QUESTIONS FOR THE SCIENCE ADVISORY PANEL

What guidance or direction did the Science Advisory Panel use to craft its recommendation?

What scientific literature has been published on the subject of optimal size of marine reserves for conservation and fisheries management?

Explain the similarities between conserving ecosystem biodiversity and sustaining fisheries.

Is a reduction in fishing effort plus a small reserve network comparable to a large marine reserve?

Can other current management measures (e.g. the cowcod closure) reduce the recommended reserve size?

What species, if any, are unique to the Channel Islands?
Where are they located?

What are the criteria for risk of extinction at the Channel Islands?
How does extinction factor into the recommendation?

TABLES AND FIGURES

Table 4. Estimates of replacement threshold levels for 85 populations of 27 fished species, grouped by geographic location (Mace and Sissenwine 1993).

Table 6. Relationship between marine protected area objectives, size, and design complexity.

Table 7. Representative and unique marine habitats in the Channel Islands region

Table 8. Species of interest in the Channel Islands National Marine Sanctuary

Table 9. Vulnerable, threatened, or endangered marine fish stocks that can be found in the Channel Islands National Marine Sanctuary during at least one stage of their life history.

QUESTIONS FOR THE SCIENCE ADVISORY PANEL

What guidance or direction did the Science Advisory Panel use to craft its recommendation?

The Science Advisory Panel used the goals and objectives for Ecosystem Biodiversity, Sustainable Harvested Populations and Research to guide their deliberations of reserve location and size in the Channel Islands National Marine Sanctuary. The goals for Ecosystem Biodiversity, Sustainable Harvest Populations and Research were ratified by the MRWG at their June 8, 2000 meeting.

Ecosystem Biodiversity:

To protect representative and unique marine habitats, ecological processes, and populations of interest.

Objectives -
1. To include representative marine habitats, ecological processes, and populations of interest.
2. To identify and protect multiple levels of diversity (e.g. species, habitats, biogeographic provinces, trophic structure).
3. To provide a buffer for species of interest against the impacts of environmental fluctuations.
4. To identify and incorporate representative and unique marine habitats.
5. To set aside areas which provide physical, biological, and chemical functions.
6. To enhance long-term biological productivity.
7. To minimize short-term loss of biological productivity.
8. To develop methods for evaluating ecosystem integrity.

Sustainable Harvested Populations:

To provide a buffer against impacts of environmental fluctuations on commercial and recreationally important species.

Objectives -
1. To facilitate recovery and sustainability of harvested populations.
2. To enhance spillover into non-reserve areas.
3. To establish long-term monitoring programs in, adjacent to, and distant from reserves.
4. To monitor impacts of reserves on commercial and recreational industries.
5. To document changes of catch characteristics of users adjacent to and distant from reserves.
6. To study and evaluate the effects of predators on marine populations in, adjacent to and distant from reserves.
7. To evaluate the effectiveness of reserves as a tool in the context of integrated fishery management.
8. To develop an adaptive management design for reserves as an experimental fishery management tool.

9. To assess the short- and long-term effectiveness of reserves as an experimental fishery management tool.

Research

1. **To monitor ecosystem functions and acquire baseline data to assess natural and human impacts between reserve and other areas; and**

2. **To evaluate the short- and long-term effectiveness of reserves as resource and fishery management tools.**

Objectives -
1. To design reserves that will be tractable for monitoring of biological and physical processes.
2. To develop a monitoring and evaluation program that will provide enough information for adaptive management.
3. To establish long-term monitoring of ecological patterns and processes in, adjacent to, and distant from marine reserves.
4. To establish areas for systematic study of nearshore marine species, including (1) larval export, (2) adult migration, (3) relative abundances, (4) size-frequency distributions, and (5) other topics of interest.
5. To evaluate short- and long-term differences between reserve and non-reserve areas.
6. To provide long-term continuity in effort, expertise, and funding during reserve monitoring and evaluation.

QUESTIONS FOR THE SCIENCE ADVISORY PANEL

What scientific literature has been published on the subject of optimal size of marine reserves for conservation and fisheries management?

The Science Advisory Panel reviewed the scientific literature on marine reserves. In particular, Panel members considered papers that addressed the question of reserve size and location for conservation and fisheries management. The following bibliography contains papers that were considered by members of the Science Advisory Panel.

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Explain the similarities between conserving ecosystem biodiversity and sustaining fisheries.

The conservation of ecosystem biodiversity requires the maintenance of ecological roles of all species, including those that are fished, in natural population densities and size structures. Populations of fished species are more vulnerable than other species because their rates of mortality increase proportionally with the fishing effort. If the rate of natural plus fishing mortality exceeds the rate of birth plus immigration, fished populations will decline. As population sizes decrease, the populations become more susceptible to environmental fluctuations, catastrophic events, and demographic stochasticity. Consequently, estimates of the minimum area required sustain fished species are likely to provide the best basis for the size of reserves for conservation of biodiversity. If no-take reserves are designed to sustain the natural populations of fished species, the reserve is likely to protect the necessary habitat for other, non-fished species in the ecosystem. Consequently, estimates of the reserve area required to sustain fished species are likely to provide the best basis for determining the percentage of habitat or stock required for protecting ecosystem biodiversity.

Because species diversity increases with area, and because some species require larger areas to maintain self-sustainability, marine reserves for conservation must be as large as possible within the constraints imposed by fishers and other users. Data from harvested populations indicate that species differ greatly in the degree to which they can be reduced below normal carrying capacity before they are not self-sustainable in the long term. Given the available empirical data, a minimum reserve size of 30% would sustain approximately 80% of the species for which data are currently available. To meet the minimum requirements for all species, the fraction set aside in reserves would need to exceed 70%. If reserves are designed for fisheries enhancement and sustainability, numerous theoretical studies and limited empirical data indicate that protecting approximately 35% of fishing grounds will maximize catches. Thus a reserve area of 30-50% of an area of interest will achieve some measure of protection for both conservation and fisheries goals. Because of the complexity upon which this estimate is based, continued evaluation of reserve effectiveness is absolutely necessary to determine whether alteration (reduction or increase) is appropriate.

Table 4. Estimates of replacement threshold levels for 85 populations of 27 fished species, grouped by geographic location (Mace and Sissenwine 1993).

Common Name	Scientific Name	Replacement Threshold Level (%)
ICES Stocks (NE Atlantic)		
1. Irish Sea cod	*Gadus morhua*	3.9
2. Irish Sea whiting	*Merlangius merlangus*	11.4
3. Irish Sea plaice	*Pleuronectes platessa*	10.1
4. Irish Sea sole	*Solea vulgaris*	23.5
5. Celtic Sea cod	*Gadus morhua*	6.6
6. Celtic Sea whiting	*Merlangius merlangus*	6.9
7. Celtic Sea plaice	*Pleuronectes platessa*	5
8. Celtic Sea sole	*Solea vulgaris*	19.2
9. Blue whiting, southern stock	*Merlangius merlangus*	7.4
10. NE Arctic cod	*Gadus morhua*	5.8
11. NE Arctic haddock	*Melanogrammus aeglefinus*	24.3
12. NE Arctic saithe	*Pollachius virens*	9.8
13. Redfish in areas IIA and B	*Sebastes marinus*	18.2
14. Greenland halibut in areas I and II	*Reinhardtius hippoglossodes*	21.6
15. Icelandic summer herring	*Clupea harengus*	18.6
16. North Sea sole	*Solea vulgaris*	12.3
17. North Sea plaice	*Pleuronectes platessa*	11.2
18. Div VIId sole	*Solea vulgaris*	11.5
19. Div VIIe sole	*Solea vulgaris*	25.8
20. Bay of Biscay sole	*Solea vulgaris*	5.6
21. Div VIIe plaice	*Pleuronectes platessa*	7.3
22. North Sea cod	*Gadus morhua*	3.4
23. Div Via cod	*Gadus morhua*	11
24. Div VIId cod	*Gadus morhua*	5.3
26. North Sea haddock	*Melanogrammus aeglefinus*	15.5
27. Div Via haddock	*Melanogrammus aeglefinus*	18.2
28. North Sea whiting	*Merlangius merlangus*	50.1
29. Div. VIa whiting	*Merlangius merlangus*	37.2
30. Div VIId whiting	*Merlangius merlangus*	42.7
31. North Sea saithe	*Pollachius virens*	16.7
32. Div. VI saithe	*Pollachius virens*	24.6
33. Kattegat cod	*Gadus morhua*	8.2
34. Skagerrak Cod	*Gadus morhua*	6.1
35. Kattegat plaice	*Pleuronectes platessa*	8.7
36. North Sea herring	*Clupea harengus*	10.8
37. Celtic Sea herring	*Clupea harengus*	27.9
38. Div. VIa north herring	*Clupea harengus*	16.8
39. Clyde herring	*Clupea harengus*	23

Table 4. Estimates of replacement threshold levels for 85 populations of 27 fished species, grouped by geographic location.

Common Name	Scientific Name	Replacement Threshold Level (%)
40. Div. VIa south and VIIb,c herring	*Clupea harengus*	23.4
41. Div. VIIa herring	*Clupea harengus*	14.6
42. Baltic cod in area 22	*Gadus morhua*	2.5
43. Baltic cod in area 22 and 24	*Gadus morhua*	2.9
44. Baltic cod in areas 25-32	*Gadus morhua*	8.8
45. Western Baltic and Kattegat herring	*Clupea harengus*	6.8
46. Gulf of Riga and areas 25-29 herring	*Clupea harengus*	30.4
47. Herring in coastal areas 25-27	*Clupea harengus*	39.5
48. Herring in the Gulf of riga	*Clupea harengus*	27.1
49. Herring in areas 30E	*Clupea harengus*	63.5
50. Herring in area 31E	*Clupea harengus*	63.5
51. Herring in area 31E	*Clupea harengus*	65.4
52. Herring in the Gulf of Finland	*Clupea harengus*	17.5
53. Sprat in areas 26 and 28	*Sprattus sprattus*	45.8
54. Sprat in areas 22-32	*Sprattus sprattus*	35.7
55. Mackerel, western stock	*Scomer scombrus*	42.8
56. Greenland halibut in areas V and XIV	*Reinhardtius hippoglossodes*	8.5
57. Icelandic saithe	*Pollachius virens*	24.9
58. Faroe saithe	*Pollachius virens*	21.4
59. Faroe Plateau cod	*Gadus morhua*	17.2
60. Faroe haddock	*Melanogrammus aeglefinus*	31.5
61. Hake, northern stock	*Merluccius merluccius*	51.5
62. Hake, southern stock	*Merluccius merluccius*	34.1
63. Megrim in areas VII and VIII	*Lepidorhombus whiffragonis*	55.1
64. Sardine in areas VIIIe and IXa	*Sardina pilchardis*	55.4
65. Horse mackerel, southern stock	*Trachurus trachurus*	22.3
Northwest Atlantic Stock (Canada)		
66. Pollock in NAFO areas 4VWX and 5Zc	*Theragra chalcogramma*	23.7
67. Haddock in NAFO area 4X	*Melanogrammus aeglefinus*	26
68. Herring in NAFO area 4T	*Clupea harengus*	9.5

Table 4. Estimates of replacement threshold levels for 85 populations of 27 fished species, grouped by geographic location.

Common Name	Scientific Name	Replacement Threshold Level (%)
Northwest Atlantic Stock (USA)		
69. Georges Bank cod	*Gadus morhua*	11.9
70. Gulf of Maine cod	*Gadus morhua*	8.4
71. Georges Bank haddock	*Melanogrammus aeglefinus*	20.6
72. Silver hake, northern stock	*Merluccius bilinearis*	30.8
73. Silver hake, southern stock	*Merluccius bilinearis*	42.4
74. Georges Bank yellowtail flounder	*Limanda ferruginea*	14.2
75. Southern New England yellowtail flounder	*Limanda ferruginea*	10.3
76. Summer flounder	*Paralichthys dentatus*	3.7
77. Gulf of Maine herring	*Clupea harengus*	14.9
78. NW Atlantic mackerel	*Scomer scombrus*	40.7
79. Georges Bank scallops	*Placopecten magellanicus*	2
80. Mid-Atlantic scallops	*Placopecten magellanicus*	2.9
Atlantic Stocks		
81. North Atlantic swordfish	*Xiphias gladius*	8.6
82. NW Atlantic swordfish	*Xiphias gladius*	10.1
Pacific Coast Stocks		
83. Bering Sea walleye pollock	*Theragra chalcogramma*	43.8
84. Pacific halibut	*Hippoglossus sternolepis*	24.6
85. Bering sea yellowfin sole	*Limanda aspera*	20.4

Is a reduction in fishing effort plus a small reserve network comparable to a large marine reserve?

A reduction in fishing effort plus a small reserve network is NOT comparable to a large marine reserve.

First, reduced effort does not translate into reduced catch. As technology improves, catch often increases as effort decreases. This is true particularly for bottom fishing, with technological improvements such as bottom maps and fish finders.

Second, if the rate of removals already exceeds the replacement, a small reduction in fishing effort (e.g. 10%) may not be sufficient to sustain the fished population of over the long term. The population will continue to decline in fished areas, but at a slower rate than before the reduction in fishing effort.

Third, one of the primary objectives of a reserve is to reestablish stable age structure and allow adult fish to live longer and reach larger sizes than in fished areas. Effort regulations kill either (1) a cross-section of all sizes, or (2) focus on retaining larger, more valuable fish (e.g. minimum size limit). In the present study, fishing reduces the average age of individuals in the population until there are few reproductive adults. Consequently, recruitment limitation can reduce population growth.

Can other current management measures reduce the recommended reserve size for conservation (e.g. the proposed cowcod closure)?

Other current management measures cannot reduce the recommended reserve size of 30-50% of the Channel Islands National Marine Sanctuary for ecosystem conservation. The proposed cowcod closure provides some protection for groundfish species within a limited depth range (below 120 ft) and areas (south of the Channel Islands, including San Nicolas and Santa Barbara Islands). With the exception of the Anacapa Reserve, closures in the Channel Islands region have been limited to a single or several species, or a single or several gear types. Single (or several) species (or gear type) closures do not meet the Marine Reserves Working Group goal of protecting ecosystem biodiversity. One of the primary objectives for marine reserves is to "protect representative and unique marine habitats, ecological processes, and populations of interest". The Marine Reserves Working Group and the Science Panel have identified 20 representative and unique marine habitats (Table 7) and 119 populations of interest (Table 8). Ecological processes link the species with their habitats and with other species through direct and indirect interactions.

In response to stock status classified as over-fished, the Pacific Fisheries Management Council adopted tentative guidelines for the development of draft rebuilding plans for canary rockfish and cowcod. For canary rockfish, the tentative guidelines include substantially reduced take limits that would be in place for several decades or until the populations are rebuilt. Reduced limits on canary rockfish do not prevent accidental or by-catch of canary rockfish during other fishing efforts. To protect cowcod, found almost exclusively in waters off southern and central California, large area closures in the best cowcod areas will be closed to all groundfish fishing below 120 ft, and retention of cowcod will be restricted in all fisheries in open areas. Fishing will be permitted at depths shallower than the officially recognized cowcod habitat (>120 ft). Consequently, there is little benefit to most rockfish species (including the occasional cowcod) that inhabit kelp beds and to depths of 120 ft. The proposed cowcod closure does not substitute for protection of marine ecosystems in the northern Channel Islands where we have little suitable cowcod habitat, and do not expect to protect significant populations of cowcod.

As reserve size is decreased, which goals and objectives are not met?

Table 6. Relationship between marine protected area objectives, size, and design complexity.

Objective	Relative Size	Complexity
Conserving biodiversity	Large (or a network)	Simple to complex
Protecting a migratory species	Large (or a network)	Simple to complex
Providing sites for scientific research	Network of small, medium, and large	Simple to complex
Protecting habitat from multiple threats	Medium to large	Complex
Protecting habitat from a single threat	Medium	Simple
Preventing overfishing	Small to medium (or a network)	Simple
Enhancing stocks	Small to medium (or a network)	Simple
Protecting an endangered species	Small to medium	Simple
Promoting marine ecotourism	Small to medium	Simple
Protecting areas of historic or cultural interest	Small	Simple

Modified from Table 2 in Agardy, T. 2000. Information needs for marine protected areas: scientific and societal. Bulletin of Marine Science 66(3):875-888.

Table 7. Representative and unique marine habitats in the Channel Islands region

Habitat Type	Units
1. Rocky coastline	Linear miles
2. Sandy coastline	Linear miles
3. Wave-cut coastline	Linear miles
4. Nearshore sandy habitat (0-30 m)	Square nautical miles
5. Nearshore rocky habitat (0-30 m)	Square nautical miles
6. Sandy shallow continental shelf (30-100 m)	Square nautical miles
7. Rocky shallow continental shelf (30-100 m)	Square nautical miles
8. Sandy deep continental shelf (100-200 m)	Square nautical miles
9. Rocky deep continental shelf (100-200 m)	Square nautical miles
10. Sandy continental slope (>200 m)	Square nautical miles
11. Rocky continental slope (>200 m)	Square nautical miles
12. Emergent nearshore rocks	Number
13. Emergent offshore rocks	Square nautical miles
14. Submerged rocky features and pinnacles	Square nautical miles
15. Submarine canyons	Square nautical miles
16. Kelp forest	Square nautical miles
17. Eelgrass	Square nautical miles
18. Surfgrass	Square nautical miles
19. Bird rookeries	Linear miles
20. Marine mammal haulouts	Linear miles

Table 8. Species of interest in the Channel Islands National Marine Sanctuary

	Species	Scientific Name
	PLANTS	
1	Giant Kelp	*Macrocystis pyrifera*
2	Feather Boa Kelp	*Egregia menziesii and laevigata*
3	Elk Kelp	*Pelagophycus porra*
4	Oar Weed	*Laminaria farlowii*
5	*Agarum fimbriatum*	*Agarum fimbriatum*
6	*Eisenia arborea*	*Eisenia arborea*
7	*Pterygophora californica*	*Pterygophora californica*
8	Scoulder Surfgrass	*Phyllospadix scoulei*
9	Torrey Surfgrass	*Phyllospadix torreyi*
10	Eelgrass	*Zostera spp.*
	INVERTEBRATES	
11	California Hydrocoral	*Allopora californica*
12	Hydroid	*Abietinaria spp.*
13	Ostich-Plume Hydroid	*Aglaophenia latirostris*
14	Ostich-Plume Hydroid	*Aglaophenia struthionides*
15	Hydroid	*Clytia bakeri*
16	Hydroid	*Garveia annulata*
17	Hydroid	*Obelia spp.*
18	Hydroid	*Sarsia spp.*
19	Hydroid	*Sertularella turgida*
20	Hydroid	*Sertularia frucata*
21	Hydroid	*Tubularia crocea*
22	Red Gorgonian	*Lophogorgia chilensis*
23	California Golden Gorgonian	*Muricea californica*
24	Brown Gorgonian	*Muricea fructicosa*
25	Colonial Sand Tube Worm	*Phragmatopoma californica*
26	Giant Acorn Barnacle	*Balanus nubilus*
27	Aggregating Anemone	*Anthopleura elegantisima*
28	Giant Starfish	*Pisaster giganteus*
29	Ochre Starfish	*Pisaster ochraceus*
30	California Sea Cucumber	*Parastichopus californicus*
31	Warty Sea Cucumber	*Parastichopus parvamensis*
32	Red Sea Urchin	*Strongylocentrotus franciscanus*
33	Purple Sea Urchin	*Strongylocentrotus purpuratus*
34	Pink Abalone	*Haliotis corrugata*
35	Black Abalone	*Haliotis cracherodii*
36	Green Abalone	*Haliotis fulgens*

Table 8. Species of interest in the Channel Islands National Marine Sanctuary

	Species	Scientific Name
	INVERTEBRATES	
37	Red Abalone	*Haliotis rufescens*
38	White Abalone	*Haliotis sorenseni*
39	Owl Limpet	*Lottia gigantea*
40	Wavy Turban Snail	*Lithopoma undosum*
41	Kellet's Whelk	*Kelletia kellettii*
42	California Mussel	*Mytilus californianus*
43	Rock Scallop	*Hinnites giganteus*
44	Pismo Clam	*Tivela stultorum*
45	Geoduck Clam	*Panopea generosa*
46	Market Squid	*Loligo opalescens*
47	California Spiny Lobster	*Panulirus interruptus*
48	Red Rock Shrimp	*Lysmata californica*
49	Spot Prawn	*Pandalus platyceros*
50	Ridgback Prawn	*Sicyonia ingentis*
51	Red Crab	*Cancer productus*
52	Rock Crab	*Cancer antennarius*
53	Sheep Crab	*Loxorhynchus grandis*
	FISH	
54	Leopard Shark	*Triakis semifasciata*
55	Pacific Angel Shark	*Squatina californica*
56	Soupfin Shark	*Galeorhinus galeus*
57	Thornback Ray	*Platyrhinoidis triseriata*
58	Pacific Herring	*Clupea pallasii*
59	Pacific Sardine	*Sardinops sagax*
60	Northern Anchovy	*Engraulis mordax*
61	Pacific Cod	*Gadus macrocephalus*
62	California Grunion	*Leuresthes tenuis*
63	California Scorpionfish	*Scorpaena guttata*
64	Pacific Ocean Perch	*Sebastes alutus*
65	Kelp Rockfish	*Sebastes atrovirens*
66	Brown Rockfish	*Sebastes auriculatus*
67	Gopher Rockfish	*Sebastes carnatus*
68	Copper Rockfish	*Sebastes caurinus*
69	Greenspotted Rockfish	*Sebastes chlorostictus*
70	Black and Yellow Rockfish	*Sebastes chrysomelas*
71	Dark-blotched Rockfish	*Sebastes crameri*
72	Starry Rockfish	*Sebastes constellatus*
73	Calico Rockfish	*Sebastes dallii*
74	Widow Rockfish	*Sebastes entromelas*

Table 8. Species of interest in the Channel Islands National Marine Sanctuary

	Species	Scientific Name
	FISH	
75	Cowcod	*Sebastes levis*
76	Black Rockfish	*Sebastes melanops*
77	Vermilion Rockfish	*Sebastes miniatus*
78	Blue Rockfish	*Sebastes nystinus*
79	Speckled Rockfish	*Sebastes ovalis*
80	Bocaccio	*Sebastes paucispinis*
81	Canary Rockfish	*Sebastes pinniger*
82	Grass Rockfish	*Sebastes rastrelliger*
83	Yelloweye Rockfish	*Sebastes ruberrimus*
84	Flag Rockfish	*Sebastes rubrivinctus*
85	Olive Rockfish	*Sebastes serranoides*
86	Treefish	*Sebastes serriceps*
87	Honeycomb Rockfish	*Sebastes umbrosus*
88	Shortspine Thornyhead	*Sebastolobus alascanus*
89	Lingcod	*Ophiodon elongatus*
90	Cabezon	*Scorpaenichthys marmoratus*
91	Giant Seabass	*Stereolepis gigas*
92	Broomtail Grouper	*Mycteroperca xenarcha*
93	Kelp Bass	*Paralabrax clathratus*
94	Ocean Whitefish	*Caulolatilus princeps*
95	White Seabass	*Atractoscion nobilis*
96	Halfmoon	*Medialuna californiensis*
97	Black Surfperch	*Embiotoca jacksoni*
98	Barred Surfperch	*Amphistichus argenteus*
99	Shiner Surfperch	*Cymatogaster aggregata*
100	Walleye Surfperch	*Hyperprosopon argenteum*
101	Silver Surfperch	*Hyperprosopon ellipticum*
102	Rubberlip Surfperch	*Rhacochilus toxotes*
103	Blacksmith	*Chromis punctipinnis*
104	Garibaldi	*Hypsypops rubicundus*
105	California Sheephead	*Semicossyphus pulcher*
106	Tidewater Goby	*Eucylogobius newberryi*
107	California Halibut	*Paralichthys californicus*
108	Starry Flounder	*Platichthys stellatus*
109	CO-Turbot	*Pleuronichthys coenosus*

Table 8. Species of interest in the Channel Islands National Marine Sanctuary

	Species	Scientific Name
	BIRDS	
110	Ashy Storm Petrel	*Oceanodroma homochroa*
111	California Brown Pelican	*Pelecanus occidentalis californicus*
112	Snowy Plover	*Charadrius alexandrinus*
113	California Least Tern	*Sterna antillarum browni*
114	Pigeon Guillemot	*Cepphus columba*
115	Xantus' Murrelet	*Synthliboramphus hypoleucus*
116	Cassin's Auklet	*Ptychoramphus aleuticus*
	MAMMALS	
117	Harbor Seal	*Phoca vitulina*
118	Northern Fur Seal	*Callorhinus ursinus*
119	Southern Sea Otter	*Enhydra lutris nereis*

What species, if any, are unique to the Channel Islands? Where are they located?

Most marine species found in the Channel Islands have the potential to disperse into other regions. For some species (e.g. California spiny lobster), the Channel Islands form the northern limit of their geographical distribution. For other species (e.g. black rockfish) the Channel Islands form the southern limit of their geographical distribution. The marine ecosystem differs fundamentally from the terrestrial system because marine species have greater potential for passive or active dispersal. Many marine species have pelagic dispersal phases. Their eggs or larvae are released into open water where they develop over periods of days to a few months. Some larvae drift passively with currents, while others may be able to influence or control dispersal. Consequently, replenishment of populations may depend on reproduction that occurs in other places. Tundi Agardy (1997) eloquently describes the marine system as "dynamic and without defined boundaries. Living things are suspended in a moving, fluid three dimensions, where even plants—the foundation for large and complex food chains—can move."

The marine ecosystems around the Channel Islands are unique, not in terms of species identities, but in terms of interactions among species. The Channel Islands form the boundary between two vast biogeographical regions, the cold-water Oregonian Province to the north, and the warm-water California Province to the south. Species that range from the Bering Sea to Point Conception (e.g. darkblotched rockfish) overlap in the Channel Islands with species that are found from Point Conception to Baja California (e.g. calico rockfish).

San Miguel Island supports six species of pinnipeds, more than anywhere in the North Pacific. They included the California sea lion (*Zalophus californianus*), Northern seal lion (*Eumetopias jubatus*), Northern fur seal (*Callorhinus ursinus*), Guadalupe fur seal (*Artocephalus townsendi*), Northern elephant seal (*Mirounga angustirostris*), and harbor seal (*Phoca vitulina*). At certain times of the year, the Point Bennett area supports more than 10,000 animals in one of the most outstanding displays of marine mammal life found on the Southern California Islands. California sea otters (*Enhydra lutris nereis*) were a common around the Channel Islands in the early 19th century but they were exterminated in this region due to excessive hunting.

The ocean itself forms a barrier to dispersal of terrestrial species that inhabit the Channel Islands. Numerous animal and plant species found on the Channel Islands are *endemic,* in other words, they occur no where else in the world.

There are four endemic species and subspecies of terrestrial mammals which occur on Santa Cruz Island, the Santa Cruz Island fox (*Urocyon littoralis santacruzae*), the spotted skunk (*Spilogale gracilis amphialus*), the deer mouse (*Peromyscus maniculatus santacruzae*), and the western harvest mouse (*Reithrodontomys megalotis santacruzae*).

There is one terrestrial mammal on Santa Barbara Island, the endemic subspecies of deer mouse (*Peromyscus maniculatus elusus*).

The Island night lizard (*Xantusia riversiana*) is found only on Santa Barbara, San Nicholas and San Clemente Islands. The Island night lizard was listed as endangered in 1967.

There are 10 birds which are Channel Island subspecies or races, including Allen's hummingbird, western flycatcher, horned lark, Santa Cruz Island jay, Bewick's wren, loggerhead shrike, orange-crowned warbler, house finch, rufous-sided towhee and the Catalina quail (introduced). Anacapa and Santa Barbara Islands support a variety of endangered and vulnerable breeding seabird species, including the two major rookeries of the endangered California brown pelican (*Pelecanus occidentalis californicus*), and breeding populations of the ashy storm-petrel (*Oceanodroma homochroa*), black storm-petrel (*Oceanodroma melania*), Leach's storm-petrel (*Oceanodroma leucorhoa*), Cassin's auklet (*Ptychoramphus aleuticus*), and Xantus's murrelet (*Synthliboramphus hypoleucus*). The endemic Santa Barbara Island song sparrow (*Melospiza melodia graminea*) is thought to be extinct. In 1959, a fire destroyed much of the bird's habitat and the population of Santa Barbara Island song sparrows survived only eight years after the fire.

There are over 650 different plants on Santa Cruz Island, including both native and introduced species. Forty-two of these plants are endemic to the Channel Islands and 9 are endemic to Santa Cruz Island, in particular. There are four plants restricted to Santa Rosa Island: Live-forever (*Dudleya blochmanae insularis*), manzanita (*Arctostaphylos confertiflora*), gilia (*Gilia tenuiflora hoffmannii*), and a variety of Torrey Pine (*Pinus torreyana insularis*). Torrey pines are found on the northeast side of Santa Rosa Island at elevations between 200-500 feet. This is the only native stand of Torrey pines on any Channel Island. Another subspecies of Torrey Pine occurs naturally at only one other location, on the southern California coast just south of Del Mar in San Diego County.

Although there are no endemic plant species on San Miguel Island, there is a subspecies of buckwheat (*Eriogonum grande dunklei*) known only from this island.

There are three plants restricted to Santa Barbara Island, including a shrubby buckwheat (*Eriogonum giganteum compactum*), a small succulent (*Duleya traskiae*), and the annual poppy (*Platystemon californicus ciliatus*).

What are the criteria for risk of extinction of species in the Channel Islands region? How does extinction factor into the Science Panel recommendation?

There is a difference between *evolutionary extinction* and *ecological extinction* (or stock collapse).

Evolutionary extinction is the complete loss of a species from its global geographic range.

Ecological extinction or stock collapse is the decline of populations, or species, to levels at which the species no longer play an effective role in the ecosystem, and no longer are economically viable. *Ecological extinction* or stock collapse is the central operating principle of the Science Panel recommendation.

The collapse of stock depends heavily on stock resilience or intrinsic rate of increase. Musick *et al.* (1999, 2000) developed provisional decline thresholds based on population resistance. If decline, defined as steady decline of populations over the longer of 10 years or 3 generations, reaches a threshold level, populations should be listed as vulnerable and subjected to close scrutiny for further listing (Musick *et al.* 1999). Musick *et al.* (1999) estimate that populations with very low productivity (such as herring) are vulnerable when they decline by 70% (which is equal to 0.3k, where k is the natural carrying capacity in the absence of fishing). Populations with relatively low productivity (such as cod) are vulnerable when they reach 85% decline (or 0.15k) and populations with intermediate to high levels of productivity (such as scallops) are vulnerable after approximately 95% decline or (0.05k).

The Pacific Fisheries Management Council (Parrish *et al.* 2000) identified a number of populations of West coast groundfish that have declined significantly, making some populations vulnerable to collapse. The species considered overfished include the Pacific Ocean perch (*Sebastes alutus*), cowcod (*Sebastes levis*), bocaccio (*Sebastes paucispinis*), canary rockfish (*Sebastes pinniger*), and lingcod (*Ophiodon elongatus*). Populations of Pacific Ocean perch exhibited very low productivity (Love et al. in press) and have declined 81-91% in Washington and Oregon (Ianelli and Zimmerman 1998). Populations of cowcod exhibit very low productivity (Love et al. in press) and have declined in all populations by 91-97% (Butler et al. 1999). Populations of bocaccio in Washington, Oregon, and California exhibit very low productivity and have declined 96-98% in all populations. Canary rockfish exhibit very low productivity and populations in Washington, Oregon and California have declined 77-93% (Stock Assessment Team 1999). Lingcod exhibit low productivity and populations in Washington, Oregon and California have declined 92.5% (Adams et al. 1999).

Musick *et al.* (2000) identified 82 marine, estuarine, and diadromous stocks at risk of stock collapse in North America (exclusive of Pacific salmonids). Fourteen of the species with populations at risk in North America occur (or have occurred) in the Channel Islands National Marine Sanctuary during at least one stage of their life history (Table 9).

Table 9. Vulnerable, threatened, or endangered marine fish stocks that can be found in the Channel Islands National Marine Sanctuary during at least one stage of their life history. *Endangered* populations are at high risk of extinction in the wild in the immediate future (years). *Threatened* populations are not endangered but facing risk of extinction in the near future (decades). *Vulnerable* populations are not endangered or threatened, but are at possible risk of falling into one of these categories in the near future.

Species	Scientific Name	Populations at Risk	Percent Decline
1. White Shark	*Carcharodon carcharias*	Rare in Gulf of California.	Low to very low productivity.
2. Big Skate	*Dipturus binoculata*	Vulnerable, little data exist on recent population trends.	Low productivity and stock collapses and local extirpations in closely related species suggest it is at risk (Casey and Meyers 1998).
3. Pacific Hake	*Merluccius productus*	Vulnerable in Puget Sound. Populations in the CINMS appear to be stable.	Stocks in Puget Sound declined from 45.1 million lbs in 1983 to 1.1 million lbs. In 1998 (Palsson et al. 1997; Wright 1999b). High predation by pinnipeds may be preventing recovery despite stringent fishing regulations (Schmitt *et al.* 1996).
4. Copper Rockfish	*Sebastes caurinus*	Vulnerable.	Stocks in Puget Sound exhibited a long-term decline since the mid-1980s (Wright 1999b). Spawner output declined by >80% form 1979 to 1992 (WA DFG 1997).
5. Dark Blotched Rockfish	*Sebastes crameri*	Vulnerable.	Stocks in Washington, Oregon, and California exhibited 77-89% decline (Rogers *et al*. 2000).
6. Widow Rockfish	*Sebastes entromelas*	Vulnerable.	Stocks in Washington, Oregon, and California exhibited 81-82% decline (Williams *et al.* 2000).
7. Cowcod	*Sebastes levis*	Vulnerable. Considered overfished in California.	Stocks in the US exhibited 91-97% decline (Butler *et al.* 1999).
8. Black Rockfish	*Sebastes melanops*	Vulnerable.	Stocks in Puget Sound exhibited a long-term decline (Barker 1998, Crawford 1999, Wright 1999b).

Table 9. Vulnerable, threatened, or endangered marine fish stocks that can be found in the Channel Islands National Marine Sanctuary during at least one stage of their life history.

Species	Scientific Name	Populations at Risk	Percent Decline
9. Bocaccio	*Sebastes paucispinis*	Vulnerable. Considered overfished in California.	Stocks in Washington, Oregon, and California exhibited 96-98% decline (McCall et al. 1999).
10. Canary Rockfish	*Sebastes pinniger*	Vulnerable. Considered overfished in California.	Little information available on the status of this large, uncommon species (Findley, pers. obs.).
11. Yelloweye Rockfish	*Sebastes ruberrimus*	Vulnerable.	Stocks in Puget Sound exhibited a long-term decline (Wright 1999b); the species has virtually disappeared from recreational catches (Barker 1998).
12. Shortspine Thornyhead	*Sebastologus alascanus*	Vulnerable. Populations in the CINMS appear stable.	Stocks in Washington, Oregon, and California exhibited 73% decline (Rogers *et al*. 2000).
13. Giant Sea Bass	*Stereolepis gigas*	Vulnerable. Populations exhibited a slight resurgence in the recent past.	Populations in the US are vulnerable; populations in the Gulf of California are threatened (Sala, pers. obs.).
14. Lingcod	*Ophiodon elongatus*	Vulnerable.	Stocks in Washington, Oregon, and California exhibited 92.5% decline (Adams *et al.* 1999).

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