**	*Sebastes caurinus*	Adults	**x**	**x**			**x**				nearshore	
			Juveniles		**x**	**x**	**x**	**x**				nearshore	Seagrass. Low growing algae. Rock and cobble. High-relief rock. Sand and low rock.
			Lg Juveniles	**x**	**x**			**x**				nearshore	
			Larvae					**x**					
14	**Dungeness crab**	*Cancer magister*	Adults			**x**		**x**		**x**		mixed	Sand. Occasionally mud. Eelgrass.
			Juveniles			**x**		**x**		**x**		mixed	Sand, mud. Eelgrass.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**					mixed	Upper 20 m of water column. Larvae are carried offshore by surface currents during late winter and spring.
15	**Eulachon**	*Thaleichthys pacificus*	Adults				**x**	**x**			**x**		Anadromous.
			Juveniles				**x**				**x**		
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**	**x**			**x**		Carried downstream and out to sea.
16	**Flat abalone**	*Haliotis walallensis*	Adults		**x**				**x**			nearshore	Kelp. Rocky reefs.
			Juveniles		**x**				**x**			nearshore	Crevices. Rocky reefs, rocks, boulders.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**					nearshore	
17	**Giant octopus**	*Octopus dofleini*	Adults	**x**		**x**			**x**			nearshore	Prefer rocky substrates. Rock, sand, mud.
			Juveniles				**x**					nearshore	
			Lg Juveniles	**x**					**x**			nearshore	Rocks, crevices, rocky substrate.
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	

	Common Name	Scientific Name	Life History Stage	Habitat Type(s): Hard Bottom Subtidal (no kelp)	Hard Bottom Subtidal (with kelp)	Soft Bottom Subtidal	Pelagic	Estua-rine	Rocky Inter-tidal	Soft Bottom Inter-tidal	Habitat Un-known	Predom-inately Nearshore, Offshore, or Mixed?	Habitat Notes
18	**Gopher rockfish**	*Sebastes carnatus*	Adults	**x**	**x**	**x**						nearshore†	† Species does not occur throughout Oregon (Cape Blanco northern extent of range). Spawning not known to occur in Oregon waters.
			Juveniles	**x**	**x**	**x**	**x***		**x**			nearshore†	* Pelagic juveniles not known to occur in Oregon waters.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae		**x***		**x***					*	* Not known to occur in Oregon waters.
19	**Grass rockfish**	*Sebastes rastrelliger*	Adults	**x**	**x**							nearshore†	† Species does not occur throughout Oregon (Yaquina Bay northern extend of range).
			Juveniles	**x**	**x**	**x**			**x**			nearshore†	Low growing algae. Tidepools.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**						
20	**Gray whale**	*Eschrichtius robustus*	Adults		**x**	**x**	**x**	**x***				nearshore	* Breeding occurs in bays in Baja.
			Juveniles			**x**	**x**	**x***				nearshore	* Breeding occurs in bays in Baja.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
21	**Green sturgeon**	*Acipenser medirostris*	Adults			**x**		**x**			**x**	nearshore	
			Juveniles					**x**				nearshore	Migrate to sea during second year.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae										Freshwater rivers.
22	**Harbour porpoise**	*Phocoena phocoena*	Adults			**x**	**x**				**x**	mixed	
			Juveniles				**x**				**x**		
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
23	**Kelp greenling**	*Hexagrammos decagrammus*	Adults	**x**	**x**			**x**				nearshore	
			Juveniles	**x**	**x**		**x**	**x**				mixed	
			Lg Juveniles	**x**	**x**			**x**				nearshore	
			Larvae				**x**	**x**				mixed	Newly hatched larvae move out of estuaries or shallow nearshore into open waters.

				Habitat Type(s)									
	Common Name	**Scientific Name**	**Life History Stage**	**Hard Bottom Subtidal (no kelp)**	**Hard Bottom Subtidal (with kelp)**	**Soft Bottom Subtidal**	**Pelagic**	**Estua-rine**	**Rocky Inter-tidal**	**Soft Bottom Inter-tidal**	**Habitat Un-known**	**Predom-inately Nearshore, Offshore, or Mixed?**	**Habitat Notes**
24	**Lingcod**	*Ophiodon elongatus*	Adults	**x**	**x**	**x**		**x**				mixed	
			Juveniles	**x**	**x**		**x**	**x**				nearshore	
			Lg Juveniles	**x**	**x**	**x**		**x**				nearshore	
			Larvae				**x**	**x**				nearshore	
25	**Northern anchovy**	*Engraulis mordax*	Adults				**x**					mixed	
			Juveniles				**x**					nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**					mixed	
26	**Northern elephant seal**	*Mirounga angustirostris*	Adults	**x**	**x**		**x**			**x**		mixed	Generally do not breed in Oregon. Cape Arago State Park (Coos Bay) is only spot where elephant seals haul-out year-round in Oregon. Supratidal on sandy and gravel beaches.
			Juveniles							**x**		nearshore	Weaners stay mainly on land, with short periods of time spent in the water.
			Lg Juveniles	**x**	**x**		**x**			**x**		mixed	The majority of the elephant seals seen in Oregon are sub-adult animals that come to shore to molt.
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
27	**Ochre sea star**	*Pisaster ochraceus*	Adults	**x**					**x**			nearshore	Rocky shores. Exposed and protected areas.
			Juveniles	**x**					**x**			nearshore	Found in crevices and under rocks. Little known.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**					nearshore	
28	**Pacific harbor seal**	*Phoca vitulina*	Adults	**x**	**x**		**x**	**x**	**x**	**x**		nearshore	
			Juveniles		**x**		**x**	**x**		**x**		nearshore	Also on land.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
29	**Pacific herring**	*Clupea pallasii*	Adults				**x**	**x**				mixed	
			Juveniles				**x**	**x**					
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae					**x**					

				Habitat Type(s)									
	Common Name	**Scientific Name**	**Life History Stage**	**Hard Bottom Subtidal (no kelp)**	**Hard Bottom Subtidal (with kelp)**	**Soft Bottom Subtidal**	**Pelagic**	**Estua-rine**	**Rocky Inter-tidal**	**Soft Bottom Inter-tidal**	**Habitat Un-known**	**Predom-inately Nearshore, Offshore, or Mixed?**	**Habitat Notes**
30	**Pile perch**	*Rhacochilus vacca*	Adults	**x**	**x**	**x**						nearshore	Surfgrass.
			Juveniles		**x**	**x**		**x**				nearshore	Surfgrass.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
31	**Purple sea urchin**	*Strongylocentrotus purpuratus*	Adults	**x**	**x**				**x**			nearshore	Rocky shores. Strong wave action.
			Juveniles	**x**	**x**				**x**			nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**						
32	**Quillback rockfish**	*Sebastes maliger*	Adults	**x**	**x**			**x**				mixed	
			Juveniles	**x**	**x**	**x**	**x**	**x**				nearshore	
			Lg Juveniles	**x**	**x**			**x**				nearshore	
			Larvae				**x**	**x**				nearshore	
33	**Razor clam**	*Siliqua patula*	Adults			**x**				**x**		nearshore	Exposed/open sandy beaches.
			Juveniles			**x**				**x**		nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**					nearshore	Eggs and larvae are dispersed by ocean currents. Free swimming in water column near bottom.
34	**Red abalone**	*Haliotis rufescens*	Adults		**x**				**x**			nearshore[†]	† Species does not occur throughout Oregon (Cape Arago northern extent of range). Exposed/open. Boulders and rocky reefs.
			Juveniles		**x**				**x**			nearshore[†]	Settle on coralline red algae. Found inbetween rocks and boulders.
			Lg Juveniles		**x**				**x**			nearshore[†]	Rock crevices.
			Larvae				**x***					nearshore[†]*	* Do not mate at northern end of range (Cape Arago, OR). Pelagic until developing shell becomes too heavy.
35	**Red sea urchin**	*Strongylocentrotus franciscanus*	Adults	**x**	**x**				**x**			nearshore	
			Juveniles	**x**	**x**				**x**			nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**				**x**		

				Habitat Type(s)									
	Common Name	**Scientific Name**	**Life History Stage**	**Hard Bottom Subtidal (no kelp)**	**Hard Bottom Subtidal (with kelp)**	**Soft Bottom Subtidal**	**Pelagic**	**Estua-rine**	**Rocky Inter-tidal**	**Soft Bottom Inter-tidal**	**Habitat Un-known**	**Predom-inately Nearshore, Offshore, or Mixed?**	**Habitat Notes**
36	**Redtail surfperch**	*Amphistichus rhodoterus*	Adults			**x**						nearshore	Shallow surf and sandy bottoms.
			Juveniles					**x**					
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
37	**Rock greenling**	*Hexagrammos lagocephalus*	Adults	**x**	**x**							nearshore	
			Juveniles	**x**	**x**		**x**					nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**				**x**		
38	**Rock scallop**	*Hinnites giganteus*	Adults	**x**					**x**			nearshore	Protected rocky shores. Rock crevices. Attached to hard substrate.
			Juveniles	**x**			**x**		**x**			nearshore	Protected outer coast.
			Lg Juveniles	**x**					**x**			nearshore	
			Larvae				**x**						
39	**Sea palm**	*Postelsia palmaeformis*	Adults						**x**			nearshore	High energy areas only.
			Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
40	**Shiner perch**	*Cymatogaster aggregata*	Adults	**x**	**x**	**x**		**x**				nearshore	
			Juveniles					**x**				nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
41	**Spiny dogfish**	*Squalus acanthias*	Adults	**x**		**x**	**x**	**x**				mixed	
			Juveniles				**x**	**x**				mixed	
			Lg Juveniles	**x**		**x**	**x**	**x**				mixed	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
42	**Starry flounder**	*Platichthys stellatus*	Adults			**x**		**x**				nearshore	Gravel, sand, and mud.
			Juveniles					**x**				nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**	**x**				mixed	

				Habitat Type(s)									
	Common Name	**Scientific Name**	**Life History Stage**	**Hard Bottom Subtidal (no kelp)**	**Hard Bottom Subtidal (with kelp)**	**Soft Bottom Subtidal**	**Pelagic**	**Estua-rine**	**Rocky Inter-tidal**	**Soft Bottom Inter-tidal**	**Habitat Un-known**	**Predom-inately Nearshore, Offshore, or Mixed?**	**Habitat Notes**
43	**Steller sea lion**	*Eumetopias jubatus*	Adults	**x**	**x**		**x**	**x**	**x**			mixed	
			Juveniles	**x**	**x**		**x**		**x**			nearshore	
			Lg Juveniles	**x**	**x**		**x**		**x**			mixed	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
44	**Striped perch**	*Embiota lateralis*	Adults	**x**	**x**		**x**	**x**				nearshore	
			Juveniles	**x**	**x**			**x**				nearshore	Shallow water reefs amongst algae.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
45	**Surf grass**	*Phyllospadix spp.*	Adults	**x**	**x**				**x**			nearshore	
			Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
46	**Surf smelt**	*Hypomesus pretiosus*	Adults				**x**	**x**			**x**	nearshore	Little is known about habits in ocean.
			Juveniles				**x**				**x**	nearshore	Little known of juvenile habits.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**				**x**	nearshore	Little known about.
47	**Tiger rockfish**	*Sebastes nigrocinctus*	Adults	**x**								mixed	
			Juveniles	**x**			**x**				**x**		
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**				**x**		
48	**Topsmelt**	*Atherinops affinis*	Adults	**x**	**x**	**x**	**x**	**x**				nearshore	Surfgrass.
			Juveniles	**x**	**x**		**x**	**x**				nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**	**x**				nearshore	
49	**Vermilion rockfish**	*Sebastes miniatus*	Adults	**x**	**x**	**x**						mixed	Rocky shelf and boulder fields.
			Juveniles	**x**	**x**	**x**	**x**					nearshore	Nearshore sand-rock interface. Rocky shelf.
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**					nearshore	

				Habitat Type(s)									
	Common Name	**Scientific Name**	**Life History Stage**	**Hard Bottom Subtidal (no kelp)**	**Hard Bottom Subtidal (with kelp)**	**Soft Bottom Subtidal**	**Pelagic**	**Estua-rine**	**Rocky Inter-tidal**	**Soft Bottom Inter-tidal**	**Habitat Un-known**	**Predom-inately Nearshore, Offshore, or Mixed?**	**Habitat Notes**
50	**White sturgeon**	*Acipenser transmontanus*	Adults			**x**		**x**			**x**	nearshore	
			Juveniles					**x**				nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae					**x**				nearshore	Carried downstream to estuaries.
51	**Wolf-eel**	*Anarrhichthys ocellatus*	Adults	**x**	**x**							mixed	
			Juveniles				**x**					mixed	
			Lg Juveniles	**x**	**x**							mixed	
			Larvae				**x**				**x**		
52	**Yelloweye rockfish**	*Sebastes ruberrimus*	Adults	**x**								mixed	
			Juveniles	**x**			**x**					nearshore	
			Lg Juveniles	**na**	**na**	**na**	**na**	**na**	**na**	**na**	**na**	na	
			Larvae				**x**				**x**		
53	**Yellowtail rockfish**	*Sebastes flavidus*	Adults	**x**		**x**	**x**					mixed	
			Juveniles	**x**	**x**	**x**	**x**		**x**			mixed	
			Lg Juveniles	**x**		**x**	**x**					nearshore	
			Larvae				**x**					nearshore	

Appendix D. California MPA Guidelines – excerpt from Marine Life Protection Act

CALIFORNIA MARINE LIFE PROTECTION ACT INITIATIVE

MLPA MASTER PLAN FRAMEWORK

Adopted by the
California Fish and Game Commission
August 18, 2005
California Department of Fish & Game
August 22, 2005

Section 3. Considerations in the Design of MPAs
Accomplishing MLPA goals and objectives to improve a statewide network of MPAs will require the consideration of a number of issues, some of which are addressed in the MLPA itself. These are as follows:

- Goals of the Marine Life Protection Program
- MPA networks
- Types of MPAs
- Settling goals and objectives for MPAs
- Geographical regions
- Representative and unique habitats
- Species likely to benefit from MPAs
- Enforcement considerations in setting boundaries
- Information used in the design of MPAs
- Monitoring and evaluation strategies and resources
- Other activities affecting resources of concern

Each of these issues is discussed below.

Goals of the Marine Life Protection Program
The foundation for achieving the goals and objectives of the MLPA is a Marine Life Protection Program (Program), which must be adopted by the Commission. The MLPA sets the following goals for the Program [FGC subsection 2853(b)]:
(1) To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
(2) To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
(3) To improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.
(4) To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.
(5) To ensure that California's MPAs have clearly defined objectives, effective management

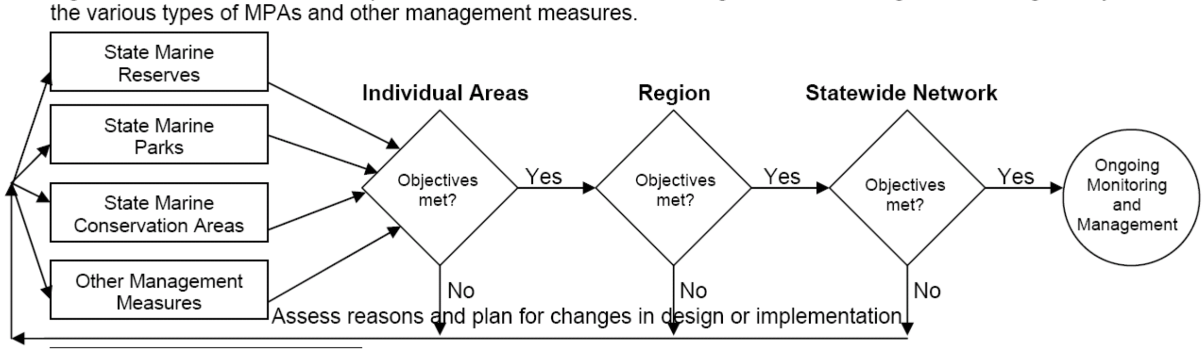
measures, and adequate enforcement, and are based on sound scientific guidelines.
(6) To ensure that the state's MPAs are designed and managed, to the extent possible, as a network.
The goals, objectives, management, monitoring, and evaluation of an MPA network must be consistent with the MLPA goals and objectives.

The goals of the MLPA go beyond the scope of traditional management of activities affecting living marine resources, which has focused upon maximizing yield from individual species or groups of species. For example, the first goal emphasizes biological diversity and the health of marine ecosystems, rather than the abundance of individual species. The second goal recognizes a role of an MPA system as a tool in fisheries management. The third recognizes the importance of recreation and education in MPAs, and balances these with the protection of biodiversity. The fourth recognizes the value of protecting representative and unique marine habitats for their own value. The fifth and sixth goals address the deficiencies in California's existing MPAs that the MLPA identifies elsewhere in the law.

The MLPA also states that the preferred siting alternative for MPA networks, which the Department must present to the Commission, must include an "improved marine life reserve[4] component" and must be designed according to all of the following guidelines:
(1) Each MPA shall have identified goals and objectives. Individual MPAs may serve varied primary purposes while collectively achieving the overall goals and guidelines of this chapter.
(2) Marine Life Reserves in each bioregion shall encompass a representative variety of marine habitat types and communities, across a range of depths and environmental conditions.
(3) Similar types of marine habitats shall be replicated, to the extent possible, in more than one marine life reserve in each biogeographical region.
(4) Marine life reserves shall be designed, to the extent practicable, to ensure that activities that upset the natural functions of the area are avoided.
(5) The MPA network and individual MPAs shall be of adequate size, number, type of protection, and location to ensure that each MPA meets its objectives and that the network as a whole meets the goals and guidelines of the MLPA.

Overall, proposed MPAs in each region must meet their individual goals and objectives, and the collection of MPAs and other management measures in each region and throughout the State must meet the goals and objectives of the MLPA. A simple decision tree for examining this is shown in Figure 3. This diagram indicates how the various types of MPAs along with other management measures work together to meet individual goals, regional goals, and the goals of the MLPA.

Figure 3. Flowchart of the review process to determine if individual, regional, and MLPA goals are being met by the various types of MPAs and other management measures.



[4] As noted previously, marine life reserve in the context of the MLPA is synonymous with a state marine reserve.

MPA Networks
One of the goals of the Marine Life Protection Program calls for improving and managing the state's MPAs as a network, to the extent possible. Although neither statute nor legislative history defines "network," the ordinary dictionary usage contemplates *interconnectedness* as a characteristic of the term. The first finding of the MLPA highlights the fact that California's MPAs "were established on a piecemeal basis rather than according to a coherent plan" [Fish and Game Code Section 2851(a)]. The term "reserve network" has been defined as a group of reserves which is designed to meet objectives that single reserves cannot achieve on their own (Roberts and Hawkins, 2000). In general this definition may infer some direct or indirect connection of MPAs through the dispersal of adult, juvenile, and/or larval organisms or other biological interactions. In most cases, larval and juvenile dispersal rates are not known and oceanography or ocean current patterns may be combined with larval biology to help determine connectivity.

Portions of the overall network will likely differ in each region of the state. The MLPA also requires that the network as a whole meet the various goals and guidelines set forth by the law and contemplates the adaptive management of that network [Fish and Game Code Section 2857(c)(5)]. In order to meet those goals a strict interpretation of an ecological network across the entire state, based on biological connectivity, may not be possible.

As stated above, the MLPA also requires that MPAs be managed as a network, to the extent possible. This implies a coordinated system of MPAs. MPAs might be linked through biological function as in the case of adult and juvenile movement or larval transport. MPAs managed as a network might also be linked by administrative function. The important aspects of this interpretation are that MPAs are linked by common goals and a comprehensive management and monitoring plan, and that they protect areas with a wide variety of representative habitat as required by the MLPA. MPAs should be based on the same guiding principles, design criteria, and processes for implementation. In this case, a statewide network could be one that has connections through design, funding, process, and management. At a minimum, the master plan should insure that the statewide network of MPAs reflects a consistent approach to design, funding and management. The desired outcome would include components of both biological connectivity and administrative function to the extent each are practicable and supported by available science.

Because of the long-term approach of the MLPA Initiative, the statewide network of MPAs called for by the MLPA will be developed in phases, region by region. Within each region, components of the statewide network will be designed consistent with the MLPA and with regional goals and objectives. Each component ultimately will be presented as a series of options, developed in a regional process involving a regional stakeholder group and a subgroup of the science team. Each will include a preferred alternative identified by the Department and delivered to the Commission. Another application of phasing may be an incremental implementation of a portion of the statewide MPA network within a single region. This type of phasing could allow for the completion of baseline surveys or the time necessary to secure additional funding for enforcement and management. Final proposals should include an explanation of the timing of implementation.

Science Advisory Team Guidance on MPA Network Design
The MLPA calls for the use of the best readily available science, and establishes a science team as one vehicle for fostering consistency with this standard. The MLPA also requires that the MPA network and individual MPAs be of adequate size, number, type of protection, and location as to ensure that each MPA and the network as a whole meet the objectives of the MLPA. In addition, the MLPA requires that representative habitats in each bioregion be replicated to the extent possible in more than one marine reserve.

The availability of scientific information is expected to change and increase over time. As with the rest of this framework, the following guidelines should be modified if new science becomes available that indicates changes. Additionally, changes should be made based on adaptive management and lessons learned as MPAs are monitored throughout various regions of the state.

The science team provided the following guidance in meeting these standards. This guidance, which is expressed in ranges for some aspects such as size and spacing of MPAs, should be the starting point for regional discussions of alternative MPAs. Although this guidance is not prescriptive, any significant deviation from it should be consistent with both regional goals and objectives and the requirements of the MLPA. The guidelines are linked to specific objectives and not all guidelines will necessarily be achieved by each MPA. For each recommendation below, detailed references are provided in the bibliography with notation linking them to the appropriate section.

Overall MPA and network guidelines:
• The diversity of species and habitats to be protected, and the diversity of human uses of marine environments, prevents a single optimum network design in all environments.
• For an objective of protecting the diversity of species that live in different habitats and those that move among different habitats over their lifetime, every 'key' marine habitat should be represented in the MPA network.
• For an objective of protecting the diversity of species that live at different depths and to accommodate the movement of individuals to and from shallow nursery or spawning grounds to adult habitats offshore, MPAs should extend from the intertidal zone to deep waters offshore.
• For an objective of protecting adult populations, based on adult neighborhood sizes and movement patterns, MPAs should have an alongshore span of 5-10 km (3-6 m or 2.5-5.4 nm) of coastline, and preferably 10-20 km (6-12.5 m or 5.4-11 nm). Larger MPAs would be required to fully protect marine birds, mammals, and migratory fish.
• For an objective of facilitating dispersal of important bottom-dwelling fish and invertebrate groups among MPAs, based on currently known scales of larval dispersal, MPAs should be placed within 50-100 km (31-62 m or 27-54 nm) of each other.
• For an objective of providing analytical power for management comparisons and to buffer against catastrophic loss of an MPA, at least three to five replicate MPAs should be designed for each habitat type within a biogeographical region.
• For an objective of lessening negative impact while maintaining value, placement of MPAs should take into account local resource use and stakeholder activities.
• Placement of MPAs should take into account the adjacent terrestrial environment and associated human activities.
• For an objective of facilitating adaptive management of the MPA network into the future, and the use of MPAs as natural scientific laboratories, the network design should account for the need to evaluate and monitor biological changes within MPAs.

1. MPAs should be in different marine habitats, biogeographical regions and upwelling cells *(See references noted "A" in literature cited)*
The strong association of most marine species with particular habitat types (e.g., sea grass beds, submarine canyons, shallow and deep rock reefs), and variation in species composition across latitudinal, depth clines and biogeographical regions, implies that habitat types must be represented across each of these larger environmental gradients to capture the breadth of biodiversity in California's waters.

Different species use marine habitats in different ways. As a result, protection of all the key habitats along the California coast is a critical component of network design. A 'key' habitat type is one that provides distinctive benefits by harboring a different set of species or life stages, having special physical characteristics, or being used in ways that differ from the use of other habitats. In addition, many species require different habitats at different stages of their life cycle - for example, nearshore species may occur in offshore open ocean habitats during their larval phase. Thus, protection of these habitats, as well as designs that ensure connections between habitats, is critical to MPA success. Individual MPAs that encompass a diversity of habitats will both ensure the protection of species that move among habitats and protect adjoining habitats that benefit one another (e.g., exchange nutrients, productivity). Habitats with unique features (educationally, ecologically, archeologically, anthropologically, culturally, spiritually), or those that are rare should be targeted for inclusion. Habitats that are uniquely productive (e.g. upwelling centers or kelp forests) or aggregative (e.g., fronts) or those that sustain distinct use patterns (e.g. dive training centers, fishing or whale watching hot spots) should also get special consideration in design planning.

2. Target species are ecologically diverse *(See references noted "B" in literature cited)*
MPAs protect a large number of species within their borders, and these species can have dramatically different requirements. As a result, MPA networks cannot be designed for the specific needs of each individual species. Rather, design criteria need to focus on maximizing collective benefits across species by minimizing compromises where possible. Commonly, it is more practical to consider protecting groups of species based on shared functional characteristics that influence MPA function and design (e.g., patterns of adult movement; patterns of larval dispersal; dependence on critical locations such as spawning grounds, mammal haul out areas, bird rookeries). It is also reasonable to emphasize protection of ecologically and economically dominant species groups when siting MPAs. The former play the largest roles in the function of coastal ecosystems, and the latter often experience the greatest impacts from human activities. In addition, knowledge of the distribution of rare, endemic, and endangered species should supplement the use of species groups. Generally, MPAs should not be used solely to enhance single-species management goals.

3. ***Uses of marine and adjacent terrestrial environments are diverse*** *(See references noted "C" in literature cited)*
The way people use coastal marine environments is highly diversified in method, goals, timing, economic objectives, spatial patterns, etc. The wide spectrum of environmental uses should be a part of decisions comparing alternatives networks of MPAs. The heterogeneity of uses, both between and within consumptive and non-consumptive categories make it unlikely that any one design will satisfy all user groups. The design will need to make some explicit provisions for trading off between the various negative and positive impacts to user groups. Placement of MPAs should also take into account the adjacent terrestrial environment and associated human activities. Freshwater runoff can be an important source of nutrients but also a potential source of contaminants to the adjacent marine environment. Terrestrial protected areas (e.g., preserves, parks) can regulate human access, restrict discharge of contaminants and provide enforcement support to adjoining MPAs.

4. MPA permanence is especially critical for long lived animals
Two clear objectives for establishing self-sustaining MPAs are to protect areas that are important sources of reproduction (nurseries, spawning areas, egg sources) and to protect areas that will receive recruits and thus be future sources of spawning potential. To meet the first objective of protecting areas that serve as sources of young, protection should occur both for areas that historically contained high abundances and for areas that currently contain high abundances. Historically productive fishing areas, which are now depleted, are likely to show a larger, ultimate response to protective measures if critical habitat has not been damaged. Protecting areas where targeted populations were historically abundant alone is insufficient, however, because the pace of recovery may be slow, especially for species with relatively long life spans and sporadic recruitment (for example, top marine predators). Including areas with currently high abundances in an MPA network helps buffer the network from the inevitable time lag for realizing the responses of some species. The biological characteristics of longevity and sporadic recruitment also suggest that the concept of a rotation of open and closed areas will probably not work well for the diversity of coastal species in California.

5. Size and shape guidelines *(See references noted "D" in literature cited)*
To provide any significant protection to a target species, the size of an individual MPA must be

large enough to encompass the typical movements of many individuals. Movement patterns vary greatly among species. Some are completely immobile or move only a few meters. Others forage widely. The more mobile the individuals, the larger the individual MPA must be to afford protection. Therefore, minimum MPA size constraints are set by the more mobile target species. Because some of California's coastal species are known to move hundreds of miles, MPAs of any modest size are unlikely to provide real protection for these species. Fortunately, tagging studies indicate that net movements of many of California's nearshore bottom-dwelling fish species, particularly reef-associated species, are on the order of 5-20 km (3-12.5 m or 2.5-11 nm) or less over the course of a year. These individual adult neighborhood or home range sizes must be combined with knowledge of how individuals are distributed relative to one another (e.g., in exclusive versus overlapping neighborhoods) to determine how many individuals a specific MPA design will protect. Current data suggest that MPAs spanning less than about 5-10 km (3-6 m or 2.5-5.4 nm) in extent along coastlines may leave many individuals of important species poorly protected. Larger MPAs, spanning 10-20 km (6-12.5 m or 5.4-11 nm) of coastline, are probably a better choice given current data on adult fish movement patterns. With MPAs of this size, pelagic species with very large neighborhood sizes will likely receive little protection unless the MPA network as a whole affords significant reductions in mortality during the cumulative periods that individuals spend in different MPAs, or unless other ecological benefits are conferred (e.g., protection of feeding grounds, reduction in bycatch). Protection for highly mobile species will come from other means, such as state and federal fisheries management programs, but MPAs may play a role.

Less is known about the net movements of most of the deeper water sedentary and pelagic fishes, especially those associated with soft-bottom habitat, but it is reasonable to suspect that the range of movements will be similar or greater than those of nearshore species. One cause of migration in demersal fishes is the changing resource/habitat requirements of individuals as they grow. Thus, individual ranges can reflect the gradual movement of an individual among habitats, and MPAs that encompass more diverse habitat types will more likely encompass the movement of an individual over its lifetime. Although fisheries may not target younger fish, offshore MPAs that include inshore nursery habitats increase the likelihood of replenishment of adult populations offshore. Such MPAs would also protect younger fish from incidental take (i.e. by-catch). Fish with moderate movements, especially those in deeper water, will require larger MPA sizes. Because several species also move between shallow and deeper habitat, MPAs that extend offshore (from the coastline to the three-mile offshore boundary of State waters) will accommodate such movement and protect individuals over their lifetime. Typically, the relative amount of higher relief rocky reef habitat decreases with distance from shore. In such situations, a MPA shape that covers an increasing area with distance offshore (i.e. a wedge shape) may be an effective design. This shape also better accommodates the greater movement ranges of deeper water and soft-bottom associated fishes and the larval/juvenile stages of nearshore species which may occur offshore during their planktonic phase of life. However, this may conflict with the optimum design for enforcement purposes of using lines of latitude and longitude for boundaries.

Coupling of pelagic and benthic habitats is an important consideration in both offshore and nearshore MPA design. The size of a protected area should also be large enough to facilitate enforcement and to limit deleterious edge effects caused by fishing adjacent to the MPA. MPA shape should ultimately be determined on a case-by-case basis using a combination of information about bathymetry, habitat complexity, and species distribution and relative abundance.

6. Spacing between MPAs *(See references noted "E" in literature cited)*
The exchange of larvae among MPAs is the fundamental biological rationale for MPA "networks". Larval exchange has at least three primary objectives: to assure that populations within MPAs are not jeopardized by their reliance on replenishment from less protected populations outside MPAs; to ensure exchange and persistence of genetic traits of protected populations (e.g., fast growth, longevity); and to enhance the independence of populations and

communities within MPAs from those outside MPAs for the use of MPAs as reference sites. For MPAs to act as reference sites for comparison with less protected populations or communities, MPAs must act independently from areas with less protected populations. Independence is enhanced for MPAs whose replenishment is contributed to by other MPAs. Movement out of, into and between MPAs by juveniles, larvae or spores of marine species depends on their dispersal distance. Important determinants of dispersal distance are the length of the planktonic period, oceanography and current regimes, larval behavior, and environmental conditions (e.g., temperature and sources of entrainment). As with adult movement patterns, the dispersal of juveniles, larvae and eggs varies enormously among species. Some barely move from their natal site. Others disperse vast distances. MPAs will only be connected through the dispersal of young if they are close enough together to allow movement from one MPA to another. Any given spacing of MPAs will undoubtedly provide connectivity for some species and not for others. The challenge is minimizing the number of key or threatened species that are left isolated by widely spaced MPAs.

Based on emerging genetic data from species around the world, larval movement of 50-100 km appears common in marine invertebrates. For fishes, larval neighborhoods based on genetic data appear generally larger, ranging up to 100-200 km. For marine birds and mammals, dispersal of juveniles of hundreds of km is not unusual, but for some of these species, return of juveniles to natal areas can maintain fine-scale population structure. For MPAs to be within dispersal range for most commercial or recreational groundfish or invertebrate species, they will need to be on the order of no more that 50-100 km apart. Otherwise, a large fraction of coastal species will gain no benefits from connections between MPAs.

Current patterns, retention features such as fronts, eddies, bays, and the lees of headlands may create “recruitment sinks and sources”. Such spatial variation in recruitment habitat may be predictable - dispersal distances will be shorter where retention is substantial (e.g., lees of headlands). As a result, MPAs may need to be more closely spaced in these settings. Although dispersal data appear to be valid for a wide range of species, there are only a small number of coastal marine species in California that allow these estimates of larval neighborhoods to be made with confidence. Nonetheless, it is the distribution of dispersal distances across species that really drives network design rather than the specific patterns for any particular species.

7. Minimal replication of MPAs

MPAs in a particular habitat type need to be replicated along the coast. Four major reasons for this are: to provide stepping-stones for dispersal of marine species; to insure against local environmental disaster (e.g. oil spills or other catastrophes) that can significantly impact an individual, small MPA; to provide independent experimental replicates for scientific study of MPA effects; and for the use of MPAs as reference sites to evaluate the effects of human influences on populations and communities outside MPAs. Ideally at least five replicates (but a minimum of three) containing sufficient representation or each habitat type, should be placed in the MPA network within each biogeographical region and for each habitat to serve these goals. For large biogeographical regions, fulfilling the critical stepping stone role may require even more MPA replicates. The spacing criteria discussed above will drive the number of replicates in this situation. To ensure that the effects of MPAs can be quantified, the network should be designed in a way that facilitates comparison of protected and unprotected habitats, and between different degrees of consumptive and non-consumptive uses.

8. Human activities ranges and MPA placement

The geographic extent of human activities is suggestive of size and placement of MPAs. Fishing fleets and other user groups typically have a finite home range from ports and access points along the coast. Many activities, especially in central California, are day-based and conducted from motor, sail or hand powered crafts with ranges between 1 and 29 miles (1 and 25 nautical miles). Historical patterns of fishing activity may have been concentrated much closer to ports than is true today because of declines in target species abundance from activities in the past. If MPAs are designed to limit consumptive uses, MPAs located farthest away from access points will tend to be associated with lower costs. However, MPAs often become magnets for fishing along their edges. These situations create a net benefit for consumptive users by locating MPAs close to ports and coastal access points. Similarly, MPAs designed to facilitate certain non-consumptive types of activities such as diving may be more effective closer to ports and coastal access points. As a general rule, locating MPAs at the outer reaches of the maximum range of any given user group will tend to minimize the impacts on that group, both negative (loss of opportunity) and positive (creation of opportunity). The balance between these influences must be evaluated for specific locations. In addition, if MPAs restrict transit they will carry higher social, economic and, potentially, safety costs for users seeking access to sites beyond the MPA.

9. Human activity patterns and portfolio effects

Human activities have distinct hotspots where effort is concentrated. For example, in the northern California urchin fishery, economists at the University of California at Davis have documented are-based fishing strategies around a dozen fishing locations. It is likely that there are a threshold number of these locations below which the fishery would not be feasible. Because an MPA larger than the typical harvest area could potentially eliminate a fishing location, these spatial use patterns should be part of design considerations, especially if establishing one particular MPA would spell the end of a particular activity along the entire coastline.

Consideration of Habitats in the Design of MPAs *(See additional references noted "F" in literature cited)*

The first step in assembling alternative proposals for MPAs in a region and in the context of a statewide MPA network is to use existing information to the extent possible to identify and to map the habitats that should be represented. The MLPA also calls for recommendations regarding the extent and types of habitats that should be represented.

The MLPA identifies the following habitat types: rocky reefs, intertidal zones, sandy or soft ocean bottoms, underwater pinnacles, seamounts, kelp forests, submarine canyons, and seagrass beds. The Master Plan Team convened in 2000 reduced this basic list by eliminating seamounts, since there are no seamounts in state waters. The team also identified four depth zones as follows: intertidal, intertidal to 30 meters, 30 meters to 200 meters, and beyond 200 meters. Several of the seven habitat types occur in only one zone, while others may occur in three or four zones.

The science team recommends expanding these habitat definitions in four ways:

1. Based on information about fish depth distributions provided in a new book on the ecology of California marine fishes (Allen et al. in press), the science team recommends dividing the 30-200 m depth zone into a 30-100 m and a 100-200 m zone. This establishes five depth zones for consideration:

- Intertidal
- Intertidal to 30 m (0 to 16 fm)
- 30 to 100 m (16 to 55 fm)
- 100 to 200 m (55 to 109 fm)
- 200 m and deeper.

2. The habitats defined in the MLPA implicitly focus on open coast ecosystems and ignore the critical influence of estuaries. California's estuaries contain most of the State's remaining soft bottom and herbaceous wetlands such as salt marshes, sand and mud flats, and eelgrass beds. Ecological communities in estuaries experience unique physical gradients that differ greatly from those in more exposed coastal habitats. They harbor unique suites of species, are highly productive, provide sheltered areas for bird and fish feeding, and are nursery grounds for the young of a wide range of coastal species. Emergent plants filter sediments and nutrients from the watershed, stabilize

shorelines, and serve as buffers for flood waters and ocean waves. Given these critical ecological roles and ecosystem functions, estuaries warrant special delineation as a critical California coastal habitat.

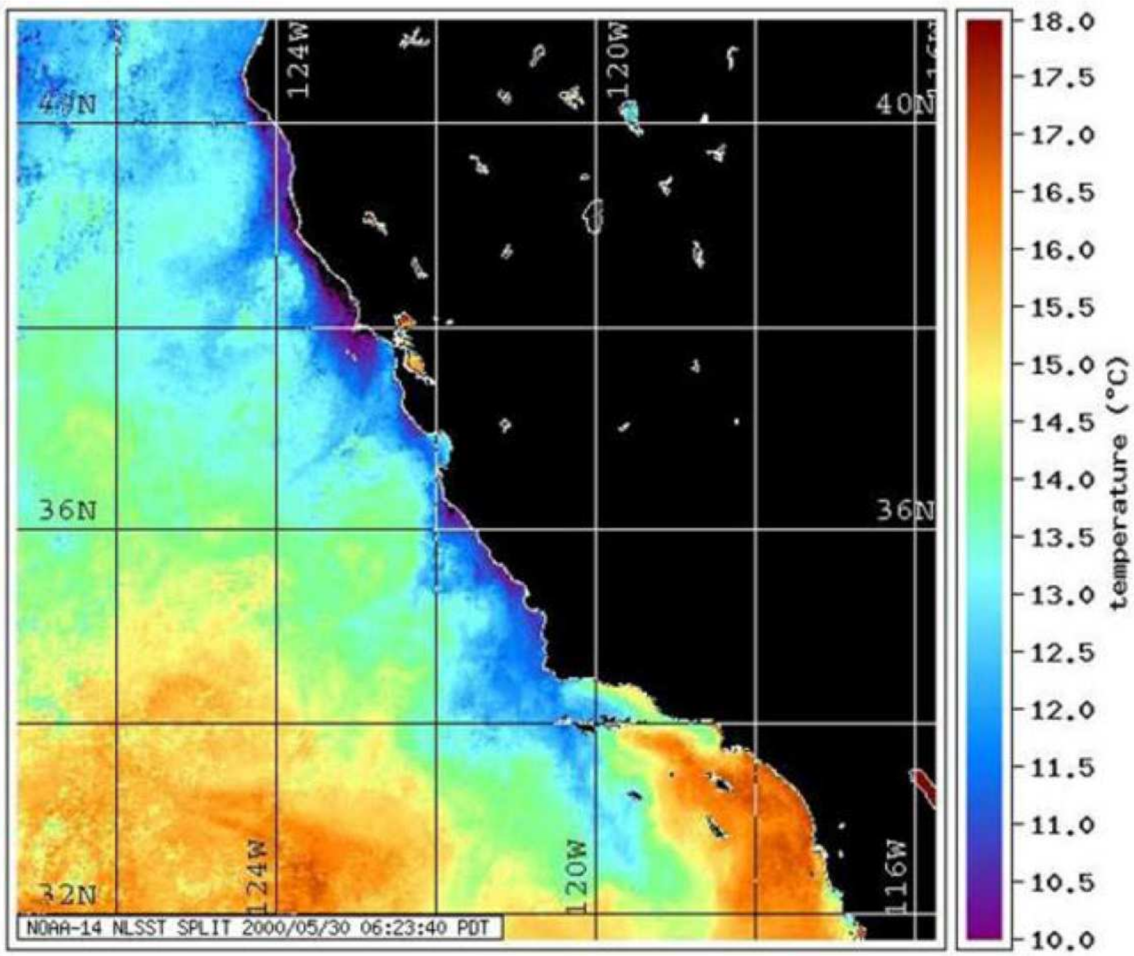
3. Three of the habitats defined in the MLPA – rocky reefs, intertidal zones, and kelp forests – are generic habitat descriptions that include distinct habitats that warrant specific consideration and protection. In the case of rocky reefs and intertidal zones, the type of rock that forms the reef greatly influences the species using the habitat. For example, granitic versus sedimentary rock reefs harbor substantially different ecological assemblages and should not be treated as a single habitat. Similarly, the term kelp forest is a generic term that subsumes two distinct ecological assemblages dominated by different species of kelp. Kelp forests in the southern half of the state are dominated by the giant kelp, *Macrocystis pyrifera.* By contrast, kelp forests in the northern half of the state are dominated by the bull kelp, *Nereocystis luetkeana*. In central California, both types of kelp forests occur. These two types of kelp forests harbor distinct assemblages and should be treated as separate habitats.

4. Habitat definitions in the MLPA should be expanded to include ocean circulation features, because habitat is not simply defined by the substrate. Seawater characteristics are analogous to the climate of habitats on land, and play a critical role in determining the types of species that can thrive in any given setting. Just as features of both the soil and atmosphere characterize habitats on land, features of both the substrate (e.g., rock, sand, mud) and the water that bathes it (e.g., temperature, salinity, nutrients, current speed and direction) characterize habitats in the sea. No one would argue that a sand dune at the beach and a sand dune in the desert are the same habitat. Similarly, rocky reefs in distinct oceanographic settings are different habitats that can differ fundamentally in the species that use the reefs.

The oceanography of the California coastline is dominated by the influence of the California Current System. On the continental shelf and slope this system consists of two primary currents - the California Current, which flows toward the equator, and the California Undercurrent, which flows toward the North Pole (Hickey, 1979; 1998). When present, the undercurrent occurs beneath the southward flowing California Current. North of Pt. Conception, the undercurrent may reach the surface as a nearshore, poleward flowing current that is best developed in fall and winter (Collins et al., 2000; Pierce et al., 2000). These currents vary in intensity and location, both seasonally and from year to year.
Organisms will also be affected by the circulation induced by tidal currents. For those living in shallow water habitats very close to shore, inshore of the surf zone, the dominant influence on transport of planktonic eggs and larvae will be the circulation generated by breaking waves.
As can be seen in a satellite image of ocean temperature along the California coastline (Figure 4), the circulation and physical characteristics of the California Current System are exceedingly complex and variable. This is not the image one would expect if ocean currents were analogous to northward or southward flowing rivers in the sea. Rather, ocean flows are greatly modified by variation in the strength and direction of winds, ocean temperatures and salinity, tides, the topography of the coastline, and the shape of the ocean bottom, among several other factors. The end result is a constantly changing sea of conditions.

The patterns are not completely random, however. Many aspects of ocean climates vary somewhat predictably in space, especially ones that are tied to key features of the coastline – points and headlands, river mouths, etc. Locations that share similar ocean climates are typically more similar in the types of species they harbor. Therefore, defining habitats for the MLPA and MPA networks must include habitats defined by coastal oceanography as well as the composition of the seafloor.

Figure 4. An example of sea surface temperature in the California coastal waters, May 30, 2000.



Although a wide range of oceanographic habitats could be defined for the California coastline, the science team suggests that three prominent habitats stand out because of their demonstrated importance to different suites of coastal species:

- Upwelling centers
- Freshwater plumes
- Retention areas

Upwelling Centers

Upwelling is one of the most biologically important circulation features in the ocean. Upwelling occurs when deep water is brought to the surface. On average deep water is colder and more nutrient rich than surface waters. When upwelling delivers nutrients to the sunlit waters near the surface, it provides the fuel for rapid growth of marine plants, both plankton and seaweeds. Ultimately the added nutrients can energize the productivity of entire marine food webs. Upwelling regions are the most productive ocean ecosystems. The west coast of North America is one of the few major coastal upwelling regions on the entire planet (Chavez and Collins, 2000; Hickey, 1998). The major driver of upwelling along the California coastline is wind. Winds that blow from the north and northwest parallel to California's generally northsouth coastline drive currents at the surface. Because of the complicated effects of friction and the rotation of the earth, surface water is pushed to the right of the direction of the wind (the Coriolis Effect). With winds blowing from the north and northwest, this effect pushes surface waters away from shore. As water is pushed offshore, it is replaced by water that is upwelled from below.

The rate of upwelling depends on many features that vary spatially along the coastline – the strength and direction of the wind, the topography of the shoreline, and the shape of the continental shelf are three of the most important. Capes and headlands play a key feature in all of these drivers of upwelling. They accelerate alongshore winds, and they channel coastal currents in such a way that upwelling intensity can increase dramatically in their vicinity. As a result, major headlands and capes from Pt. Conception north are commonly centers of upwelling associated with strong rates of offshore transport of surface waters, greatly elevated nutrient concentrations, and enhanced productivity offshore (Pickett and Paduan, 2003). Since major capes and headlands tend to be fairly regularly spaced along the California coastline, with an average spacing between 150 and 200 km (93 and 124 m or 81 and 108 nm), these upwelling centers drive cells of ocean circulation with relatively predictable patterns of flow. Enhanced offshore flow and upwelling emanates from headlands, versus eddies and locations of more frequent alongshore flow in the regions between headlands. These filaments of upwelled water are readily identified emanating from key headlands in most satellite images of ocean temperature or biomass of phytoplankton. Because the upwelling centers are locations of more frequent and intense offshore flow near the surface, which moves larvae and other plankton away from shore, and elevated nutrients, which fuels much more rapid algal productivity, these locations represent a distinct oceanographically driven coastal habitat with substantially different species composition and dynamics compared to other coastal locations.

Freshwater Plumes
A second coastal habitat driven by features of the water column is generated by the influence of rivers. Freshwater emerging from watersheds alters the physical characteristics of coastal seawater (especially salinity), changes the pattern of circulation (by altering seawater density), and delivers a variety of particles and dissolved elements, such as sediments, nutrients, and microbes. These effects all arise from the land and can have a profound influence on the success of different marine species. The mouths of watersheds set the locations of low salinity plumes, and the size and shape of the plume vary over time as functions of the volume of flow from the watershed, the concentration of particles, and the nature of coastal circulation into which the water is released. The location of California's freshwater plume habitats can be defined by both satellite and ocean-based measurements.

Larval Retention Areas
Since connectivity and movement of larvae, plankton, and nutrients play such an important role in the impact of MPAs on different species, changes in the speed and direction of coastal currents can create very different ecological settings. A number of circulation features can greatly limit the coastal particles. In particular, features characterized by rotational flows, such as eddies, can greatly enhance the length of time that a particle or larval fish stays in a general region of the coastline. Such retentive features have been shown to significantly affect the species composition of coastal ecosystems (Largier, 2004). Since many retention areas are tied to fixed features of coastal topography (e.g., eddies in the lee of coastal headlands or driven by bottom topography), they define unique regions of coastal habitat that can be predictably defined.

Experience in California and elsewhere demonstrates that individual MPAs generally include several types of habitat in different depth zones, so that the overall number of MPAs required to cover the various habitat types can be smaller than the number of total habitats. The Master Plan Team convened in 2000 also called for considering adjacent lands and habitat types, including seabird and pinniped rookeries. Since marine birds and mammals are protected by federal regulations, they are not a primary focus of the MLPA. Nonetheless, these species can play important ecological roles and their success may be impacted by changes in other components of California's coastal ecosystems that are a primary focus of MLPA. Therefore, MPA planning needs to coordinate with other efforts focused on marine birds and mammals. As noted regarding the design of MPAs, this guidance should be the starting point for regional discussions regarding representative habitats in a region. Although this guidance is not prescriptive, any significant deviation from it should be explained.

Species Likely to Benefit from MPAs

Recommending the extent of habitat that should be included in an MPA network will require careful analysis and consideration of alternatives. These recommendations may vary with habitat and region, but should be based on the best readily available science. One aspect of determining appropriate levels of habitat coverage is the habitat requirements of species likely to benefit from MPAs in a region. At Fish and Game Code subsection 2856(a)(2)(B), the MLPA requires that the master plan identify "select species or groups of species likely to benefit from MPAs, and the extent of their marine habitat, with special attention to marine breeding and spawning grounds, and available information on oceanographic features, such as current patterns, upwelling zones, and other factors that significantly affect the distribution of those fish or shellfish and their larvae."

The Department prepared a master list of such species, which appears in Appendix G. This list may serve as a useful starting point for identifying such species in each region during the development of alternative MPA proposals. With the assistance of the science team, the Department should develop a list of species specific to each study region of the state, as they are determined, for use by the appropriate regional stakeholder group. The list will indicate which species are of critical concern and why. This regional list then can assist in evaluating desirable levels of habitat coverage in alternative MPA proposals. Although the statewide list will be all inclusive, it is not likely that all species on the list will benefit from the establishment of new, or the expansion of existing, MPAs. For example, a species may be in naturally low abundance within this portion of its geographical range.

The Department, with the assistance of the science team, will develop scientifically based expectations of increases in abundance of focal species for each MPA. These expectations, while not hard targets or performance goals, will help managers determine the efficacy of MPAs. If expected increases are not realized, the process of adaptive management will allow for changes in the MPA design.

Biogeographical Regions

In calling for a statewide network of MPAs, to the extent possible, the MLPA recognizes that the state spans several biogeographical regions, and identified these, initially, as follows [FGC subsection 2852(b)]:

- The area extending south from Point Conception,
- The area between Point Conception and Point Arena, and
- The area extending north from Point Arena.

In the same provision, the MLPA provides authority for the master plan team required by FGC subsection 2855(b)(1) to establish an alternate set of boundaries. The Master Plan Team convened by the Department in 2000 determined that the three regions identified in the MLPA were not zoogeographic regions; scientists recognize only two zoogeographic regions between Baja California and British Columbia with a boundary at Pt. Conception. Instead of the term "biogeographical region," the team adopted the term "*marine region*" and identified four *marine regions*:

- North marine region: California-Oregon border to Point Arena (about 210 linear miles or 183 linear nautical miles of coastline);
- North-central marine region: Point Arena to Point Año Nuevo (about 180 linear miles or 156 linear nautical miles of coastline);
- South-central marine region: Point Año Nuevo to Point Conception (about 233 linear miles or 203 linear nautical miles of coastline); and
- South marine region: Point Conception to the California-Mexico border, including the islands of the southern California Bight (about 280 linear miles or 243 linear nautical miles of coastline).

Three of the above four regions (those north of Pt. Conception) fall within the larger zoogeographic region accepted by scientists. These sub-regions were used more or less as subdivisions of the greater zoogeographic region by the former Master Plan Team. Technically, the requirement of replicate state marine reserves encompassing a representative variety of habitat types and depths would only apply to the two recognized zoogeographic regions within the state. However, based on the concept of a network of MPAs, in whatever way it is defined, and the fact that it would likely require unusually and unacceptably large state marine reserves to incorporate a wide variety of habitat types if only two (the minimum definition of "replicate") state marine reserves were established in each zoogeographic region, it is likely that a statewide network will contain more than two state marine reserves in each biogeographical region.

MPAs in different biogeographical regions will affect different suites of species. Thus replication and network design may be considered separately for relatively distinct stretches of coastline. Biogeographical regions can be distinguished based upon data of two types: 1) the location of species' borders along the coastline; and 2) surveys of species' distribution and abundance. Historically, the locations of species' borders, i.e., places where multiple species terminate their ranges, have been used to define biogeographical regions or provinces. However, regional boundaries typically are set by only small subset of the species distributed up and down coast from these "breakpoints".

The abundances and diversity of species at locations along the coast are much more reflective of differences in biological communities and provide the best evidence of biologically distinct regions from both structural and functional standpoints. Historically, such data on abundance and biological diversity have not been available at enough locations along most coastlines for broad scale, geographic analyses. As a result, definitions of biogeographical regions have been forced to rely on a less meaningful measure of biological differences – the location of species' borders.

Biogeographers have divided all major oceans into large *biogeographic provinces*. California's coastline spans two of these large-scale provinces – the Oregonian and the Californian Provinces – with a boundary in the vicinity of Point Conception. This prominent biogeographical boundary has been recognized for more than half a century. More detailed analyses of species' borders also have led to the identification of regional scale boundaries between biogeographical sub-provinces.

Biogeographers commonly have used distributional data for subgroups of taxonomically related species (e.g., snails, seaweeds, or fish) to set biogeographical boundaries; interestingly, the boundaries for sub-provinces often differ among taxonomic groups because different types of species respond to different physical and biological characteristics in different ways (Airamé et al. 2003). Two locations, however, emerge as prominent boundaries for key coastal species. Seaweeds, intertidal invertebrates, and nearshore fishes have comparable numbers of species' borders in the vicinity of Monterey Bay as they do at Point Conception. In addition, coastal fishes have an important sub-province boundary at Cape Mendocino. Scientific data do not support a significant biological break between biogeographical regions at Point Arena, as identified in earlier MLPA documents. Therefore, on the basis of the distribution of species' borders for key coastal species groups, there are three biogeographical regional boundaries and four regions along the California coast:
1. The Mexican border to Pt. Conception,
2. Point Conception to Monterey Bay,
3. Monterey Bay to Cape Mendocino, and
4. Cape Mendocino to the Oregon border.

In the past decade, detailed data have become available on species abundances and diversity from a large number of locations along California's coast. This wealth of information on actual species assemblages now provides the opportunity to define biogeographical regions on the basis of actual ecosystem compositions, rather than the presumed composition of ecosystems inferred from species' borders. These ecosystem-based data are a better scientific fit with the goals of the MLPA. Summaries of species abundance and diversity data, especially for shallow water species (<30 m depth), suggest that there are four points of transition along the California coastline that demarcate distinct marine assemblages: Point Conception, Monterey Bay, San Francisco Bay, and Cape Mendocino.

Three of these locations are identical to those defined above solely on the basis of species' borders for prominent groups. The new boundary that emerges from abundance and biodiversity data is San Francisco Bay. The region between Monterey Bay and Cape Mendocino has two distinct biological assemblages on coastal reefs even though this is not a region characterized by large numbers of species' borders. The difference in assemblages on either side of San Francisco Bay appears to be caused by changes in the types of rock that form nearshore reefs. Since the type of rock is used to defined bottom habitats for MPA designation, this transition in species composition could be addressed in MPA designs using habitat considerations or, alternatively by designating the Monterey Bay to San Francisco Bay segment as a distinct biogeographical region.

Based on this review, there are four possible definitions of the biogeographical regions that will serve as the basic structure of the statewide network of MPAs. These options are as follows:
1) The three biogeographical regions defined in the MLPA;
2) The two *biogeographic provinces* recognized by many scientists with a boundary at Point Conception;
3) The four *marine regions* identified by the former Master Plan Team, with boundaries at Pt. Conception, Pt. Año Nuevo, and Pt. Arena; and
4) The biogeographical regions recognized by scientists who have identified borders based on species distributional patterns or on abundance and diversity data with boundaries at Pt. Conception, Monterey Bay and/or San Francisco Bay, and Cape Mendocino.

Accepting the strong scientific consensus of a major biogeographical break at Point Conception, the MLPA Blue Ribbon Task Force recommends that the Commission adopt the two biogeographic provinces as the biogeographical regions for purposes of implementation of the Marine Life Protection Act. The Task Force recommends that the more refined information on other breaks be used in designating study regions and in designing networks of MPAs.

Types of MPAs

The MLPA recognizes the role of different types of MPAs in achieving the objectives of the Marine Life Protection Program [FGC subsection 2853(c)]. While the MLPA does not define the different types, the Marine Managed Areas Improvement Act (MMAIA) does define state marine reserve, state marine park, and state marine conservation area. (See Appendix B for the text of the MMAIA as amended.)