Channel Islands: Homework Assignment

Regarding the establishment of Marine Protected Areas (MPAs), there are numerous viewpoints. So called "environmentalists" support their establishment while "fishers" claim they are not needed[1].

In this assignment, you will be writing **two** 3 page (approximate, 1.5 spaced, 11 pt font) opinion editorials ("op-eds") for the Los Angeles Times on establishment of MPAs off the coast of California. The three page limit does not include references and graphics.

In one op-ed, you will be an advocate for the group who opposes the establishment of MPAs ("fishers"). **In the other**, you will be an advocate for the group that supports their establishment ("environmentalists"). (Note: The ***size*** of the MPAs is an entirely different topic, so you do not need to address the ***size*** in your op-ed piece.)

In writing your op-ed piece, you need to use scientific findings contained in the peer-reviewed literature to support your position. In some instances, you will be able to find data and graphs that specifically support your position. In other cases, you may find it useful to focus on the uncertainty of a scientist's findings to support your position.

The definition of peer-reviewed literature for this assignment is *literature that has been published in scientific journals and has been peer-reviewed by other scientists*. This means that graphics and data you find on the internet or on an advocate's website are not information you should use in writing your op-ed piece (although if you can find the source of these data/graphics in the peer-reviewed literature, then they are certainly fair game). For each op-ed, you will need to reference at least four peer-reviewed papers. In addition, you must include in each piece **two graphs or tables** that you have taken from a peer-reviewed paper. You should use these graphs/tables to support your arguments. Be sure to effectively communicate an interpretation of the graphs so that the readers will be able to understand why you have included them. Remember that your audience may not be able to easily interpret complicated graphs. Feel free to re-make graphs using data you find in the peer-reviewed literature if you feel you could make them easier to interpret.

[1] For simplicity, the two groups are called fishers and environmentalists, but please note that not all people in these groups share the same perspective as you well know.

Please remember that the objectives of this homework assignment are to effectively use the peer-reviewed literature and effectively communicate science to the general public. Remember your audience when you write this.

You may use a number of search engines to find scientific articles. Isiknowledge.com's Web of Science is a great starting point. Scholar.google.com is also a great database. Journals where you are likely to find information on this subject include, but are not limited to, *Ecological Applications, Science, Nature, Proceedings of the National Academy of Science,* and *Ecological Monographs*. If you have not used a search engine before, then please contact members of your working group, the TAs or come to office hours for assistance.

Be sure to reference articles as follows:

In text:

Miffy et al. [1] showed that destruction of a coral reef reduced tourism revenue.

In references.

Miffy, C. V., Kitty, H. K., and Biffy, B. H. 2007. Coral reef removal impacts tourism in the land of jubilee. *Ecological Perspectives*. Vol. 4, pp. 789-854.

Channel Islands: Sample Answers

Sample Answer #1: Anti-MPA Op-Ed

MPA = Marine Problem Area?

Among the well-intentioned, the State Department of Fish & Game's widespread if unwieldy system of 84 marine reserves and conservation areas from San Diego to Humboldt County is gaining remarkable traction and support. After all, why not jump on the bandwagon with the doe-eyed seals, playful otters, and fleets of shimmering fish?

One compelling reason not to: tempting as it may be to buy into the DF&G's self-aggrandizing theory of marine protection, the science and indeed the common sense behind their painfully-specific rules are completely at odds with everything we know about the ocean.

No one disagrees that fishing pressure and the growing human consumption of marine organisms can alter the abundance of fish, and I speak for every California fisherman when I say the fishing industry more than anyone in this state has an exceptionally great interest in maintaining, sustaining, and growing those stocks—at stake is our favorite pastime and our livelihood. (Seadog or not, you might also think about the $800 million dollars generated in California by fishing revenues every year).

What it seems like only fishermen realize is: humans are just as much a part of the marine food chain as are tuna, sea urchins, and giant kelp. Small fish eat plankton, big fish eat small fish, and we eat the big fish. Taking humans out of the picture entirely, the way an MPA does, throws the entire system akimbo by releasing predation pressure on piscivorous fish, and abundant scientific research from right here in California and overseas confirms this assertion.

Diaz et al [1] investigated what really happens in an MPA, when releasing fishing pressure allowed fish stocks to grow to enormous densities, as it always will. Fish eat lobster larvae, and more fish eat more lobster larvae, thereby depleting the area's most valuable fishery while also prohibiting fishermen from catching fish. Please see Figure 1. Hobday [2] did a similar experiment on the same reef, and showed that there were as many as 15% more lobsters in areas *outside* the MPA.

In California Fanshawe et al [3] reached a similar conclusion: in an MPA, abalone populations will never grow if sea otters are present. The number of abalone in MPAs with sea otters was strikingly lower than in those without. Please see Figure 2. This results firmly debunks the idea that leaving "Nature" to run its course will benefit all species across the board. With that in mind, remember also that the vast majority of California marine habitats are already far afield from their natural equilibria, as a result of the widespread introduction and establishment of invasive species.

That's not to say that some measure of protection is in order. But what kind? The above examples show definitively that prohibiting all fishing in a given area can adversely affect stocks—thereby defeating the goals of both the conservationists and the seafood industry. Rather than sidestep the issue and circumvent the effects of fishing pressure, management practices should acknowledge and target fishermen as an important part of the ecosystem—not to mention an essential component of the economy---and regulation should remain the provenance of the fisheries management council, to be enforced by catch. Catches are concrete, definite parameters that are much more informative than rough estimates and blind guesses at total abundances. Certain species need to be regulated by season and size.

Some of the existing MPAs do allow fishing of certain species—rest assured you can still take your heart's content of monkey-faced eels at the Duxbury Reef, and though you must leave mussel-bed worms alone, you can help yourself to Dungeness crab—but the vast majority are intolerant of any sort of fishing, commercial or recreational.

Finally, it cannot be said enough that there is still a profound lack of large-scale, long-term controlled, replicated experiments that precisely quantify the effects of MPAs. Until we have that knowledge, we must not act rashly on the inexact findings that are available to us today.

Large-scale human extraction of marine resources is an ecosystem function around which communities have inevitably become structured over the last century or more in California. We are very much a part of our environment, and stepping back to watch things play out in the MPA, in the absence of human impact creates an artificial situation out of immense arrogance. Moreover, it puts certain species, including such economically important species as lobsters, abalone, and urchins, under increased pressure. What California needs is a dynamic and flexible plan to marry measurable and easily-manipulated parameters like catch limits or fishing effort with the goals of both conservationists and the seafood industry—which, after all, are one and the same.

Figures

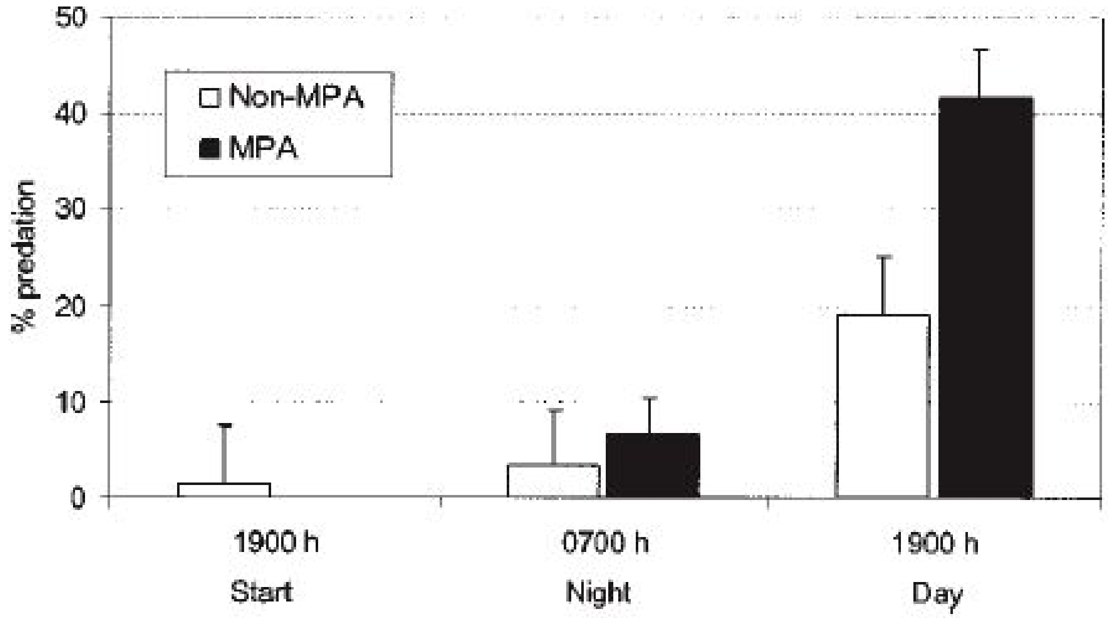

Figure 1: From Diaz et al [1]. Predation on lobsters is markedly higher in MPAs than outside of MPAs. Black bars are MPA samples and white bars are non-MPA samples.

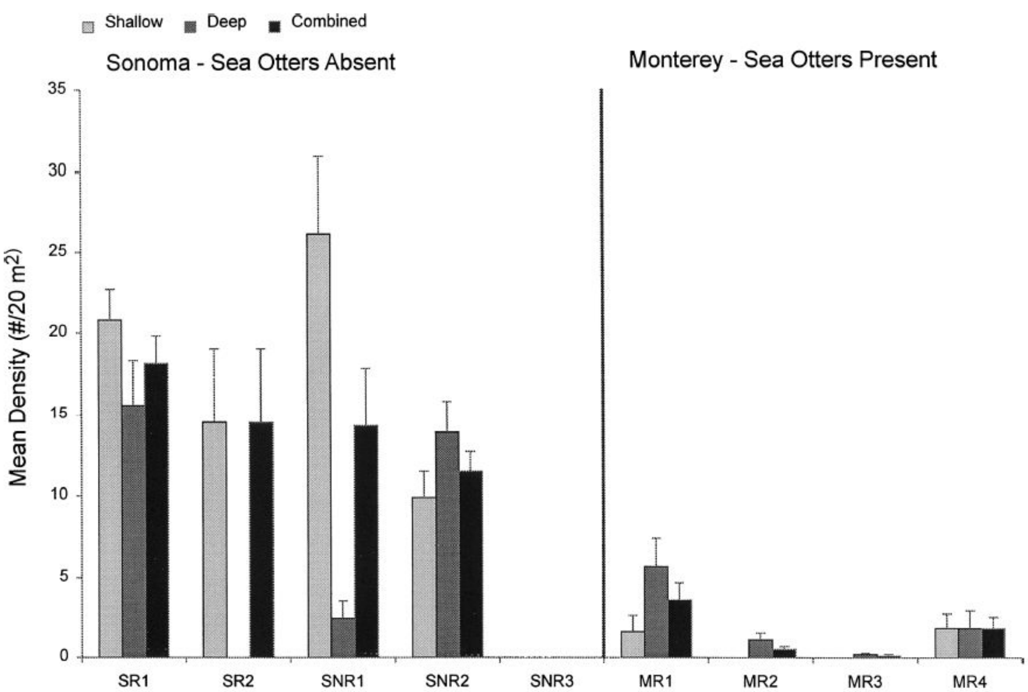

Figure 2: From Fanshawe et al [3]. Abalone densities as a function of sea otter presence/absence. In the samples at right, sea otters were present and abalone density was much lower than in samples from sites where sea otters were absent.

References

[1]
Diaz, D. A., Zabala, M., Linares, C., Hereu, B., and Abello, P. 2005. Increased predation of juvenile European spiny lobster (*Palinurus elephas*) in a marine protected area. *New Zealand Journal of Marine and Freshwater Research*. Vol. 39, pp. 447-453.

[2]
Hobday, D., Punt, A. E., and Smith, J. D. 2005. Modelling the effects of Marine Protected Areas on the southern rock lobster (*Jasus edwardsii*) fisher of Victoria, Australia. *New Zealand Journal of Marine and Freshwater Research*. Vol. 39, pp. 675-686.

[3]
Fanshawe, S., Vanblaricom, G. R., and Shelly, A. A. 2003. Restored Top Carnivores as Detriments to the Performance of Marine Protected Areas Intended for Fishery Sustainability: a Case Study with Red Abalones and Sea Otters. *Conservation Biology*. Vol. 17, No. 1, pp. 273-283.

Sample Answer #2: Anti-MPA Op-Ed

Opinion Editorial: The High Cost and Low Return of Marine Protected Areas Is a Burden to the Fishing Industry

Certainly the prospect of a healthy, clean, and fertile ocean appeals to everyone living near the ocean, particularly here in sunny California. As humans, we depend heavily on our coastal ecosystems for recreation, aesthetic pleasure, scientific exploration, and – most importantly – our livelihoods. The eagerness of California legislators to set aside Marine Protected Areas (MPAs) in all their various forms is a direct affront to those who rely on the ocean not for the abstract goals of promoting biological diversity or ecosystem services (both of which are admirable, albeit somewhat impractical, goals), but rather for the very real and direct necessity of earning an income. Instead of valuing the needs of the workers of the ocean waters, the decision makers consistently weigh the arguments of far-removed environmentalists more than the concerns of the people who have been living intimately with the ocean waters through their daily role in the fishing industry.

To the public audience, MPAs seem like the perfect solution to finding a balance between conservation and industry – just put away some of the ocean for conservation, and some of it for fishing, and everything will work out. The raw simplicity of such a proposal is its main appeal, although the drawn-out debates within planning committees over the location, size, and other specifics of reserves prove that MPAs are not nearly as simple as they appear on the surface. Despite the depths of complexity inherent in any dealings with the ocean, little has been done to propose alternatives to MPAs as a whole. Instead, vast amounts of time, energy, and money have been put into tweaking the MPA system itself. In particular, current MPA implementation gives too little merit to the concerns of the fishing industry for the ocean's health as well as their own economic viability; MPAs "only treat the symptoms and not the fundamental causes" of population declines, as Sancherico et al. [4] explain; and MPAs are by far too broad and general, instead of being tailored for specific ecological and economic conditions.

First, today's MPA process underestimates the high overhead costs in the fishing industry, especially in switching target species or gear to comply with conservation legislation. As Sancherico et al. [4] detail in their report to Resources for the Future, a Washington, D.C. non-profit environmental analysis organization, potential long- and short-term costs due to MPA implementation include increased congestion in areas that are still fishable, shifts in species being fished, even higher costs of searching for fish, and increased personal danger due to fishers being "pushed" further out to sea (with the associated heavier weather and distance from help) due to the location of coastal MPAs. Scholz et al. [5] point out that the immediate costs of marine reserve programs are paid (or lost, in this case) almost exclusively by industries that rely on the coastal waters as a source of a specific product, like fish. This imbalance in the burden carried by the fishing industry is not redeemed in the long term, either; Scholz et al. [5] continue on to say that it is recreational and scientific users who benefit the most from the eventual results of marine reserves, despite the assurances made that reserves can increase fishing yields. Ultimately, the fishing industry is paying for a program that fails to benefit the very people who rely the most on the ocean for their livelihood.

Second, MPAs are too simplistic to be truly beneficial to all of the parties involved. Current MPAs are primarily modeled on successful reserves on land, but there are significant differences between land and marine ecosystems are not addressed sufficiently, as Carr et al. [2] detail in their comparison of marine and terrestrial reserves. A simple accounting of these differences is shown below in a table from Agardy et al. [1]

Differences between marine and terrestrial systems.

Marine	**Terrestrial**
Nebulous boundaries	Relatively clearer boundaries
Large spatial scales	Small spatial scales
Fine temporal scales	Coarse temporal scales
Three-dimensional living space	Relatively two-dimensional living space
Relatively unstructured food webs	Relatively structured food webs
Nonlinear system dynamics	Relatively linear system dynamics
Not well studied	Relatively well studied

Finally, MPAs are simply a patch solution to the problems that we are facing with the declines of multiple species of economically and biologically valuable species. Although the creation of a marine protected area can limit fishing of all or some species of fish in the hopes of replenishing stock, such legislation does not address “the roots of fisheries management failure,” namely “improper incentives and institutional structures,” as Hilborn et al. [3] establish. These systemic faults are deeply entrenched in the current American fishing industry, and will require far more than a marine reserve to adequately address. Until these root problems are solved, marine reserves will fail to benefit fishers and will only lead to higher costs of remaining in business. This could very well worsen the problem by driving out small, local fishers in favor of large, wealthy aquacorportations that can absorb the costs of complying with MPAs while still remaining in business. This will prove greatly detrimental to the local ecosystem and economic climate; these large fishing companies have no obligation or connection to their place of business, leaving their employees and their fishing grounds with little stability or sustainability if times are rough. In fact, the interviews with fishers conducted by Scholz et al. [5] demonstrate that the fishers who are being effectively punished by the MPA system are just as aware of the quality of local fish stocks as government institutions.

Summary of biological information about stocks.

Stock/Fishery	Proportion of interview pool and their assessment of respective stocks	Proportion of participants in a fishery, and their assessment of it	Fishery status as assessed by CDFG
Salmon	78% -- very good health	74% -- healthy	Healthy
Crab	37% -- healthy and sustainable	44% -- sustainable	Healthy
Rockfish	33% -- certain species healthy; 81% -- shelf and/or nearshore species in serious decline	54% -- healthy; 70% -- in decline	Many in poor health (to the extent known), some overfished
Albacore tuna	30% -- improving	67% -- good health	Relatively healthy
Urchin		80% -- healthy	In decline
Halibut		67% -- healthy	In decline
Sanddab		100% -- sustainable	In good condition

In conclusion, despite the significant knowledge of fishers who are in the ocean every day, policymakers are forsaking local knowledge in favor of an overarching, generalized MPA policy that only serves to hurt the local economy, despite claims of increased catches and profits. While MPAs seem like easy and appropriate solutions to the significant problem of population declines, we must listen to the voices of the people who know the ocean best: the fishers who work it for a living. If they protest the current MPA system, we must find a better alternative to saving our oceans.

References

1. Agardy, Tundi. 2000. Information needs for marine protected areas: scientific and societal. *Bulletin of Marine Science*. Vol. 66(3), pp. 875-888.
2. Carr, M.A., Neigel, J.E., Estes, J.A., Andelman, S., Warner, R.R., and Largier, J.L. 2003. Comparing marine and terrestrial ecosystems: implications for the design of coastal marine reserves. *Ecological Applications*. Vol. 13(1) Supplement, pp. S90 – S107.
3. Hilborn, R., Stokes, K., Maguire, J., Smith, T., Botsfeld, L.W., Mangel, M., Orensanz, J., Parma, A., Rice, J., Bell, J., Cochrane, K., Garcia, S., Hall, S.J., Kirkwood, G.P., Sainsbury, K., Stefansson, G., and Walters, C. 2004. When can marine reserves improve fisheries management? *Ocean & Coastal Management*. Vol 47, pp. 197-205.
4. Sancherico, J.N., Cochran, K.A., and Emerson, P.M. 2002. Marine protected areas: economic and social implications. Resources for the Future, Washington, D.C.
5. Scholz, A., Bonzon, K., Fujita, R., Benjamin, N., Woodling, N., Black, P., and Steinback, C. 2004. Participatory socioeconomic analysis: drawing on fishermen's knowledge for marine protected area planning in California. *Marine Policy*. Vol. 28(4), pp. 335-349.

Sample Answer #3: Pro-MPA Op-Ed

Marine protection a critical and immediate need

The problems with overfishing in California and the ongoing dispute over how best to manage our limited marine resources continue to make top headlines. New and frightening statistics detailing the extent to which our most important fish stocks have been depleted, and the raging debate over the allegedly uncertain science of setting aside entire tracts of sea as no-fishing zones push the issue to the forefront of our attention. But is our problem of overfishing, and the persistent and recurrent call to address it, not old news?

Consider the hotly-contested Channel Islands Marine Protected Area (MPA) off the coast of Santa Barbara, where the Department of Fish & Game has set aside a scant patchwork of some 100 nautical miles as a conservation zone, inside the boundaries of which all marine life forms are off limits to fishermen, with the exception of sea urchins during certain months of the year. A much more extensive version of the Channel Islands MPA was first proposed in 1998 and was immediately challenged by commercial and industrial fishermen, who in spite of contrary recommendations from a panel of scientific experts succeeded in pressuring the Fish & Game Commission to whittle the proposed area down to its current size, and only this year dismissed a lawsuit against the Commission seeking an injunction against the implementation of the MPA altogether.

Those were seven long and hard-fought years, and the initial events of 1998 can seem like they happened a century ago. But in fact they were only the very most recent stretch of a much longer, if much less active, history. If you know your California literature, you know that as early as 1960—the year Scott O'Dell published his Newbery-winning <u>Island of the Blue Dolphins</u>—at least some Californians were very much aware of not only the perils of overfishing in the Channel Islands but also its increasing trend. In fact, if we are to believe O'Dell's retelling of a true historical event, the need to protect marine resources was recognized at least as early as 1847, the year a Chumash Indian girl watched Russian sailors pillage the wildlife of the island she called home.

158 years later, the waters surrounding San Nicholas (most remote of the Channel Islands) are still not included in any MPA, but tracts of sea surrounding the larger, closer Channel Islands are. Even this small, limited designation remains a point of contention because of what fishermen call an exchange of certain costs (in reduced access to fishing grounds) for uncertain benefits. Those allegedly "uncertain" benefits are the as-yet unquantified increases in fish

abundance and reproduction that should accompany the establishment and maintenance of an MPA.

Nothing could be further from the truth. In fact, many scientific studies have already shown robustly that an MPA can strongly improve both marine ecosystem function and fishing catches.

Though the science of MPAs is still a young field—the areas themselves are largely a recent phenomenon and are still undergoing long-term testing—this is what we already know:

-Fishing can significantly suppress the density of fish populations as well as change community structure by eliminating groups of species entirely, such as net-susceptible fishes. Edgar and Barrett [1] elucidated this concrete relationship between fishing pressure, fishing protection, and ecosystem function on a Tasmanian reef and suggested that it may be a worldwide phenomenon.

-MPAs increase not only the number of fish within their boundaries, but also those in surrounding waters open to fishermen. Russ and Alcala [2] showed precisely this effect, and demonstrated that yields increased as a result of reserve implementation, in a remarkable 10-year study of a Phillippine MPA and its associated fisheries. This finding was echoed by McClanahan and Mangi [3] in a seven-year study of a Kenyan MPA.

-Prohibiting fishers from bottom trawling increases seafloor complexity, a habitat quality strongly correlated with the population sizes, rates of survivorship, and species diversity that can be sustained in a given area. Lindholm et al [4] quantified this effect with a combination of dynamic modeling and real-life testing in studies of Atlantic cod. Please see Figure 1.

-Though a commercial fishing operation can indeed increase its total catch by fishing a greater area, this requires a larger staff and the actual yield *per fisher* can decrease dramatically with area fished. In that sense MPAs do not affect the efficiency of fishing operations. McClanahan and Mangi [3] determined this effect for a tropical fishery in Kenya. Please see Figure 2.

The above are just some of the findings in overwhelming support of the efficacy of MPAs in bolstering both conservation goals and the economic value of associated fisheries.

The effects of MPAs beyond terms of less than 20 years are still unknown, and even mid-term studies in California are at this point in time scarce. This uncertainty—which is actually just an early lack of long-term, California-specific evidence—remains the cornerstone in the industry argument against MPAs.

Does that hole in our knowledge justify inaction? Absolutely not. Results from elsewhere in the world, and from fairly long-term studies all support the desirable effects of

MPAs, and robustly demonstrate that this form of marine protection suits both conservation goals and economic ones.

Moreover, in California we do not have the luxury of waiting. Recall the opening passage in Island of the Blue Dolphins: the protagonist first notices a speck on the horizon, and thinks it a seashell. As it gets closer, she decides it must be a gull with folded wings. It is not until the Aleut ship, carrying Russian trappers and hunters, is nearly upon her shores that she recognizes it for what is really is. In the literary passage as in our current predicament, sometimes absolute certainty is absolutely too late in coming.

Figures

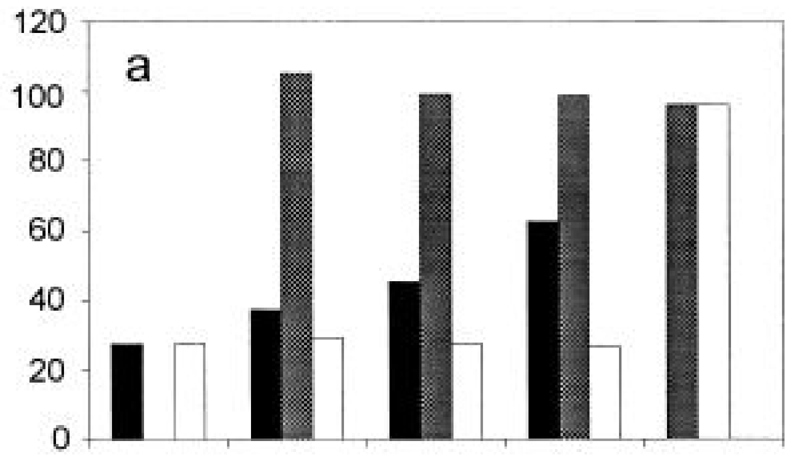

Figure 1: From Lindholm et al [4]. Cod survivorship within and outside an MPA off the Maine Coast. The y-axis is % survivorship. Grey bars represent samples inside the MPA and black bars are samples from outside the MPA; survivorship is consistently higher within the protected area.

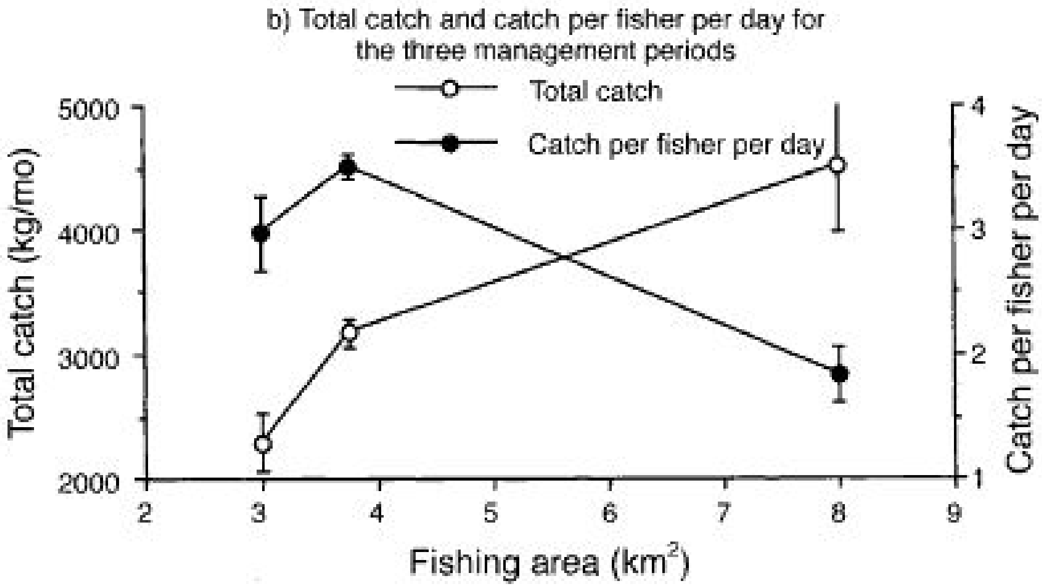

Figure 1: From McClanahan and Mangi [3]. Though total catch (white circles) increases with the area fished, the catch per fisher (black squares) tapers off.

References

[1]
Edgar, G. J., and Barrett, N. S. 1999. Effects of the declaration of marine reserves on Tasmanian reef fishes, invertebrates and plants. *Journal of Experimental Marine Biology and Ecology*. Vol. 242, No. 1, pp. 107-144.

[2]
Russ, G. R., and Alcala, A. C. 1996. Do marine reserves export adult fish biomass? Evidence from Apo Island, central Phillippines. *Marine Ecology Progress Series*. Vol. 132, No. 1-3, pp. 1-9.

[3]
McClanahan, T. R., and Mangi, S. 2000. Spillover of exploitable fishes from a marine park and its effect on the adjacent fishery. *Ecological Applications*. Vol. 10, No. 6, pp. 1792-1805.

[4]
Lindholm, J. B., Auster, P. J., Ruth, M., and Kaufman, L. 2001. Modeling the Effects of Fishing and Implications for the Design of Marine Protected Areas: Juvenile Fish Responses to Variations in Seafloor Habitat. *Conservation Biology*. Vol. 15, No. 2, pp. 424-437.

Sample Answer #4: Pro-MPA Op-Ed

Opinion Editorial: Marine Protected Areas Benefit Us Biologically and Economically, Even In The Short Time We Have Had Them

Thanks to the continued efforts of California conservationists and legislators, we are lucky to have a system of marine reserves and marine protected areas (MPAs) situated in the waters along the California coastline to serve as havens for biodiversity and sources of replenishment for various stocks of economically and ecologically valuable fish. Currently, less than one percent of the United States' oceans are in such reserves, according to the Nation Academy of Science, and scientists recommend a range of suggested percentages of protected ocean, from as low as ten to as high as seventy percent, with the most common recommendation being thirty percent, as Gell and Roberts [1] show in the table below.

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are needed to see this picture.

The MPA system has, in its short lifetime, proven beneficial to the marine ecosystem through scientific review, helping to preserve biological diversity as well as to battle the problems of declining yields faced by California's – and other coastal states' – fishers.

It is impractical to suggest that we stop harvesting the ocean altogether; MPAs serve as an efficient means to promote biodiversity, replenish fishing stocks, and conserve threatened species without sacrificing the fishing industry that is so vital to our coastal economy. Certainly some initial costs must be carried by industries that draw resources (like fish) out of the ocean, but these costs are repaid in excess by the increased populations and stability of those populations that result from implementation of MPAs, in addition to the increased revenue from tourism and other industries that rely on attractive, diverse coastal waters. Flexibility is a necessity of any change in social practices, and this is no exception; however, the apparent benefits of MPAs thus far, and the more significant predicted benefits in the longer term should provide more than enough reason to believe that marine protected areas are an excellent solution to and prevention of further depletion of our oceans.

The most apparent proof of the benefit of marine reserves, in all their various forms, is the prevalence of fishers preferentially fishing the borders of reserves rather than sites far from reserves, as Gell and Roberts [1] point out. Understandably, fishers are the people most concerned with maintaining fish populations because they rely entirely on those fish for their livelihood. In addition, Scholz et al. [4] state that our fishers are the men and women who have the most local ecological knowledge, so if they are finding improved yields, we can trust that MPAs are truly beneficial. After all, this is one of the primary goals of preserving fish stocks, although it may at first seem illogical: by reducing fishing in certain areas, fishing in nearby areas will yield more mature, valuable catches. As with any resource, we must pace our consumption, and in this case we are lucky to be able to manage fish as a renewable resource – although species are most certainly no longer renewable once they are extinct. Marine reserves protect against extinction as well economic loss by maintaining populations of a variety of species.

Despite the relative youth of the practice of establishing MPAs, the review article by Lubchenco et al. [3] indicates that the past five years have shown a rapid increase in the study of marine reserves, and that this field of study has overwhelmingly shown that reserves of all shapes and sizes are beneficial to fish populations, and thus in turn to economies related to and dependent upon these coastal resources. The table below describes the benefits, both within and outside of reserves, that Lubchenco [3] et al. found in their review of the related materials.

<table>
<tr><th>Benefits within Reserves</th><th>Benefits Outside of Reserves</th></tr>
<tr><td>Long-lasting and often rapid increases in the abundance, diversity, and productivity of marine organisms.</td><td rowspan="2">In the few studies that have examined spillover effects, the size and abudance of exploited species increase in areas adjacent to reserves.</td></tr>
<tr><td>These changes are due to decreased mortality, decreased habitat destruction, and to indirect ecosystem effects.</td></tr>
<tr><td>Reserves reduce the probability of extinction for marine species resident within them.</td><td rowspan="3">There is increasing evidence that reserves replenish populations regionally via larval export.</td></tr>
<tr><td>Increased reserve size results in increased benefits, but even small reserves have positive effects.</td></tr>
<tr><td>Full protection (which usually requires adequate enforcement and public involvement) is critical to achieve this full range of benefits. Marine protected areas do not provide the same benefits as marine reserves.</td></tr>
</table>

In addition to the benefits listed above, we can easily imagine that another five years' worth of studies will show even more diverse benefits as well as larger gains from the benefits.

A limited analogy could be made by thinking about a marine reserve as a kind of stock portfolio, as Hannesson [2] explores. In financial matters, a diversity of investments gives stability to a portfolio; if the sale of peanuts drops precipitously, at least you still have the biotech stocks to keep the overall portfolio healthy. Similarly, the multiple species in a marine reserve keep the overall fishing industry consistent. Fish that are suffering from overfishing are able to replenish themselves in the safe haven of the reserve, while successful species also benefit. However, we should not take this analogy too far – we cannot trade species out when they start to fail, and the high mobility of fish means that, by their nature, threatened fish won't necessarily stay within the bounds of the reserve to reproduce and rebuild their population.

Nevertheless, we can certainly imagine the coastal ecosystem as an investment in which we are all shareholders and from which we all benefit. In this light, we would be downright foolish not to protect and conserve it to our best abilities. Restoring the ocean's fish populations is neither a quick nor easy task, but MPAs have proven themselves to be the most rapid and effective method that we have at our disposal. While arguments can be made that MPAs are more costly than they are beneficial, we must remember that we are entering a new age of environmental awareness. We are only beginning to understand how intimately connected to the oceans we are as a species, a fact of which fishers, of all people, are most aware. When we see that maintaining ocean reserves benefits us – whether directly, indirectly, or simply potentially, in some yet-undiscovered medical breakthrough – marine protected areas prove themselves worthy of their implementation.

Resources

1. Gell, F.R. and Roberts, C.M. (2003). Benefits beyond boundaries: the fishery effects of marine reserves. *TRENDS in Ecology and Evolution*. Vol. 18(9), pp. 448-455.
2. Hannesson, R. (2002). The economics of marine reserves. *Natural resource management.* Vol. 15 (3), pp. 273-290.
3. Lubchenco, J., Palumbi, S.R., Gaines, S.D., and Andelman, S. (2003). Plugging a hole in the ocean: the emerging science of marine reserves. *Ecological Applications*. Vol. 13(1) Supplement, pp. S3-S7.
4. Scholz, A., Bonzon, K., Fujita, R., Benjamin, N., Woodling, N., Black, P., and Steinback, C. 2004. Participatory socioeconomic analysis: drawing on fishermen's knowledge for marine protected area planning in California. *Marine Policy*. Vol. 28(4), pp. 335-349.

Timeline (1938 to present)

This section details the sequence of events in the establishment process.

- Initial Development (1938 to 1998):
  - In 1938, the Channels Islands were federally recognized as a national monument by Franklin D. Roosevelt. In 1949, submerged lands within one mile of Anacapa and Santa Barbara Islands were added to Channel Islands National Monument.
  - Authority to regulate use of the submerged lands was returned to the state with the Submerged Lands Act of 1953, as affirmed by the U.S. Supreme Court in 1978. Following this U.S. Supreme Court decision in 1978, the state of California created ecological reserves in the Channel Islands that allowed fishing in all but small portions of the reserves.
  - In 1980, Congress designated the Channel Islands as a national park. This law expanded the park to include three additional islands and re-established the park boundary to the waters one nautical mile offshore to include the submerged lands and waters in the park, while recognizing the authority of California to manage the living marine resources in the park.
  - Also in 1980, in response to federal proposals to expand offshore oil and gas drilling, local residents and elected officials secured designation of 1,252 square nautical miles (all of the waters within six nautical miles of the islands) as a national marine sanctuary. This status provides permanent protection from new offshore oil rigs and also bans ocean mining operations.
  - In April 1998, the California Fish and Game Commission (FGC) received a recommendation from the Channel Islands Marine Resources Restoration Committee to set aside 20 percent of the shoreline and waters out to one mile in marine reserves, or no-take zones, around the northern Channel Islands (Santa Barbara, Anacapa, Santa Cruz, Santa Rosa, and San Miguel Islands).
  - In 1999, in response to this proposal and the need for a community process, the Channel Islands National Marine Sanctuary (CINMS) and the California Department of Fish and Game (DFG) developed a joint federal/state partnership to consider establishing marine reserves in the sanctuary.

- Channel Islands Marine Reserve Process (1999 to present):
  - March 25, 1999: The Sanctuary Advisory Council (SAC), an advisory group to the sanctuary manager, held an update meeting on the marine reserve issue. (Refer to Appendix C for a listing of SAC members.)
  - May 20, 1999: The SAC held a meeting to initiate development of a stakeholder group that would consider the marine reserve issue.
  - July 1999: The SAC created a stakeholder-based community group called the Marine Reserves Working Group (MRWG). Note: The group was originally known as the Marine Ecological Reserves Working Group (Davis, Personal Communication, 2002). (Refer to Appendix C for a listing of MRWG members.)
    - The MRWG agreed to operate by consensus, working with a locally contracted facilitator and a National Oceanic and Atmospheric Administration (NOAA) facilitator.
      - "The MRWG's definition of consensus was that each member could state 'whether or not I prefer this decision above all others, I will support it because it was reached fairly and openly'" (DFG 2002b).
  - Two advisory panels were established to inform the SAC's decision-making in addition to the work of the MRWG.
    - The Science Advisory Panel was established and travel was funded by the CINMS. (Refer to Appendix C for Science Panel Members)
      - The Science Panel 1) reviewed the literature on marine reserves and provided the MRWG with potential natural resource consequences of reserves; 2) defined scientific criteria to

achieve the goals for biodiversity and fisheries defined by the MRWG; 3) identified and evaluated existing data sets for geographic information system (GIS)-based ecological characterization; and 4) evaluated the scientific merit of different reserve scenarios provided by the MRWG (DFG 2002b).

        - The Science Advisory Panel adopted a habitat-based approach, and used a GIS computer model with maps of the locations of substrate type (e.g. rock, sand, mud), kelp, eelgrass, and surfgrass, as well as bird and mammal breeding colonies.
    - The Socioeconomic Advisory Panel was established and funded by the National Oceanic and Atmospheric Administration (NOAA) Special Projects Office with support from the SAC.
        - The Socioeconomic Panel was asked to provide baseline information and analyses on the use values associated with the project area, potential costs, and, where feasible, benefits of the establishment of reserves.
        - The panel collected and synthesized existing studies, records of catch or harvest, and other information to develop economic impact analyses of various marine reserve scenarios.
- The MRWG met monthly from July 1999 through May 2001 to receive, consider, and integrate advice from the Science Advisory Panel, the Socioeconomic Advisory Panel, and the general public to develop consensus.
    - The MRWG hosted a majority of its meetings, which were open to the public, in Ventura and Santa Barbara Counties. Individual meetings are chronicled below; however, consult the CINMS Marine Reserves Web site (*www.cinms.nos.noaa.gov/marineres/main.html*) for detailed meeting minutes. (Refer to Appendix A for dates and locations of all public meetings.)
        - July 7, 1999: Introduction to the issues and proposed process.
        - October 21, 1999: Adopted draft ground rules.
        - November 10, 1999: Discussed revisions and finalized ground rules.
        - December 9, 1999: MRWG presentations on the relationships between issues identified at last meeting; worked on preliminary goals and objectives for marine reserves; developed preliminary set of questions for the science and socioeconomic panels.
        - January 10-11, 2000: Joint meeting held with science and socioeconomic panels to learn the status of marine reserves worldwide; continued development of preliminary goals and objectives to guide development of marine reserve scenarios; adopted categories/themes as a method of framing goals and objectives, including research/education, natural and cultural heritage, socioeconomics, sustainable fisheries, ecosystem biodiversity, and reserve administration.
        - February 23, 2000: Responded to questions raised by the science panel during the January meeting; discussed goals, objectives, and task group caucuses.
        - March 16, 2000: Task group break-out sessions to work on developing goals and objectives for each individual category/theme; update on MRWG process, progress, and development.
        - April 13, 2000: Update on data collection efforts; science panel discussion on marine reserve design theory; science panel feedback on draft goals and objectives; reviewed relationships among information collection, reserve design, and management plan issues.
        - June 8, 2000: Update on science panel progress; revised and adopted goals and objectives related to ecosystem biodiversity, sustainable harvested populations, and research.
        - June 22, 2000: Update on socioeconomic panel progress; discussion on map drawing.
        - July 18, 2000: Adopted revised goals and objectives related to education and natural and cultural heritage; update on science panel progress.
        - August 22, 2000: Preliminary discussion of exclusion and inclusion areas; revised and adopted goals and objectives related to reserve administration and research, which was

revised again specifically to take the place of goals and objectives already established for sustainable harvested populations; socioeconomic panel presentation on socioeconomic analysis process.

- September 26-27, 2000: Discussed prioritization of goals and objectives; received data and recommendations from the science and socioeconomic panels.
  - According to Satie Airame, Science Coordinator for the Channel Islands National Marine Sanctuary, MRWG members were unable to assign relative importance to the goals because they agreed that all goals were equally important (Personal Communication, 2003).
  - Recommendations from the science and socioeconomic panels include the following:
    - To achieve the biodiversity and fisheries goals for the species of interest, the science panel advised creating at least one reserve—but no more than four—comprising between 30 to 50 percent of the representative habitats in each of three biogeographic regions in the sanctuary.
    - In reference to this recommendation, "analysis by the socioeconomic advisory panel indicated that a closure of 50 percent of the sanctuary would result in a maximum potential loss of about 50 percent in fishing industry revenue (commercial and recreational)" (Davis 2001a).
- October 18, 2000: Ecological analysis of marine reserve options; refined options into alternative recommendations for reserve design.
- November 15, 2000: Determined areas of agreement, unresolved issues, and a timeline to address these issues, as well as ultimately achieve consensus.
- December 14, 2000: Revised and adopted goals and objectives related to socioeconomics and sustainable fisheries; developed questions for the science and socioeconomic panels.
- January 17, 2001: Science and socioeconomic panel presentations and discussion.
- February 15, 2001: Discussed and tried to resolve key issues prior to crafting spatial options.
- February 21, 2001: Developed preliminary spatial options for review by science panel, socioeconomic panel, and general public; review of socioeconomic data.
- March 21, 2001: Science and socioeconomic analyses presented on the spatial options for marine reserves, in preparation for negotiations.
- April 18, 2001: MRWG presented new spatial options for reserves; negotiated and mapped spatial options.
- May 16, 2001: (Final meeting) Sorted through reserve options in an effort to craft a preferred option; prepared a recommendation for the SAC including the problem statement; goals and objectives, and two maps indicating areas of overlap and non-overlap between MRWG members.

- In addition to having all of its meetings open to the public, the MRWG hosted four public forums. (Refer to Appendix A for dates and locations of public forums.)

- By mid-May, CINMS and DFG received 9,161 public comments on the Channel Islands Marine Reserve process. During the monthly public meetings and forums, comments were submitted in the form of electronic mail, phone messages, letters, postcards, faxes, and comment forms (DFG 2002b). (Refer to Appendix D for specific examples of concerns expressed.)
  - "There were 8,597 comments received in support of establishing marine reserves in the Channel Islands National Marine Sanctuary. The majority suggested that at least 30 percent and up to 50 percent of the current sanctuary should be set aside in reserves to protect and replenish marine ecosystems" (DFG 2002b).
  - "There were 564 comments received in opposition to the establishment of marine reserves. Some of these comments suggested that no reserves be designated, while others called for reducing reserve size (e.g. not larger than 20 percent, 10 percent, 5 percent, etc.). Many

comments supported restricting commercial fishing but not sportfishing or diving" (DFG 2002b).
    - "The majority of opposition comments came from within the tri-county region, with a few coming from other locations within the state. Supportive comments came mostly from within the local area and the state. The balance of comments came from 46 states and three foreign countries" (DFG 2002b).
- May 23, 2001: The MRWG shared its final work with SAC. As directed by the group's ground rules, the MRWG forwarded to the SAC information developed during the process, including the problem statement, goals and objectives, and two maps indicating areas of overlap and non-overlap among MRWG members.
    - Overall, MRWG came to consensus on a set of ground rules, mission and problem statement, issues of concern, goals and objectives for reserves (i.e., ecosystem biodiversity, socioeconomics, sustainable fisheries, natural and cultural heritage, and education), and implementation recommendations. (*Note: The goals and objectives previously adopted for research and reserve administration were rolled into implementation recommendations.*)
    - The MRWG was not, however, able to arrive at one unified spatial recommendation. The MRWG developed 37 potential marine reserve designs during the two-year process, and in the end delivered a composite map that depicted two different reserve network options.
- June 19, 2001: SAC deliberated over the marine reserves recommendation and then forwarded all material developed by the MRWG, the Science Advisory Panel, and the Socioeconomic Panel, including all maps, to the CINMS sanctuary manager.
- Between June and August (2001), DFG and CINMS used feedback and materials from the SAC, the MRWG, and the advisory panels to develop a single proposal (or preferred alternative).
- August 24, 2001: CINMS and DFG staff presented the preferred alternative to the California Fish and Game Commission (FGC). Extensive public testimony was received at this meeting.
    - The DFG-recommended preferred alternative would establish eleven new no take marine reserves, one marine conservation area where only spiny lobster and pelagic finfish may be taken by recreational anglers, and one state marine conservation area where the commercial and recreational take of spiny lobster and recreational take of pelagic finfish is allowed. These areas comprise approximately 25 percent of sanctuary waters, and the initial state phase comprises approximately 19 percent (reduced from 22 percent that was initially proposed) of state waters within the sanctuary.
    - The state's boundaries extend to a distance of three nautical miles oceanward of the mainland, offshore islands and rocks. The proposed regulations were developed jointly by the DFG and CINMS, and each alternative includes some marine protected areas (including both marine reserves and marine conservation areas) in federal waters. The areas within state waters are addressed as the first phase. NOAA has indicated its intent to consider establishment of complimentary marine protected areas within federal waters.
- October 4, 2001: The FGC held a meeting in San Diego, California, that included public testimony on the proposed alternatives.
- December 6, 2001: The FGC held a meeting in Long Beach, California, that included public testimony on the proposed alternatives.
- January 9, 2002: The FGC produced an "Initial Statement of Reasons for Regulatory Action."
- February 8, 2002: The FGC held a discussion hearing in Sacramento, California to hear the Science Panel's recommendation for MPAs at the Channel Islands, and the Pacific Fishery Management Council's Scientific and Statistical Committee status of MPA proposals for CINMS.
- March 7, 2002: The FGC held a discussion hearing in San Diego, California, where public testimony was received regarding the designation of marine reserves within the CINMS.
- April 4, 2002: The FGC held a discussion hearing in Long Beach, California, where public testimony was received regarding the designation of marine reserves within the CINMS. An

advisory panel also presented a socioeconomic analysis of the proposed designation of MPAs within the CINMS.

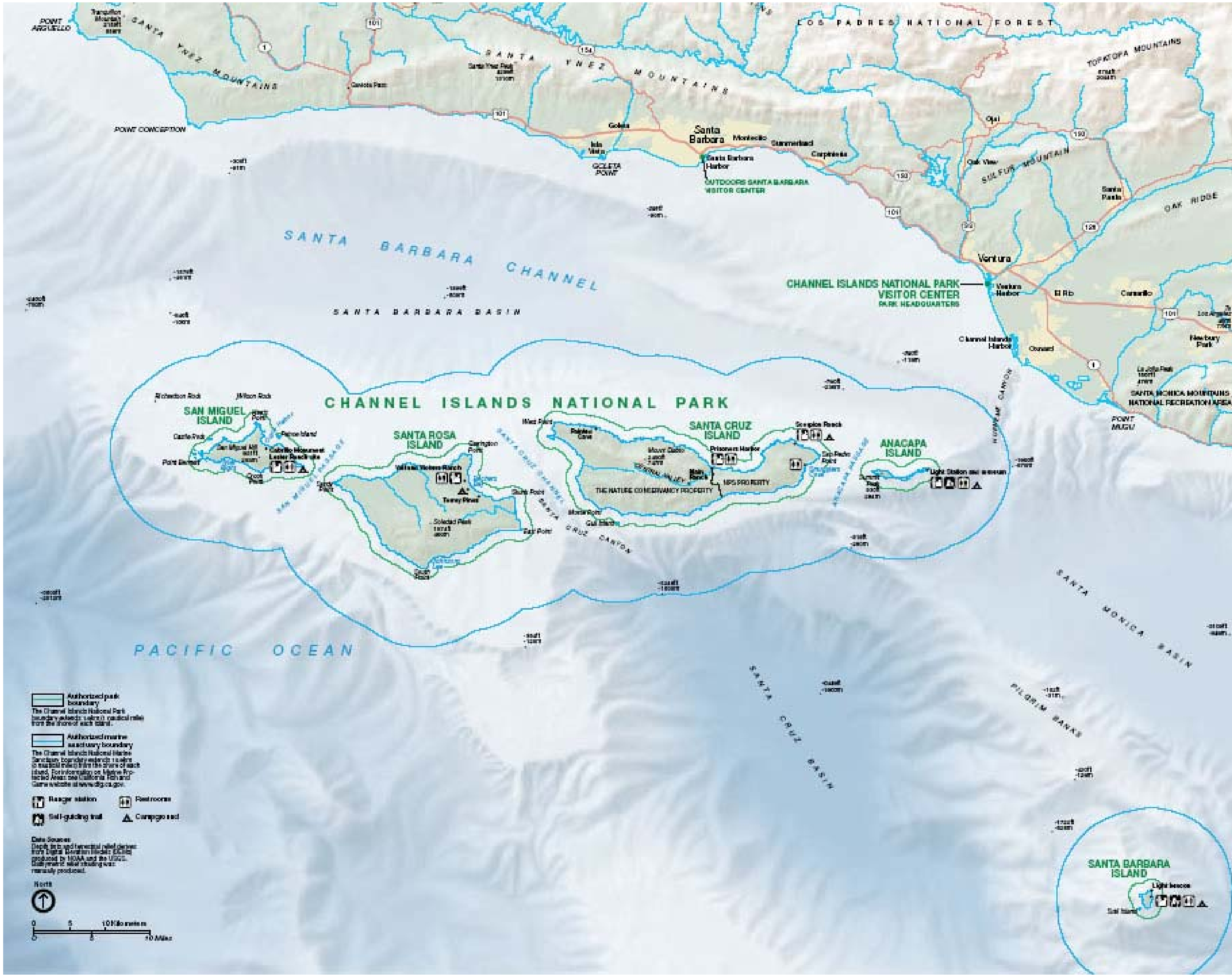
- o May 30, 2002: On behalf of the FGC, DFG released a "Draft Environmental Document, Marine Protected Areas in NOAA's Channel Islands National Marine Sanctuary" for public review and comment.
  - DFG provided public notice of the availability of the document for public review and comment.
  - DFG also made hard copies available at numerous locations including the following: the California Fish and Game Commission (FGC) office in Sacramento; the California Department of Fish and Game (DFG) offices in Sacramento, Redding, Yountville, Rancho Cordova, Fresno, Los Alamitos, San Diego, Santa Barbara, Morro Bay, Monterey, Menlo Park, Bodega Bay, Fort Bragg, and Eureka; the State Clearinghouse at the Governor's Office of Planning and Research; the county libraries in areas that may be affected; and DFG's Marine Region Web site.
- o The DFG and the FGC accepted comments regarding the draft document until July 15, 2002. The FGC then directed the DFG to extend the deadline for comments until September 3, 2002. Following this extension, written and oral comments were solicited again at a public hearing on August 1, 2002 in San Luis Obispo, California.
  - Overall, 2,492 letters, e-mails, and oral comments were received on the draft document, 2,445 of which were form letters. Thirty-nine letters and e-mails, one form e-mail, and seven oral comments (representing 221 individual comments) specifically addressed the "Draft Environmental Document" (DFG 2002b).
- o October 23, 2002: The FGC held a meeting in Santa Barbara for consideration of regulations regarding marine reserves. A vote was held and the preferred alternative passed 2-1.
- o The Office of Administrative Law approved the proposed regulations in March 2003.
- o Marine reserves (in state waters) were implemented on April 9, 2003.

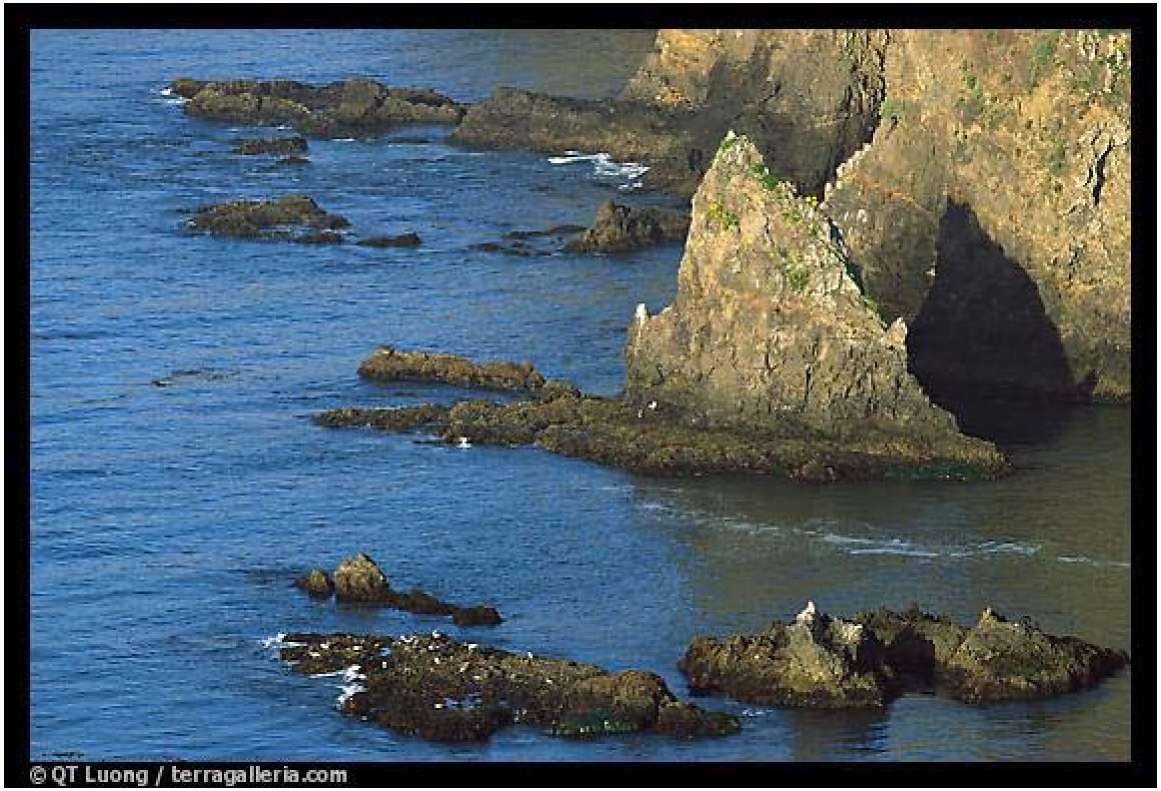
Objectives

In most cases, an MPA will have multiple objectives. These may include protection of representative habitats, conservation of rare species, fish stock restoration or enhancement, or safeguarding of historical sites, among others.

The Marine Reserves Working Group (MRWG) developed and adopted goals and objectives for the Channel Islands Marine Reserves, and these include the following:

- Ecosystem biodiversity goal: To protect representative and unique marine habitats, ecological processes, and populations of interest.
  - o To include representative marine habitats, ecological processes, and populations of interest.
  - o To identify and protect multiple levels of diversity (e.g., species, habitats, biogeographic provinces, trophic structure).
  - o To provide a buffer for species of interest against the impacts of environmental fluctuations.
  - o To identify and incorporate representative and unique marine habitats.
  - o To set aside areas that provide physical, biological, and chemical functions.
  - o To enhance long-term biological productivity.
  - o To minimize short-term loss of biological productivity.
- Socioeconomic goal: To maintain long-term socioeconomic viability while minimizing short-term socioeconomic losses to all users and dependent parties.
  - o To provide long-term benefits for all users and dependent parties.
  - o To minimize and equitably share short-term loss in activity for all users and dependent parties.


CHANNEL ISLANDS NATIONAL PARK
LOS PADRES NATIONAL FOREST
POINT ARGUELLO
SANTA YNEZ MOUNTAINS
POINT CONCEPTION
Gaviota Pass
TOPATOPA MOUNTAINS
Goleta
Isla Vista
GOLETA POINT
Santa Barbara
Montecito
Summerland
Carpinteria
Santa Barbara Harbor
OUTDOORS SANTA BARBARA VISITOR CENTER
Ojai
Oak View
SULFUR MOUNTAIN
Santa Paula
OAK RIDGE
Ventura
CHANNEL ISLANDS NATIONAL PARK VISITOR CENTER
PARK HEADQUARTERS
Ventura Harbor
El Rio
Camarillo
Channel Islands Harbor
Oxnard
Newbury Park
SANTA MONICA MOUNTAINS NATIONAL RECREATION AREA
POINT MUGU
SANTA BARBARA CHANNEL
SANTA BARBARA BASIN
Richardson Rock
Wilson Rock
SAN MIGUEL ISLAND
Harris Point
Prince Island
Castle Rock
Point Bennett
San Miguel Hill
Cabrillo Monument
Lester Ranch site
Crook Point
SAN MIGUEL PASSAGE
SANTA ROSA ISLAND
Carrington Point
Vail and Vickers Ranch
Torrey Pines
Skunk Point
Sandy Point
Soledad Peak
East Point
South Point
SANTA CRUZ CHANNEL
West Point
Painted Cave
SANTA CRUZ ISLAND
Mount Diablo
CENTRAL VALLEY
Prisoners Harbor
Main Ranch
NPS PROPERTY
THE NATURE CONSERVANCY PROPERTY
Scorpion Ranch
San Pedro Point
Morse Point
Gull Island
SANTA CRUZ CANYON
ANACAPA PASSAGE
ANACAPA ISLAND
Light Station and museum
Summit Peak
HUENEME CANYON
PACIFIC OCEAN
SANTA MONICA BASIN
PILGRIM BANKS
SANTA CRUZ BASIN
SANTA BARBARA ISLAND
Light beacon
Sutil Island
Authorized park boundary
The Channel Islands National Park boundary extends 1 nautical mile from the shore of each island.
Authorized marine sanctuary boundary
Ranger station
Restrooms
Self-guiding trail
Campground
Data Sources:
North
0 5 10 Kilometers
0 5 10 Miles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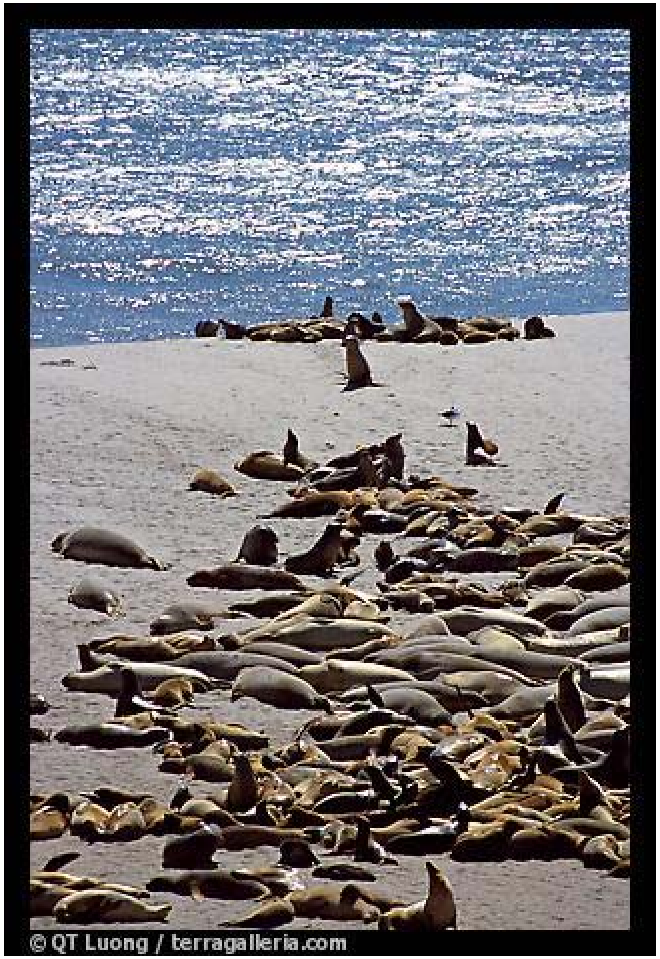
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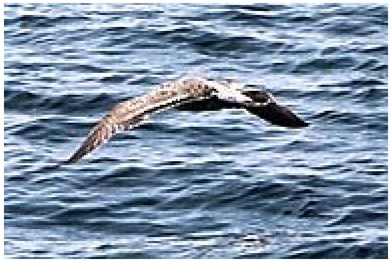




Traditional Fisheries Management

1. Determine harvest levels of single species stocks


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2. Create regulations for maintaining harvest levels (e.g. quotas, size limits, slot limits, area closures, seasonal closures, gear restrictions, total allowable catches, ITQs, etc.)

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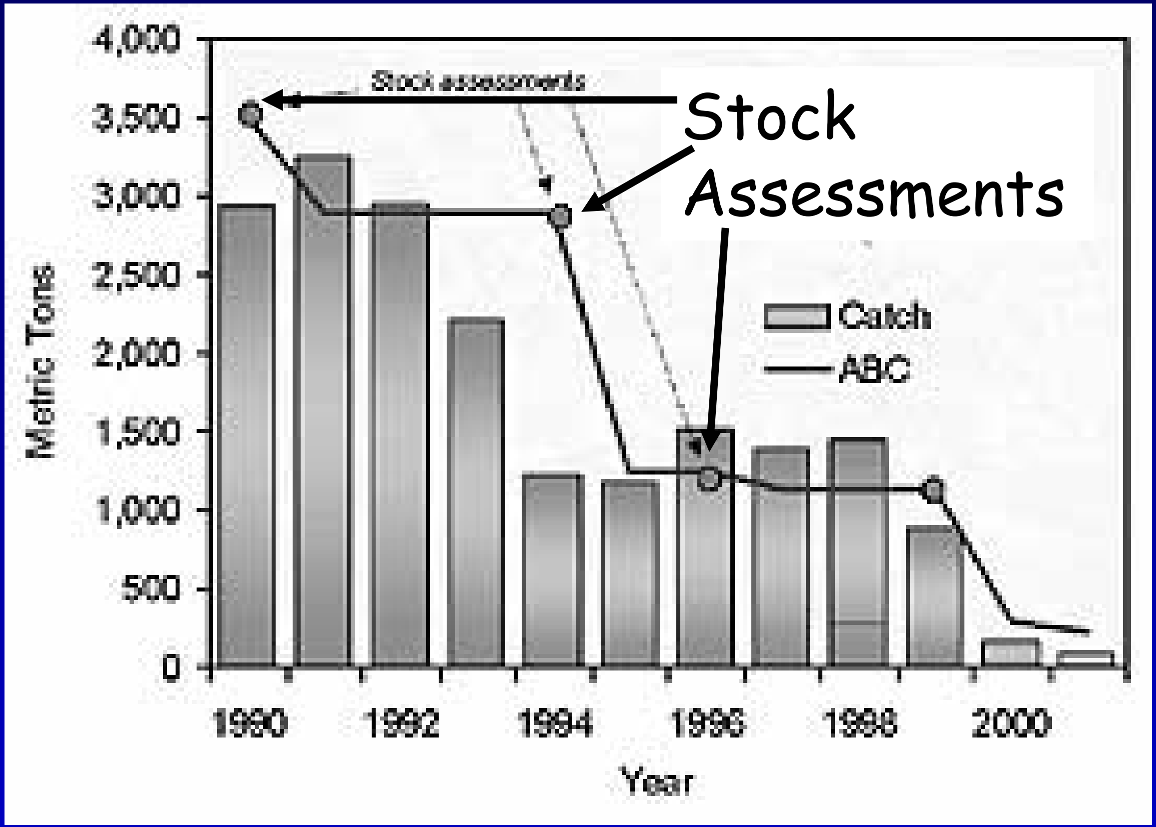
SINGLE SPECIES STOCK ASSESSMENT

Canary Rockfish



Bonita.nmfs.noaa.gov

What is Stock Assessment?

Sustainable Harvest Levels

• Estimation of the abundance (# of fish), density (# of fish per unit area), or biomass (weight x abundance) of the resource

•Estimation of rate at which being removed

• Reference level of abundance at which the stock can maintain itself in the long term

Sources of Information:

Fisheries catch data (CPUE)

Biological characteristics (age at maturity, sex ratios, growth rates)

Non-fisheries surveys (e.g. NOAA, universities)

What is a Stock Assessment?

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Sources of Information:

Fisheries catch data (CPUE)

Biological characteristics (age at maturity, sex ratios, growth rates)

Non-fisheries surveys (e.g. NOAA, universities)

Population Growth

The change in population size (N) in an interval of time is

number of births – number of deaths, or

$$\frac{\Delta N}{\Delta t} = B - D$$

(ignoring immigration and emigration)

If b (birth rate) is the number of offspring produced over a period of time by an average individual, and d is the death rate, then

$$\frac{\Delta N}{\Delta t} = bN - dN \qquad \frac{\Delta N}{\Delta t} = (b - d)N$$

Population Growth: exponential growth

The difference between the birth rate and the death rate is the per capita growth rate

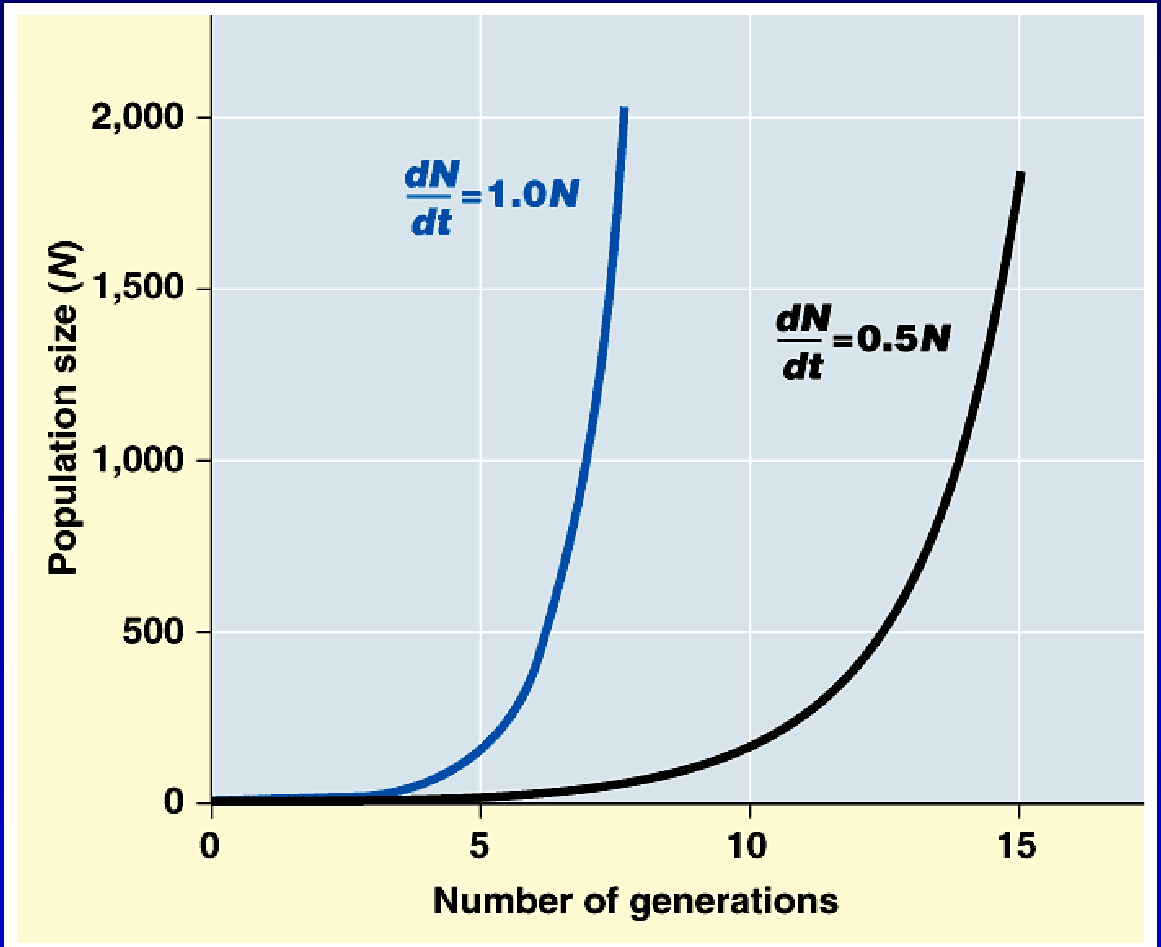
$$r = b - d$$

The growth equation can be rewritten as

$$\frac{\Delta N}{\Delta t} = rN \qquad \text{or} \qquad \frac{dN}{dt} = rN$$

Exponential growth occurs when resources are unlimited and the population is small (doesn't happen often). The r is maximal (r_{max}) and it is called the intrinsic rate of increase.

Population Growth: exponential growth



Note that:

1. r is constant, but N grows faster as time goes on.
2. What happens with different r's in terms of total numbers and time to reach those numbers?

Fig. 52.8

r can also be negative (population decreasing)

if r is zero, the population does not change in size

thus, the rate of increase (or decrease) of a population can change over time.

Population Growth: Logistic growth

Most populations are limited in growth at some carrying capacity (K) (the maximum population size a habitat can accommodate)

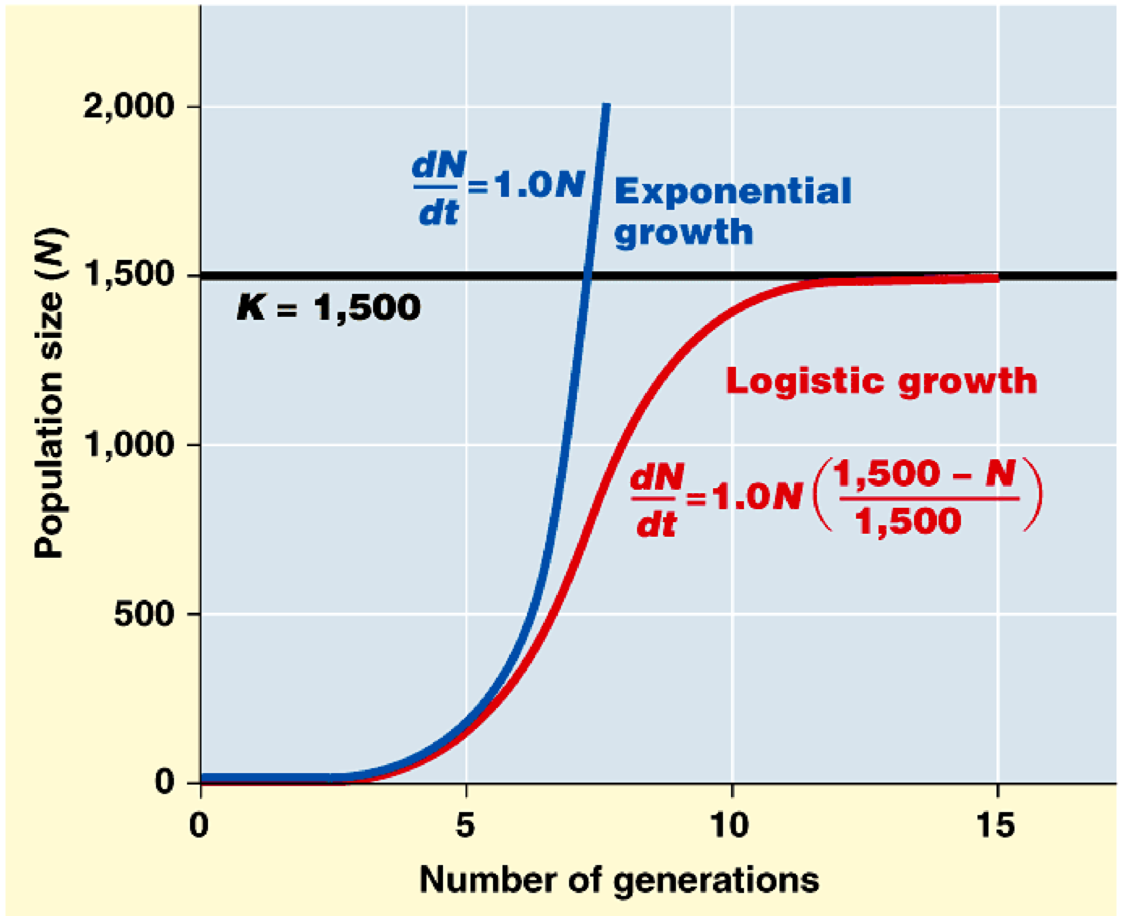


Fig. 52.11

Logistic Growth Equation: incorporates changes in growth rate as population size approaches carrying capacity.

$$\frac{dN}{dt} = r_{max}N\frac{(K - N)}{K}$$

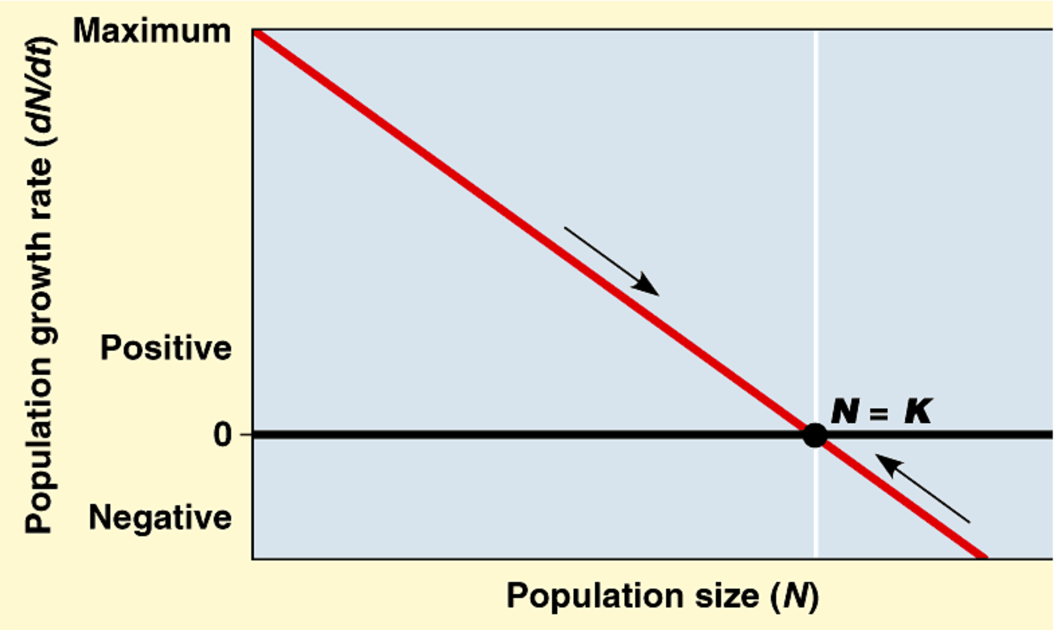


Fig. 52.10

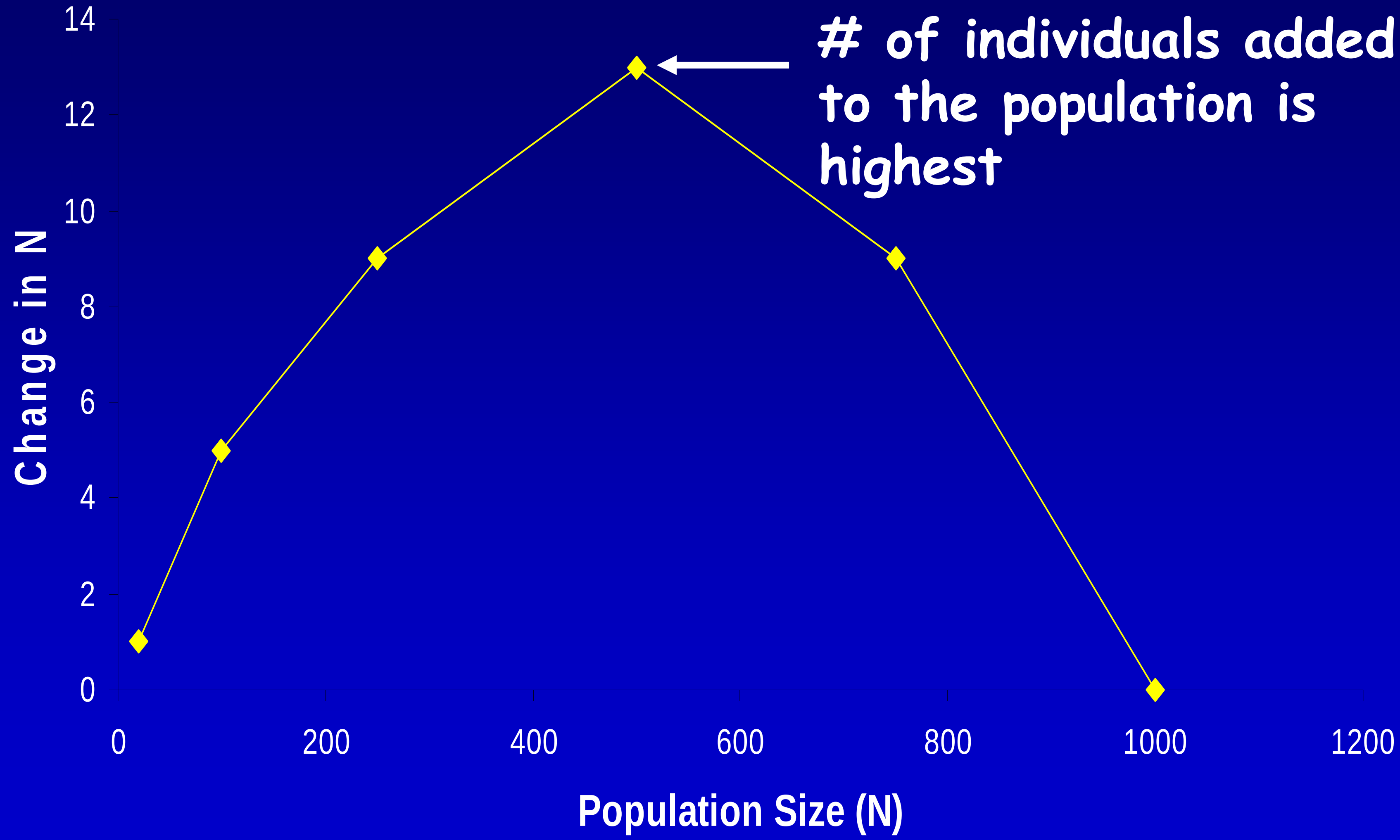
Table 52.3 A Hypothetical Example of Logistic Population Growth, Where $K = 1{,}000$ and $r_{max} = 0.05$ per Individual per Year

Population Size (N)	Intrinsic Rate of Increase (r_{max})	$\left(\frac{K-N}{K}\right)$	Rate of Population Increase (dN/dt)	ΔN^*
20	0.05	0.98	0.049	+1
100	0.05	0.90	0.045	+5
250	0.05	0.75	0.038	+9
500	0.05	0.50	0.025	+13
750	0.05	0.25	0.013	+9
1,000	0.05	0.00	0.000	0

*ΔN is rounded to the nearest whole number.

At what point is the "effective" r the highest?
At what point are the most individuals added to the population?
Are these the same?

Logistic Population Growth



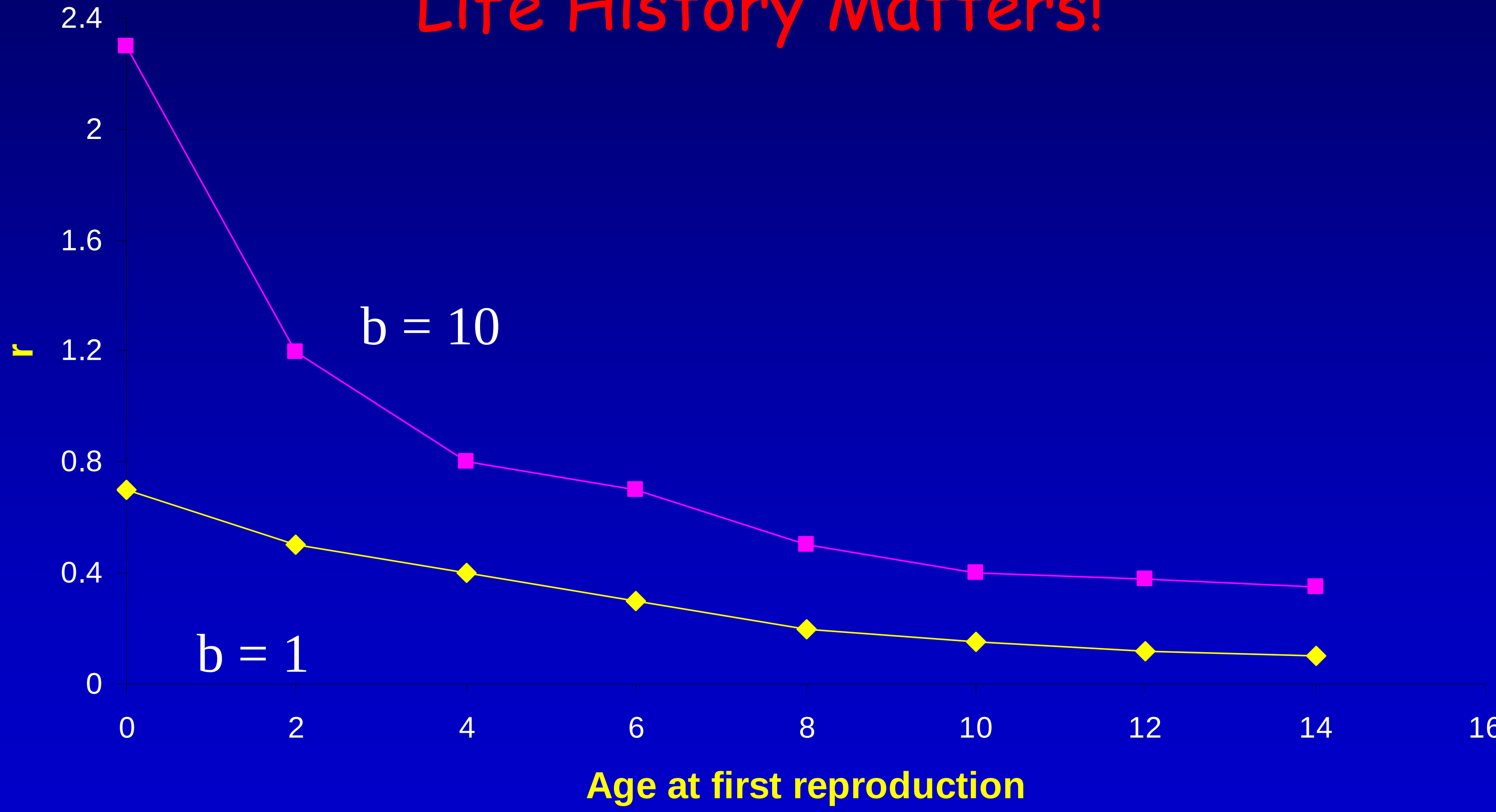
At high & low population size – low pop growth

Multiple factors affect the rates of population growth

$$dN/dt = B + I - (D + M)$$

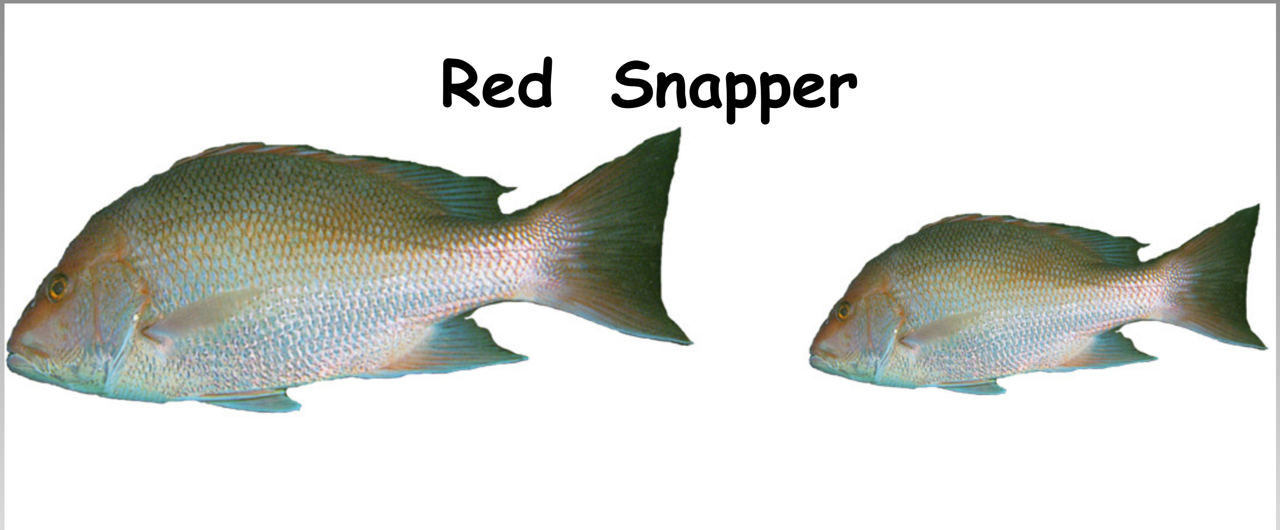
- Births (recruitment of larvae)
- Immigration (juvenile or adult movement)
- Death (predation, disease)
- Migration (juvenile or adult movement)

Effect of Age at First Reproduction and # of offspring on intrinsic growth rate (r) – Life History Matters!



b = # of offspring

Larger size individuals may lead to greater output of larvae and juveniles



Length:	60 cm	40 cm
Weight:	12.5 kg	1.1 kg
Number:	1	212

9,300,000 eggs

Bohnsack 1998

Sustainable Harvest

Goal: Remove biomass of fish without changing the size of the population

dN/dt = Recruitment + Growth – (Fishing Mortality (F) + Natural Mortality (M))

DECREASES at HIGH & LOW population sizes

- Function of harvest-related mortality

- Fishing Mortality Rate is a function of Fishing Effort

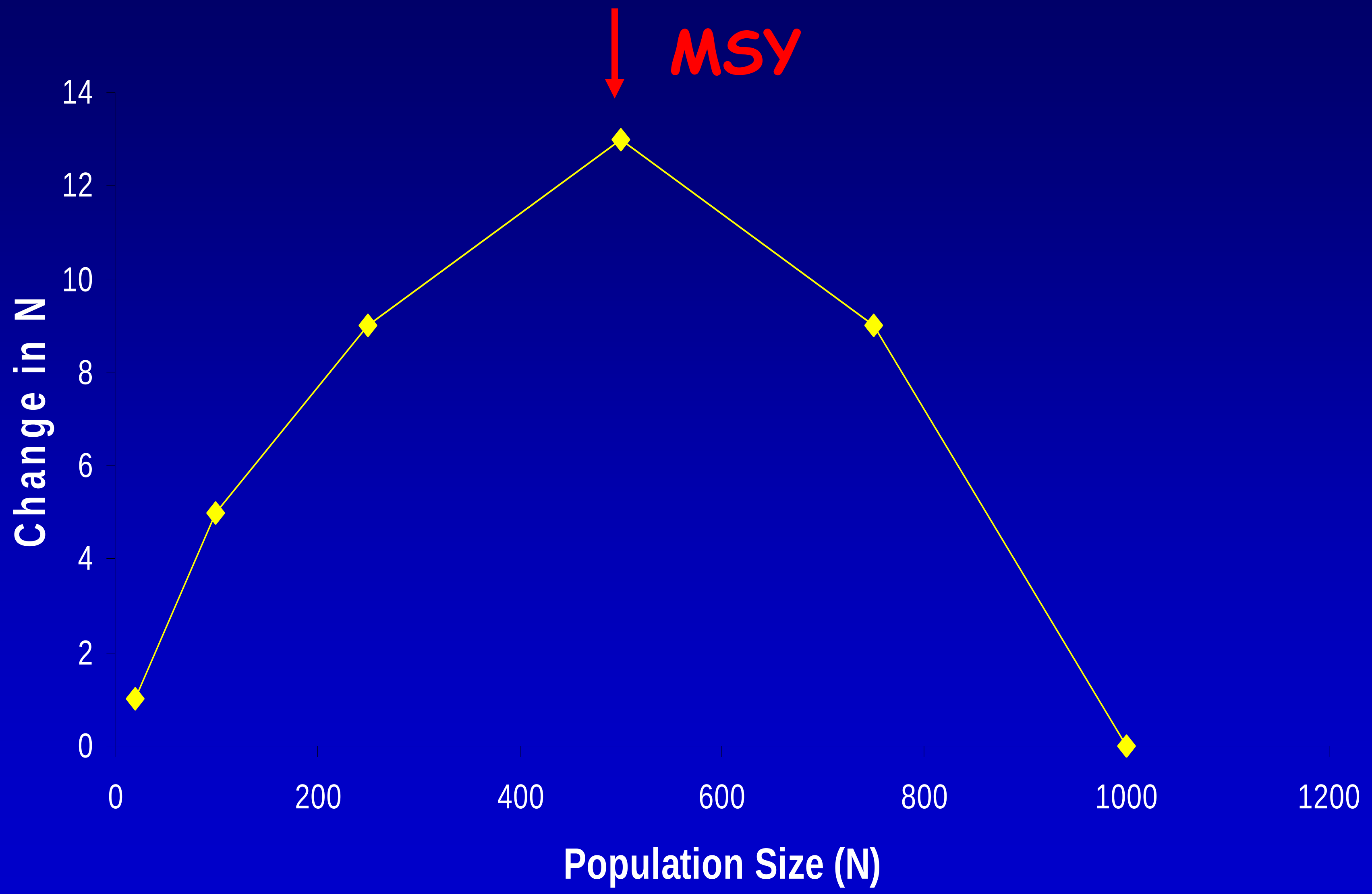
(amount, type, and effectiveness of fishing gear & time spent fishing)

MAXIMUM SUSTAINABLE YIELD (MSY)

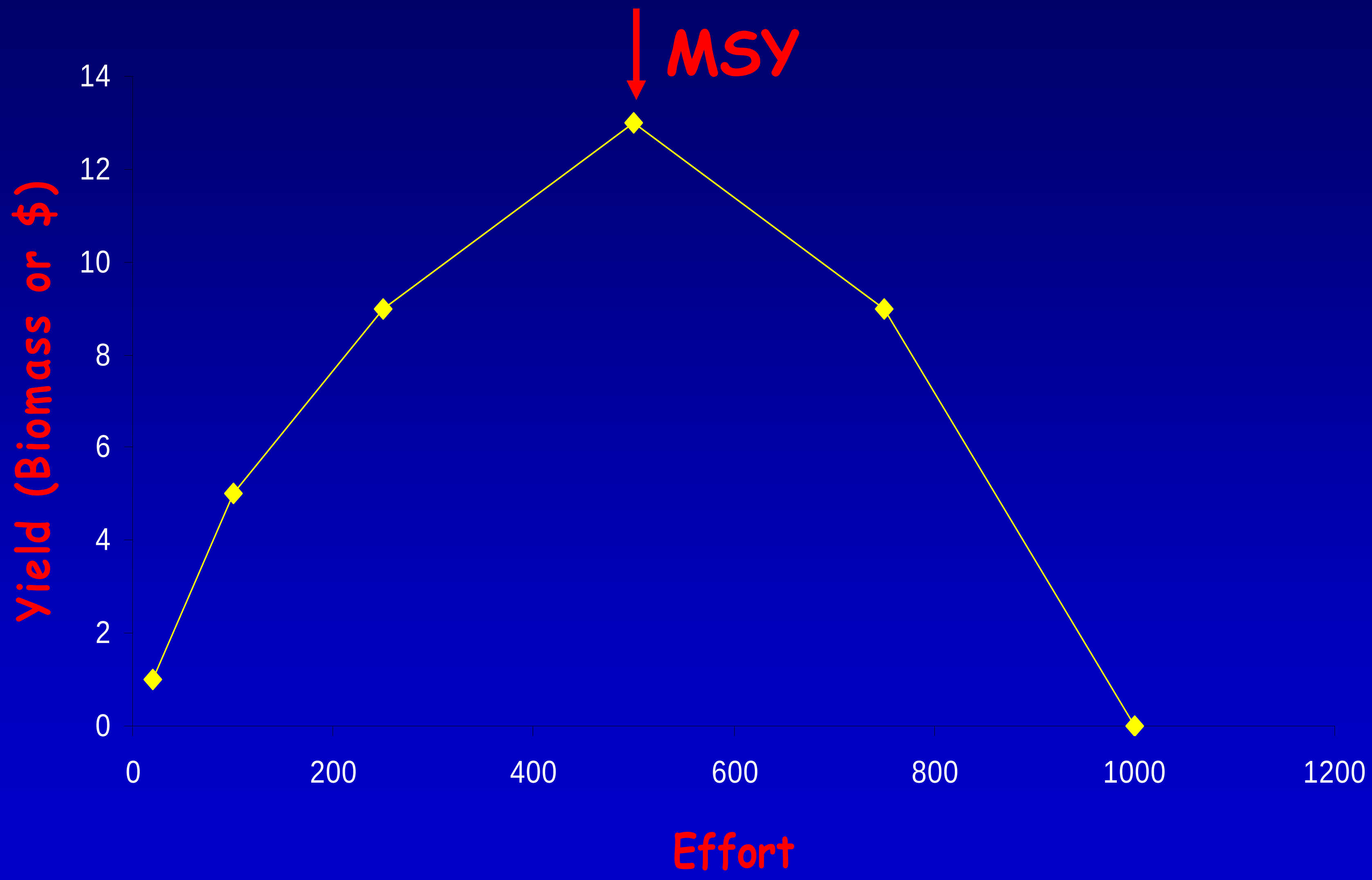
The largest *average* catch or yield that can *continuously* be taken from a stock under *existing environmental conditions*. (For species with fluctuating recruitment, the maximum might be obtained by taking fewer fish in some years than in others).

Ricker (1975)

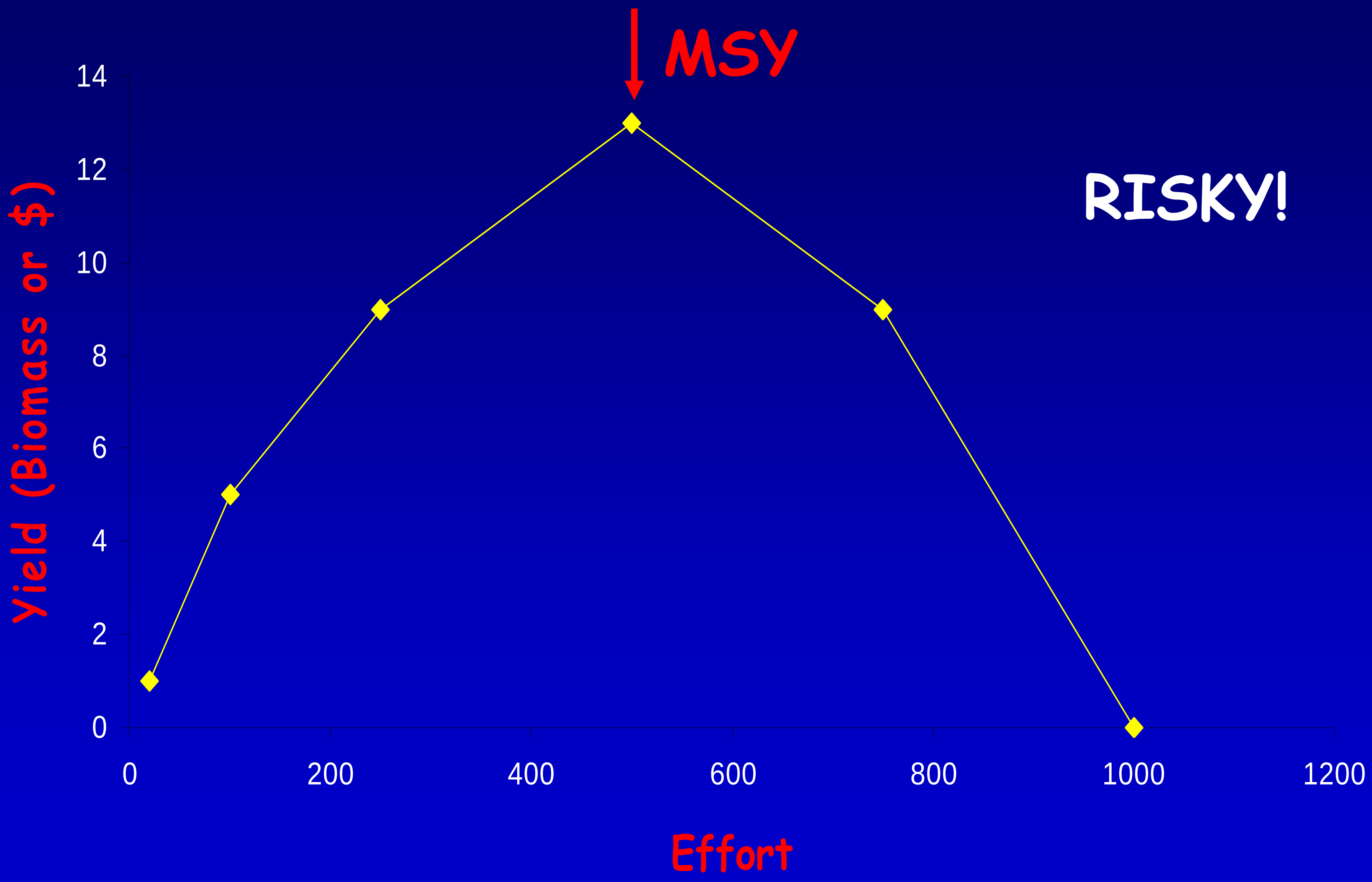
Maximum Sustainable Yield (MSY)



Maximum Sustainable Yield (MSY)



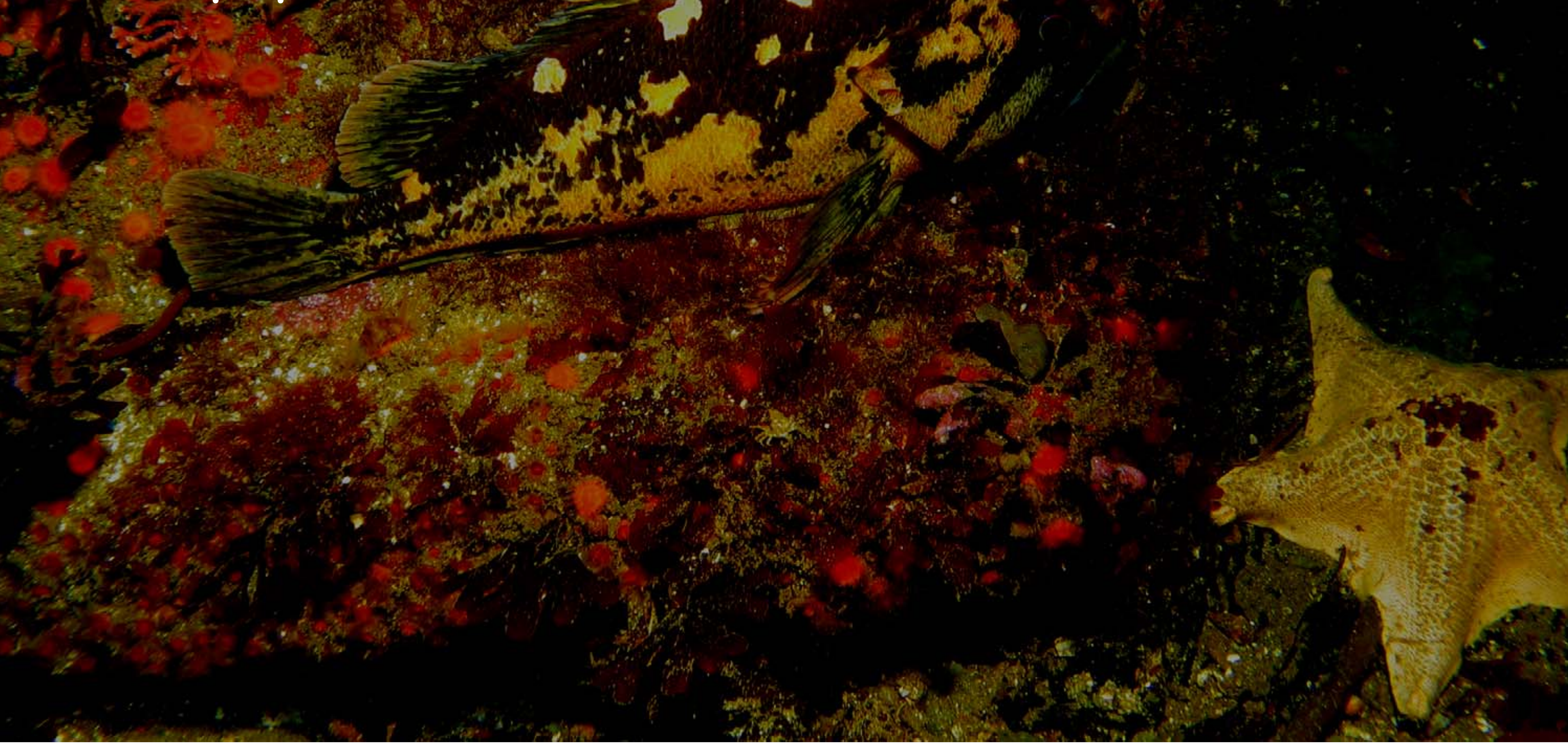
Maximum Sustainable Yield (MSY)



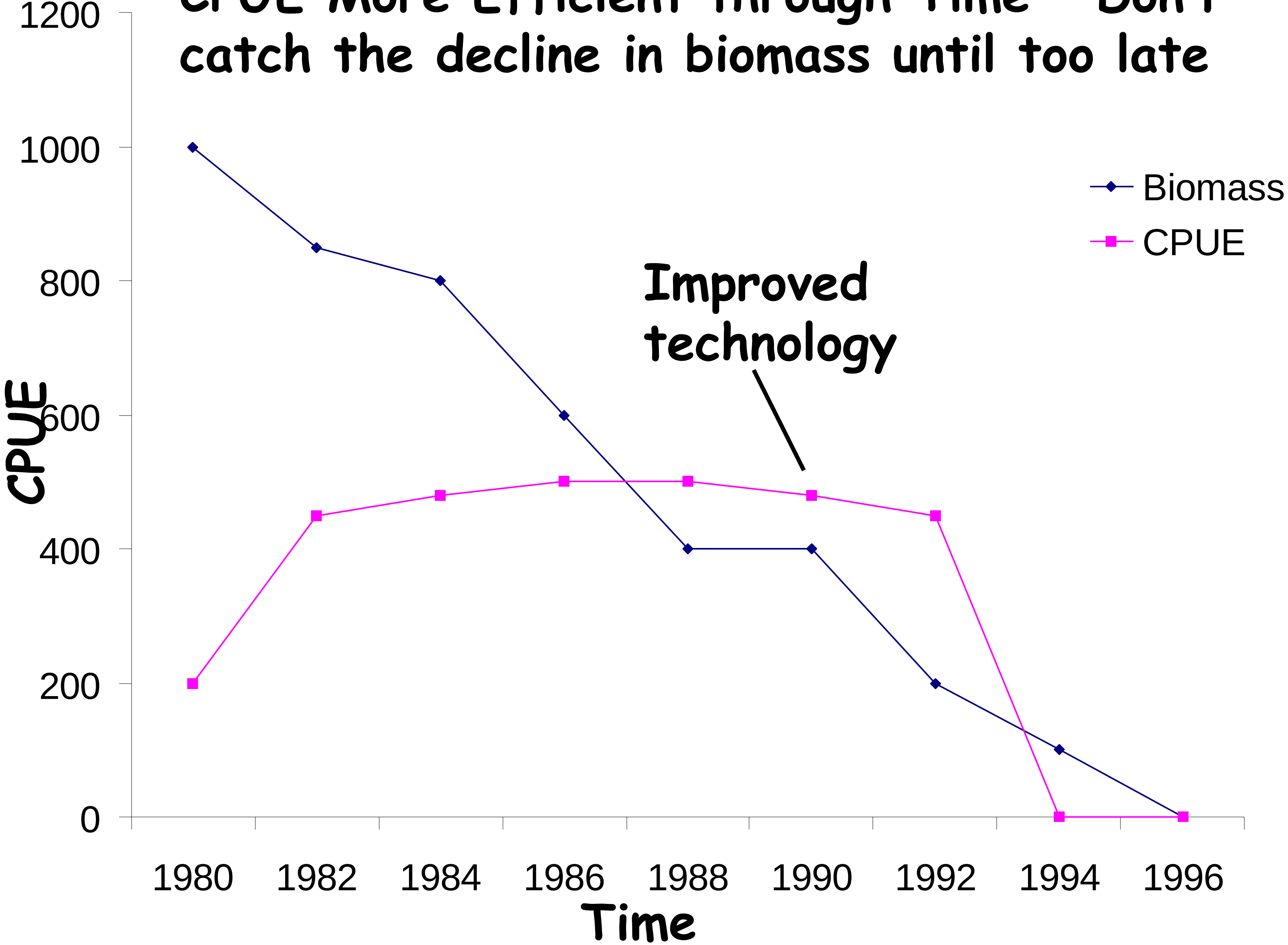
UNCERTAINTY

MAY LEAD TO OVERFISHING

- Difficult to determine abundance/biomass of the population (CPUE can be biased)



CPUE More Efficient through Time – Don't catch the decline in biomass until too late



UNCERTAINTY

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- Spatial variation in stocks - *genetic* differentiation/connectivity (e.g. squid)
- Variation in environmental variables that effect survivorship/recruitment
- Doesn't consider incidental mortality (e.g. bycatch in other fisheries; habitat destruction)
- No "insurance"

"An epitaph for the concept of Maximum Sustained Yield"

M.S.Y.

1930s-1970s

Here lies the concept, MSY.

It advocated yields too high,

And didn't spell out how to slice the pie.

We bury it with best of wishes.

Especially on behalf of fishes.

We don't know yet what will take its place.

But hope it's as good for the human race.

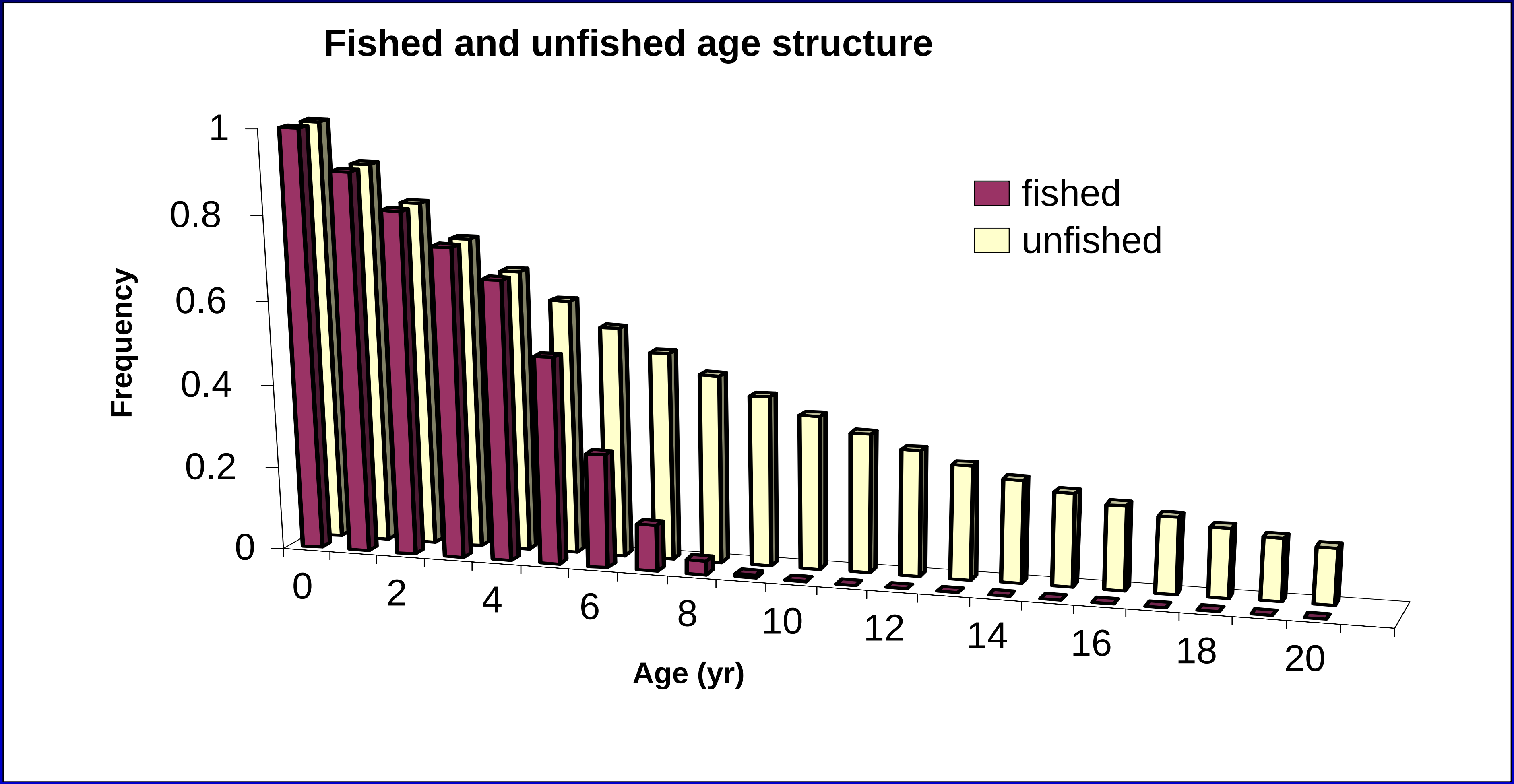
- Peter Larkin (1977)

93 out of 304 exploited stocks (30.6%) are overfished;

The status of 655 additional stocks is unknown

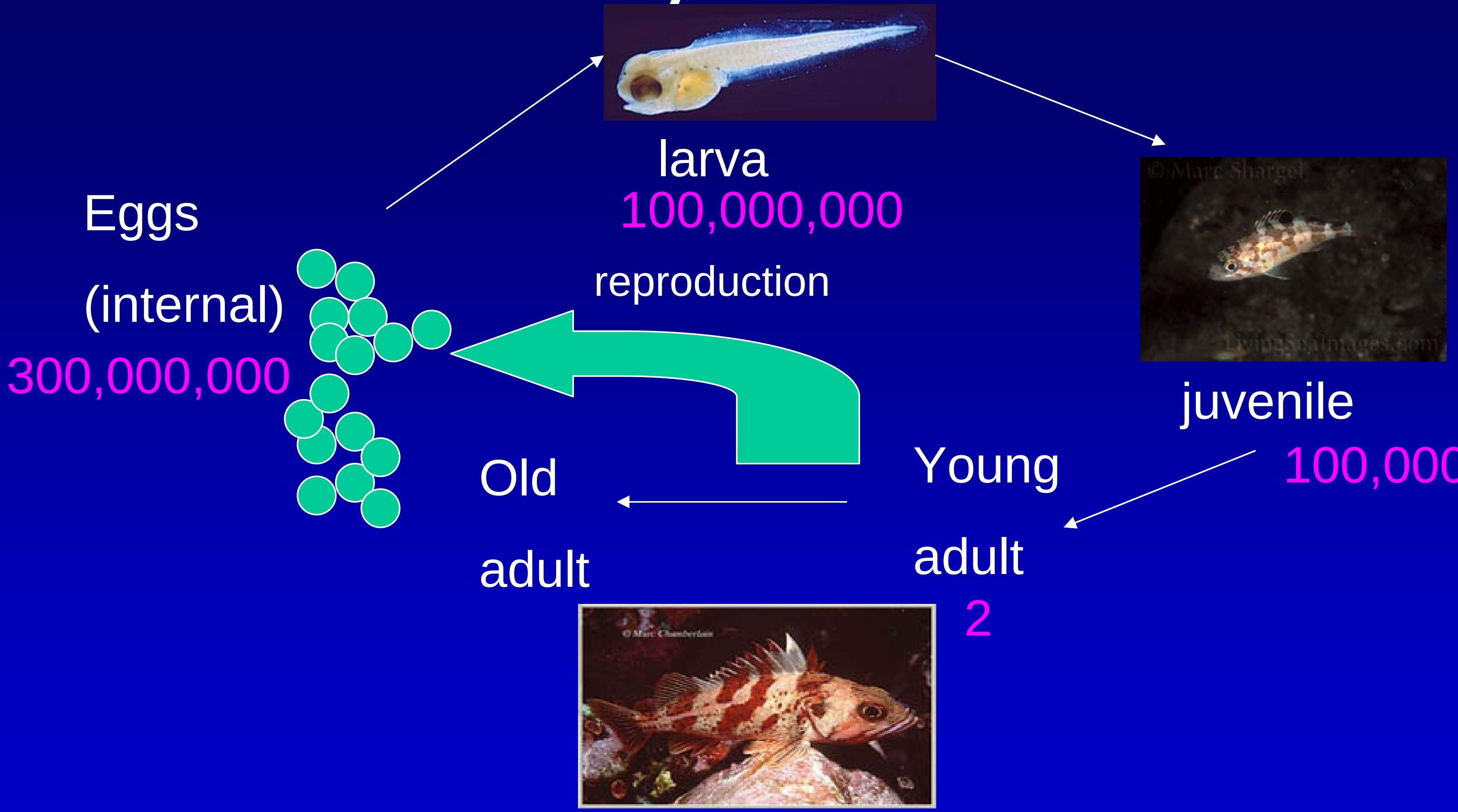
Overfished: harvested at a rate that results in the population not replacing itself (recruitment overfishing)

Effects of Fishing on sustainability of a Population



Slide courtesy Botsford et al.

Sustainability: a Rockfish Life

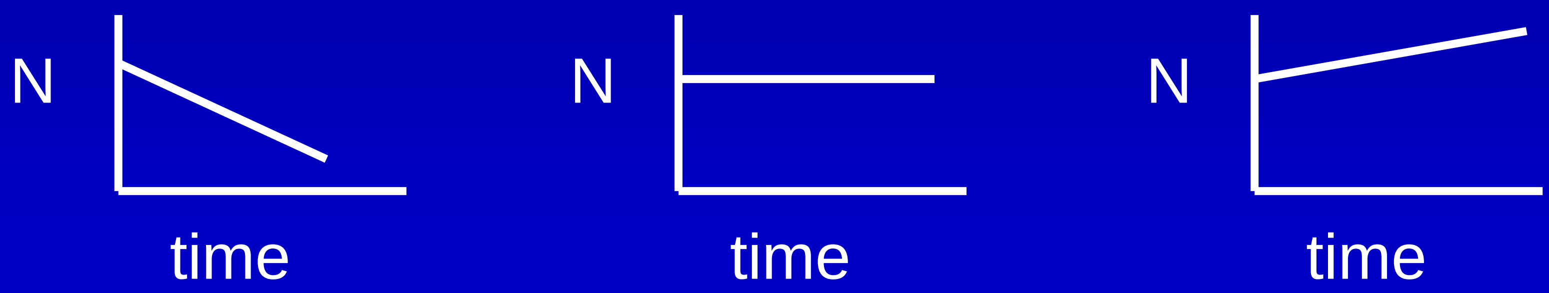


To replace itself, a young adult needs to produce hundreds of millions of eggs in its lifetime

Slide courtesy Botsford et al.

How many is enough for replacement?

Scientists believe that in fish populations, replacement (sustainability) requires a Fraction of Lifetime Egg Production (FLEP) of 35 to 60 percent of the natural (unfished) value.



FLEP<35% FLEP>35 to 60%

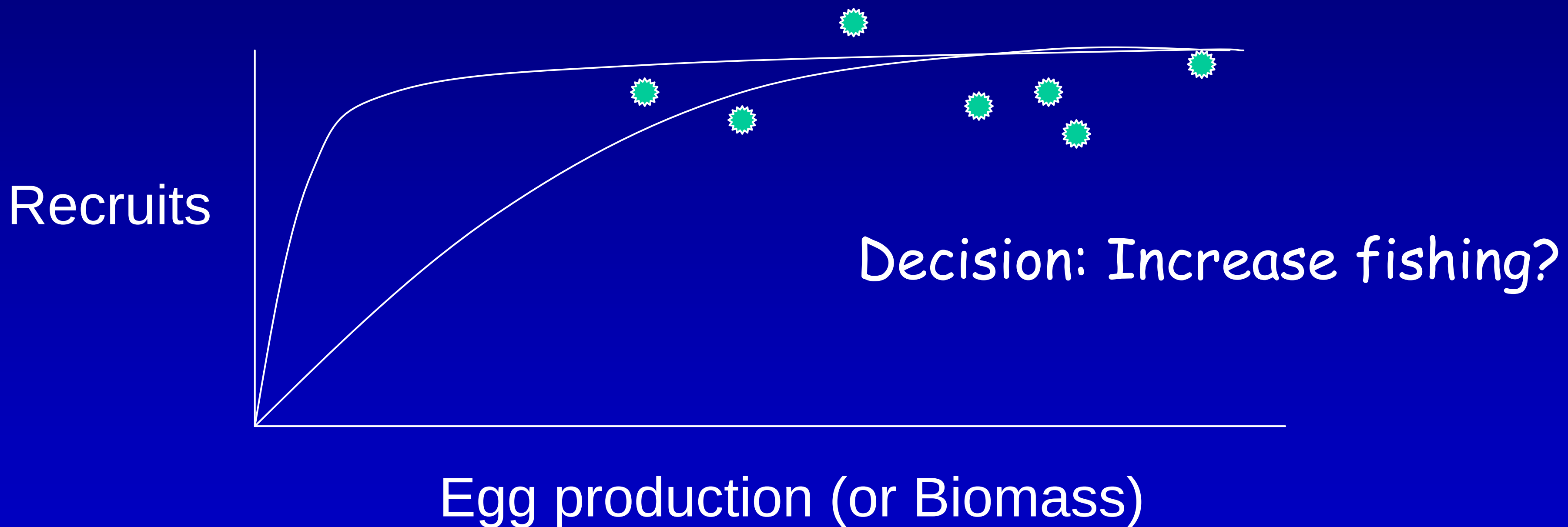
Slide courtesy Botsford et al.

Fisheries Management

Initially, we don't know the egg/recruit relationship.

Specify seasons, number of boats, size limits, etc.

As fishing increases, Lifetime Egg Production declines



There is uncertainty in:

1. Current recruitment, egg production, effects of management
2. Where population collapses (I.e., slope-at-origin)

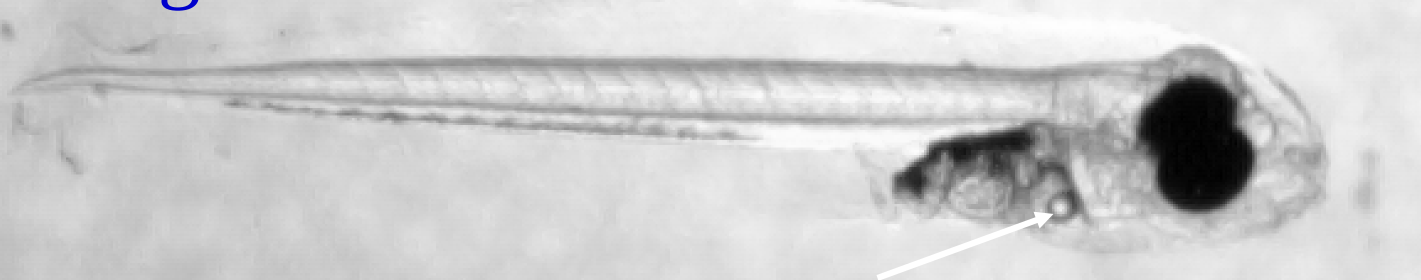
(meta-analysis: collapse occurs at 30-35 percent unfished LEP)

FLEP estimated for several California rockfish

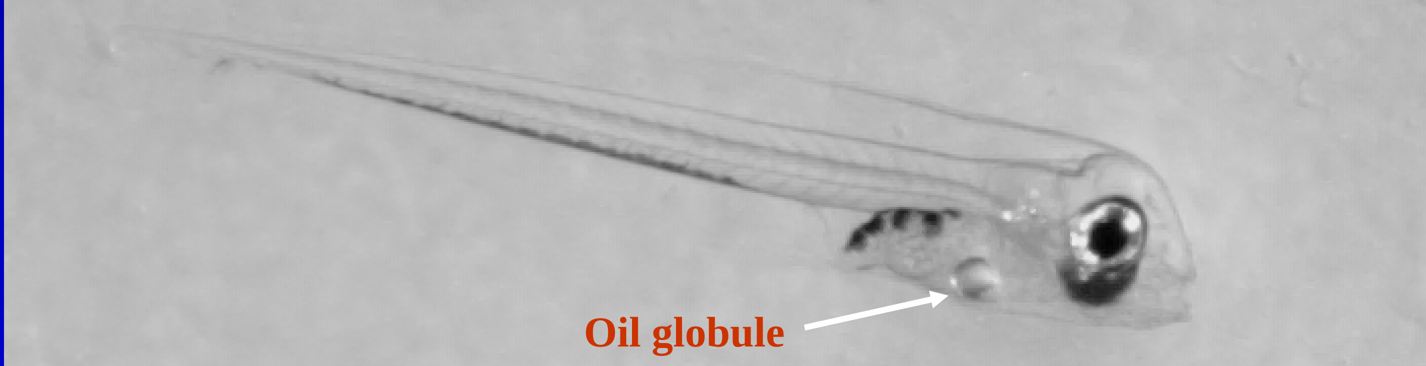
Blue rockfish	30%	Concern
Black rockfish	20%	Concern
Brown rockfish	>50%	
Copper rockfish	20%	Concern
Olive rockfish	25%	Concern

COMPLICATIONS: LARVAE HAVE DIFFERENT SURVIVAL RATES

Larvae of old females resist starvation longer



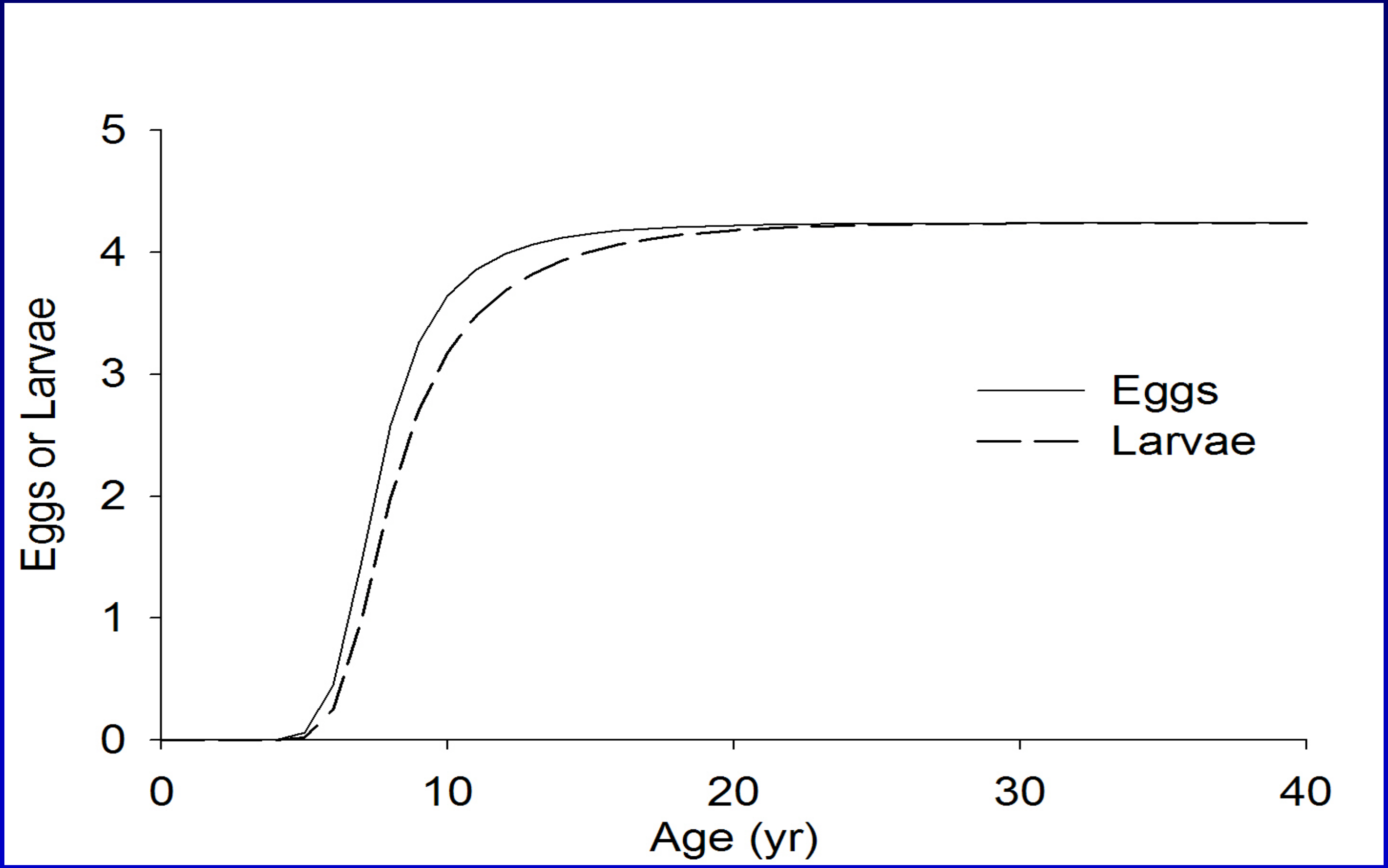
Blue rockfish larva at birth, mother age 3



Blue rockfish larva at birth, mother age 8

Slide courtesy Botsford et al.

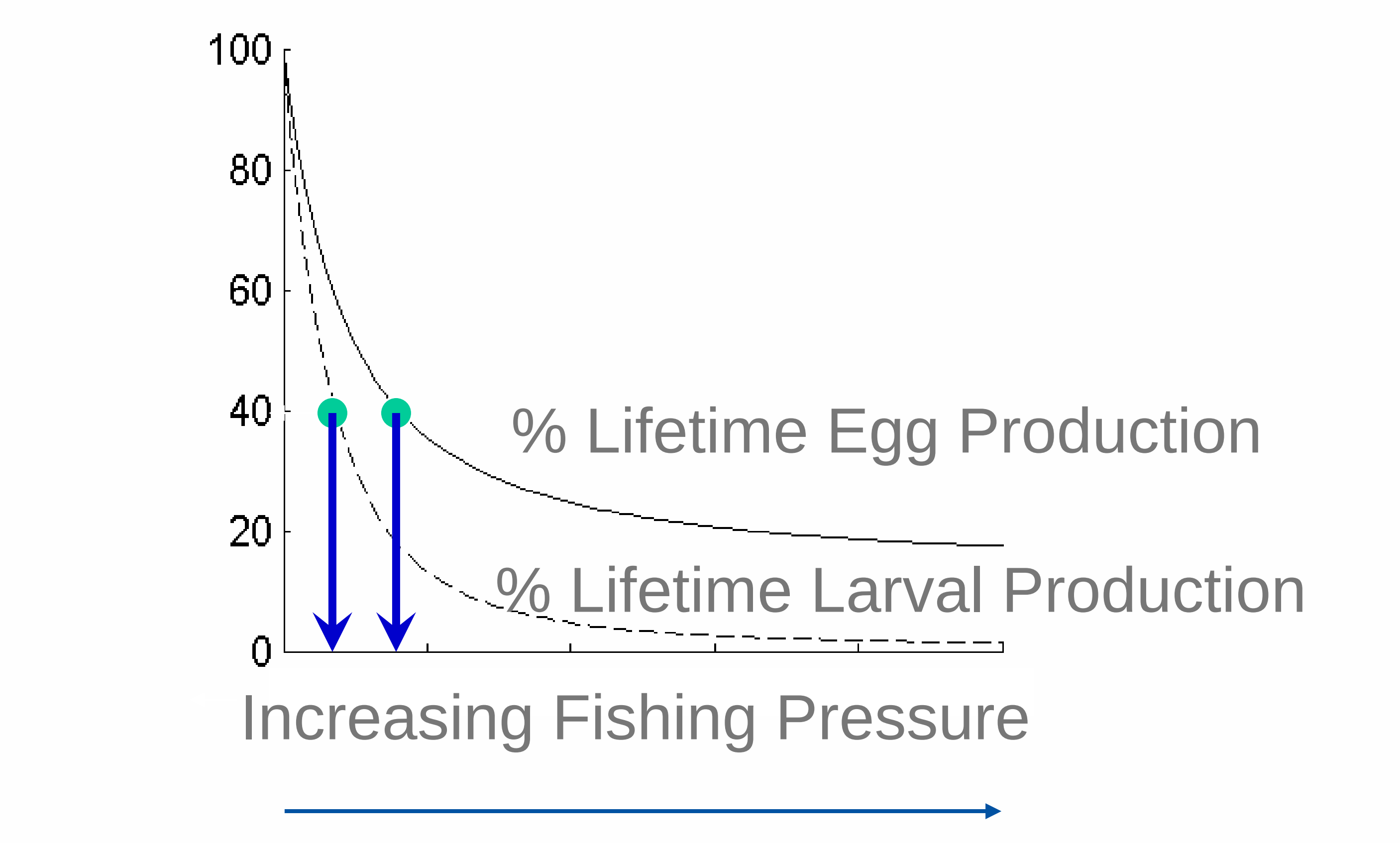
What does this mean for management?



To maintain lifetime reproduction at the original desired level, we need to use FLLP instead of FLEP

Slide courtesy Botsford et al.

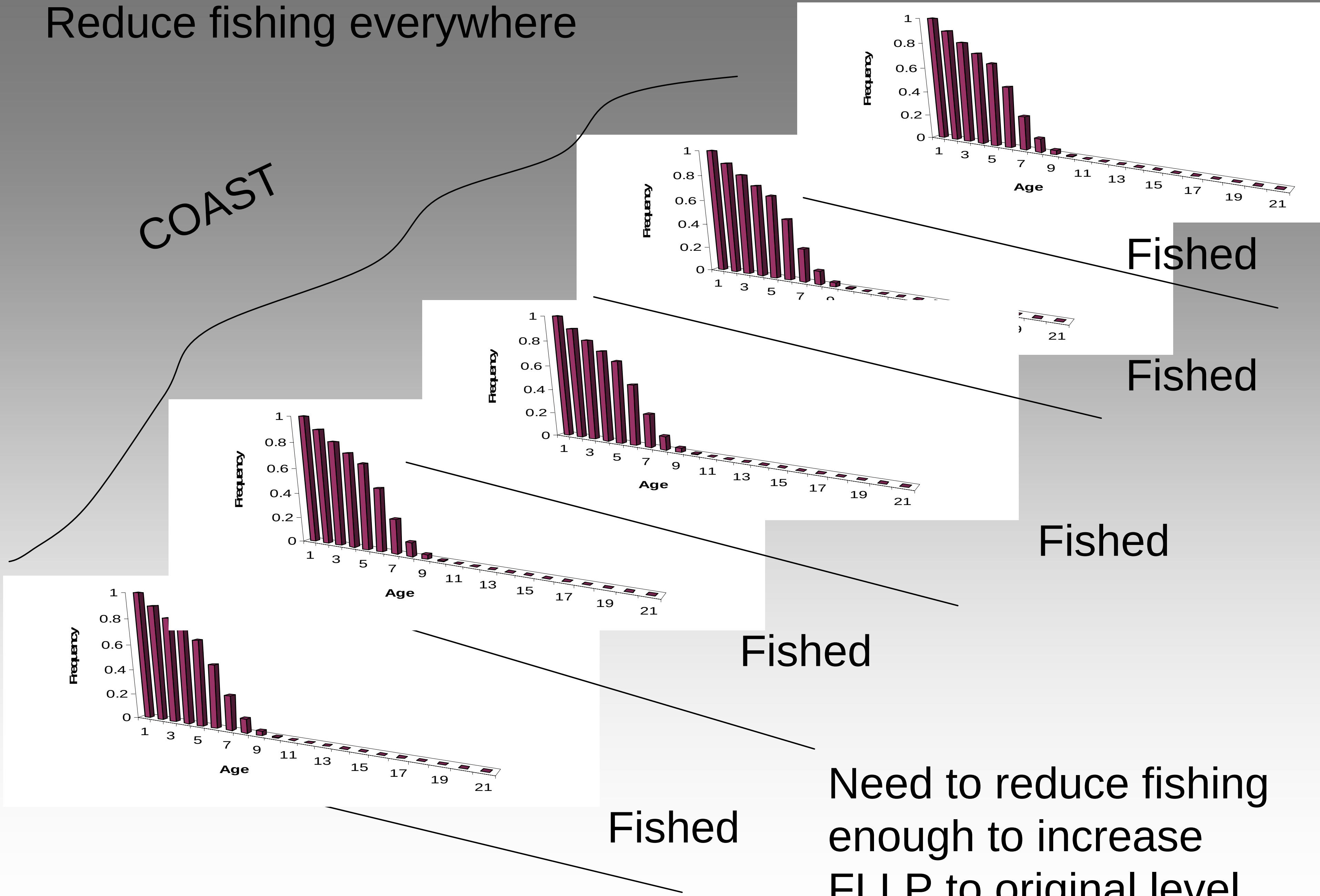
Calculation of fishing pressure



We need to reduce fishing pressure

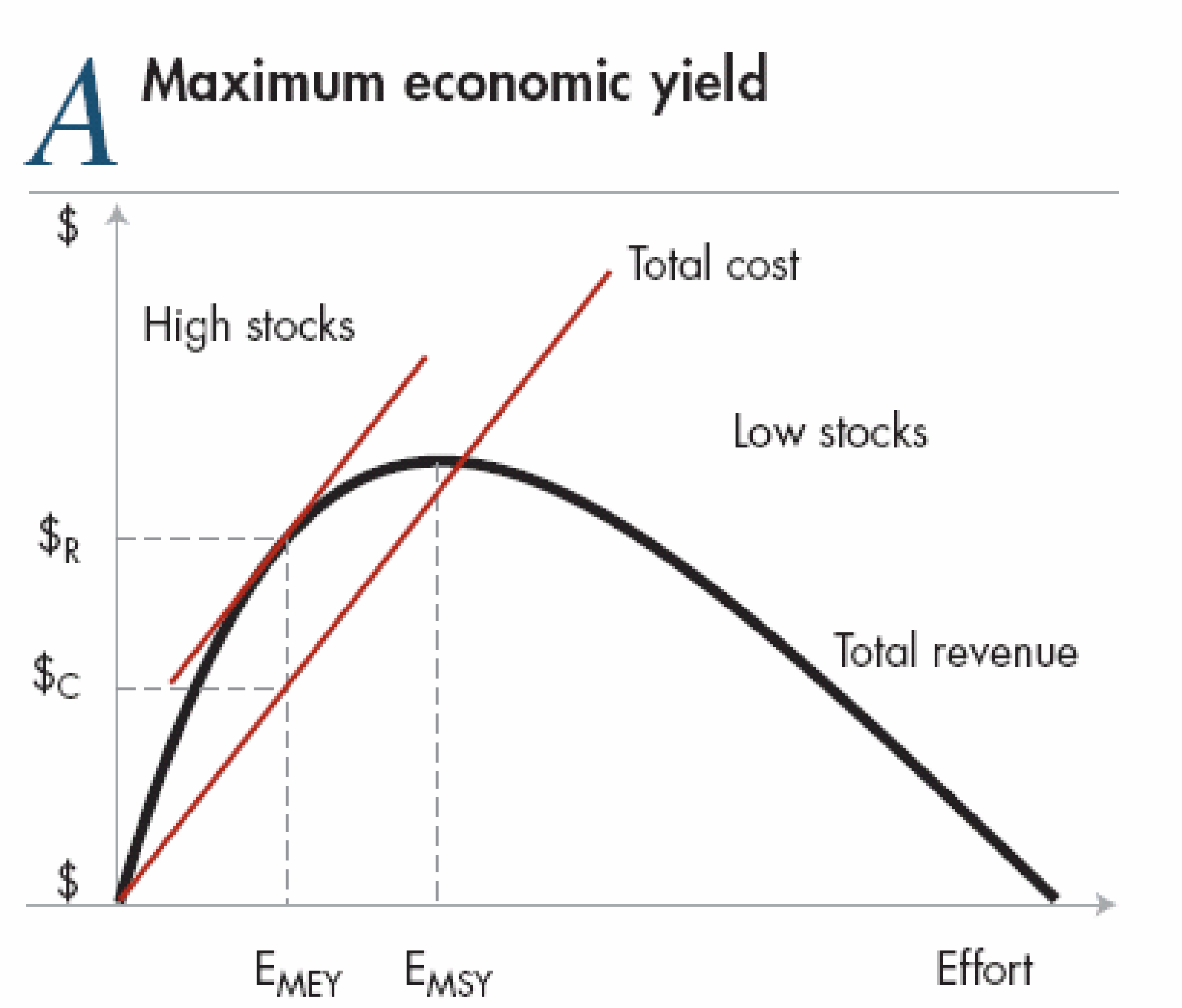
Slide courtesy Botsford et al.

Reduce fishing everywhere



Need to reduce fishing enough to increase FLLP to original level

AN ALTERNATIVE APPROACH



Traditional Fisheries Management

1. Determine harvest levels of single species stocks
2. Create regulations for maintaining harvest levels
3. Consider economic incentives for fishermen

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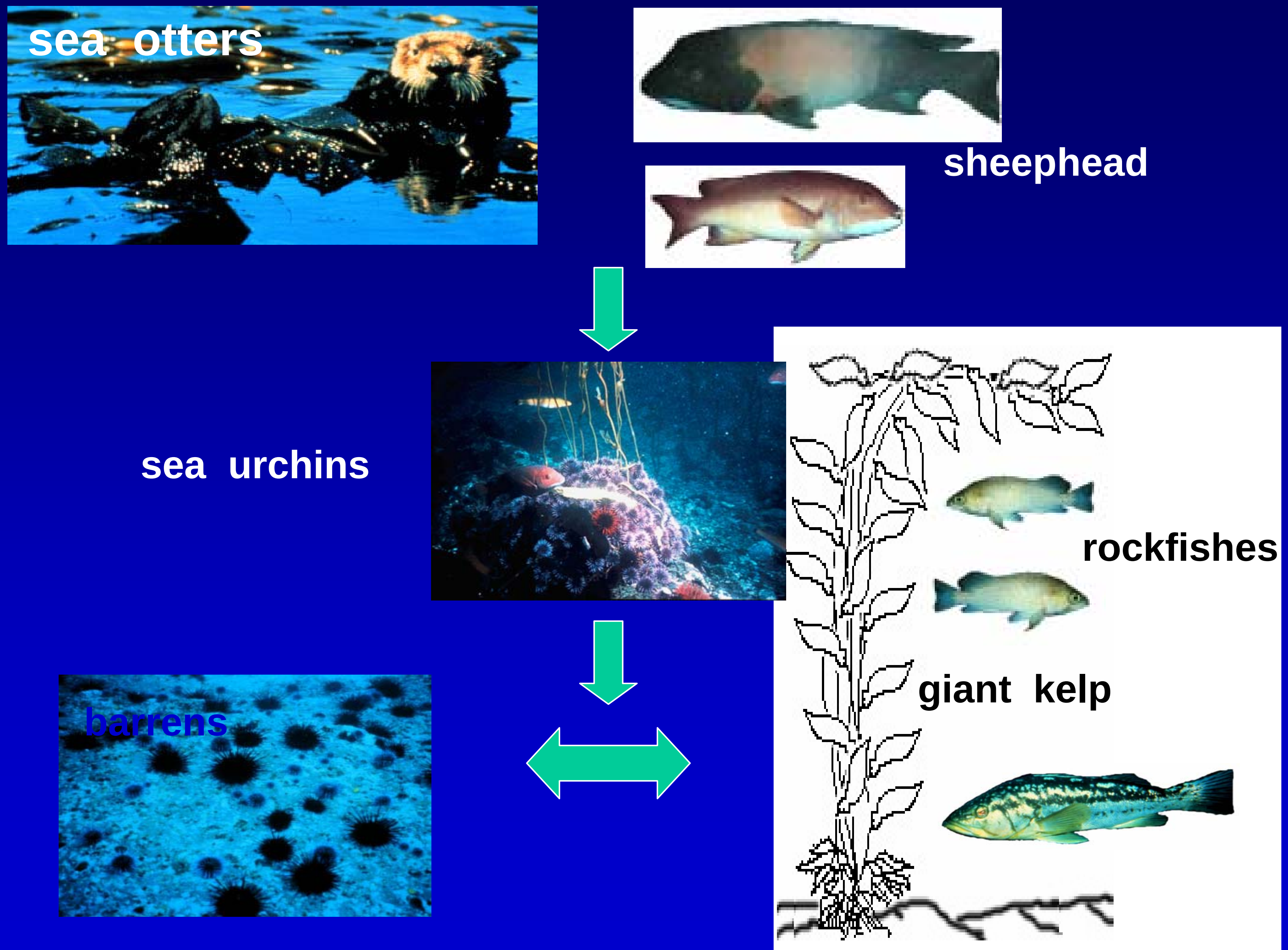
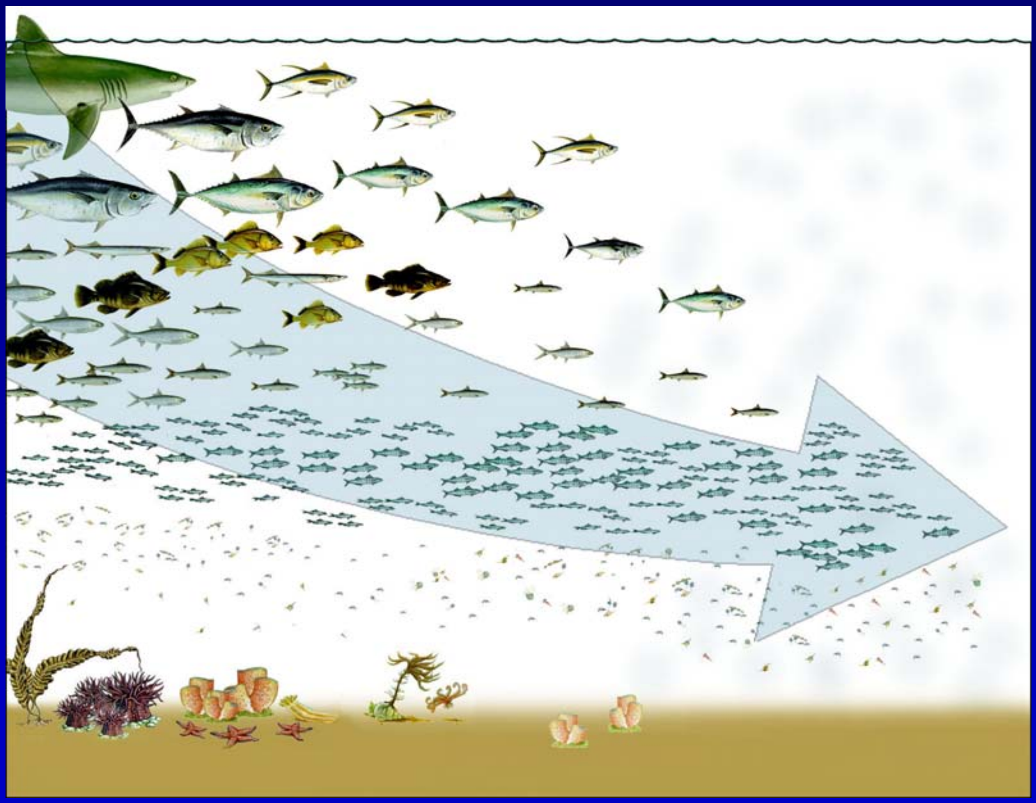
ISSUE: Don't consider the ecosystem

Trophic Cascades



Trajectory of degradation of marine ecosystems



- Macrofaunal biomass
- Biomass stability
- Fisheries productivity
- Top-down control
- Resilience

- Diseases, toxic blooms
- Bottom-up control, eutrophication
- Temporal variability

Source: Pauly 2003. Slide courtesy of B. Worm

MARINE PROTECTED AREAS

“Any area of the marine environment that has been reserved by Federal, State, territorial, tribal or local laws or regulations to provide lasting protection for part or all of the natural or cultural resources therein” (US Presidential Executive Order 13158, May 2000)

Notes for class: What are the controversies?

1. Current science does/doesn’t support reserves
2. Impacts on fishermen too great, little evidence of benefits
3. Some fisheries are impacted and not enhanced (e.g. Kelp)
4. Setting reserves important but requires input from stakeholders, not scientists
5. Networks of reserves should have clear goals & expectations, and should be replicated & large enough to ensure adequacy

MRWG Goals for Marine Reserves

- <u>Conservation of biodiversity</u>
  - Protect representative habitats and communities
  - Protect multiple species and their interactions
  - Protect ecological processes in the Channel Islands National Marine Sanctuary

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  - Protect multiple species and their interactions
  - Protect ecological processes in the Channel Islands National Marine Sanctuary
- <u>Sustainable Fisheries</u>
  - Integrate marine reserves into fisheries management
- <u>Economic Viability</u>
  - Maintain long-term socioeconomic viability, minimize short-term losses

Other Goals of MPAs

- Natural & cultural heritage
  - Maintain areas of visitor, spiritual, & recreational opportunities
- Education
- Research
- Economic enhancement via tourism and recreation
- Ecosystem services

How have reserves performed?

Reserve effectiveness

- Local increases of abundances, biomass, sizes, and species richness well known

- Spillover and local fisheries enhancement documented in some cases.

- Spillover of larvae not well documented.

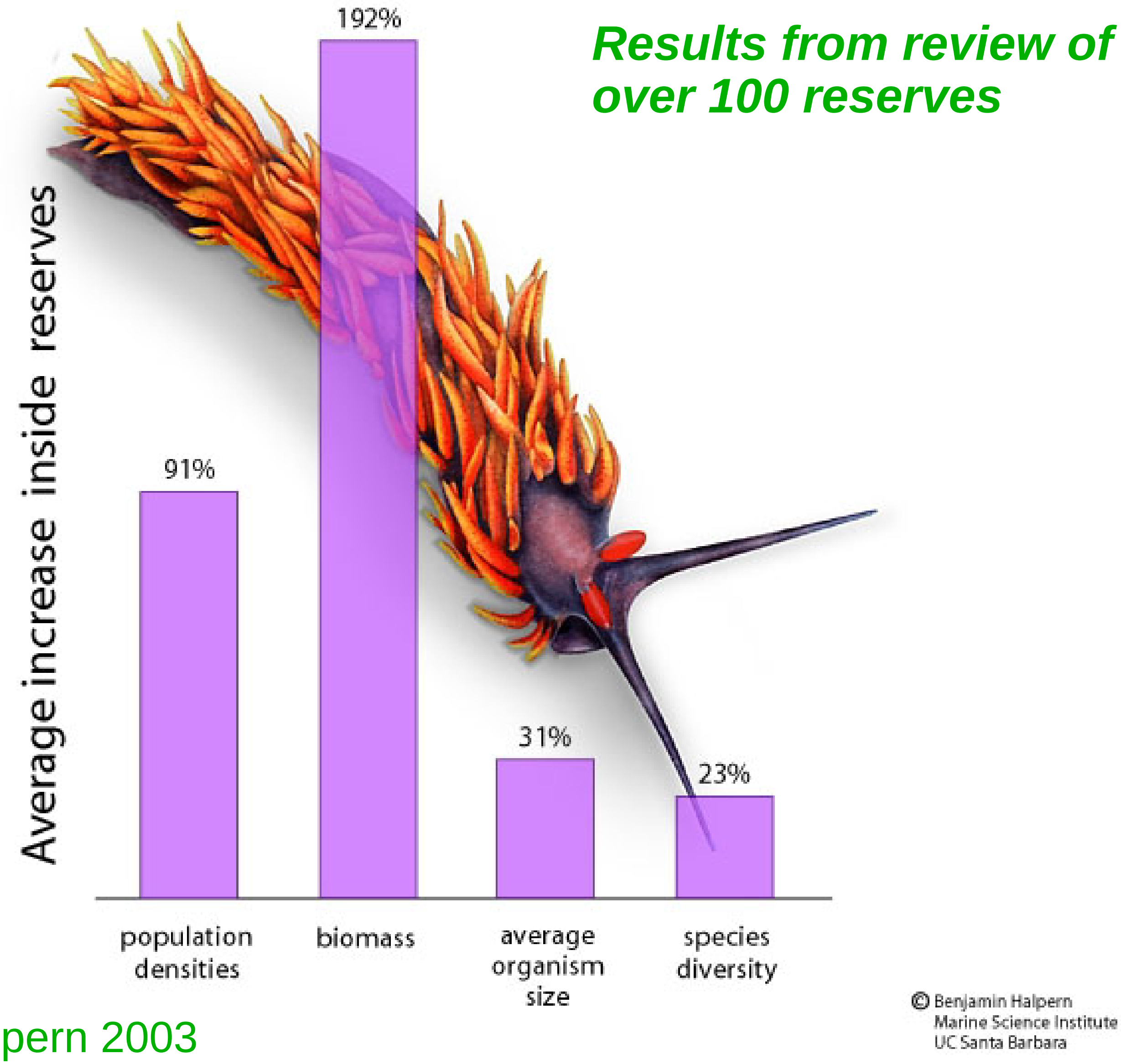
- Trophic cascades and changes in community structure

Effects of protection, from studies of existing marine reserves:

- Re-build depleted populations
- Animals live longer, grow larger, and produce more offspring
- Evidence for <u>local</u> contribution to fisheries
- Trends towards recovery of assemblage structure and diversity

UNCERTAINTIES: **<u>Fishery benefits</u>, <u>scale of protection needed</u>, <u>dispersal and source-sink dynamics</u>**

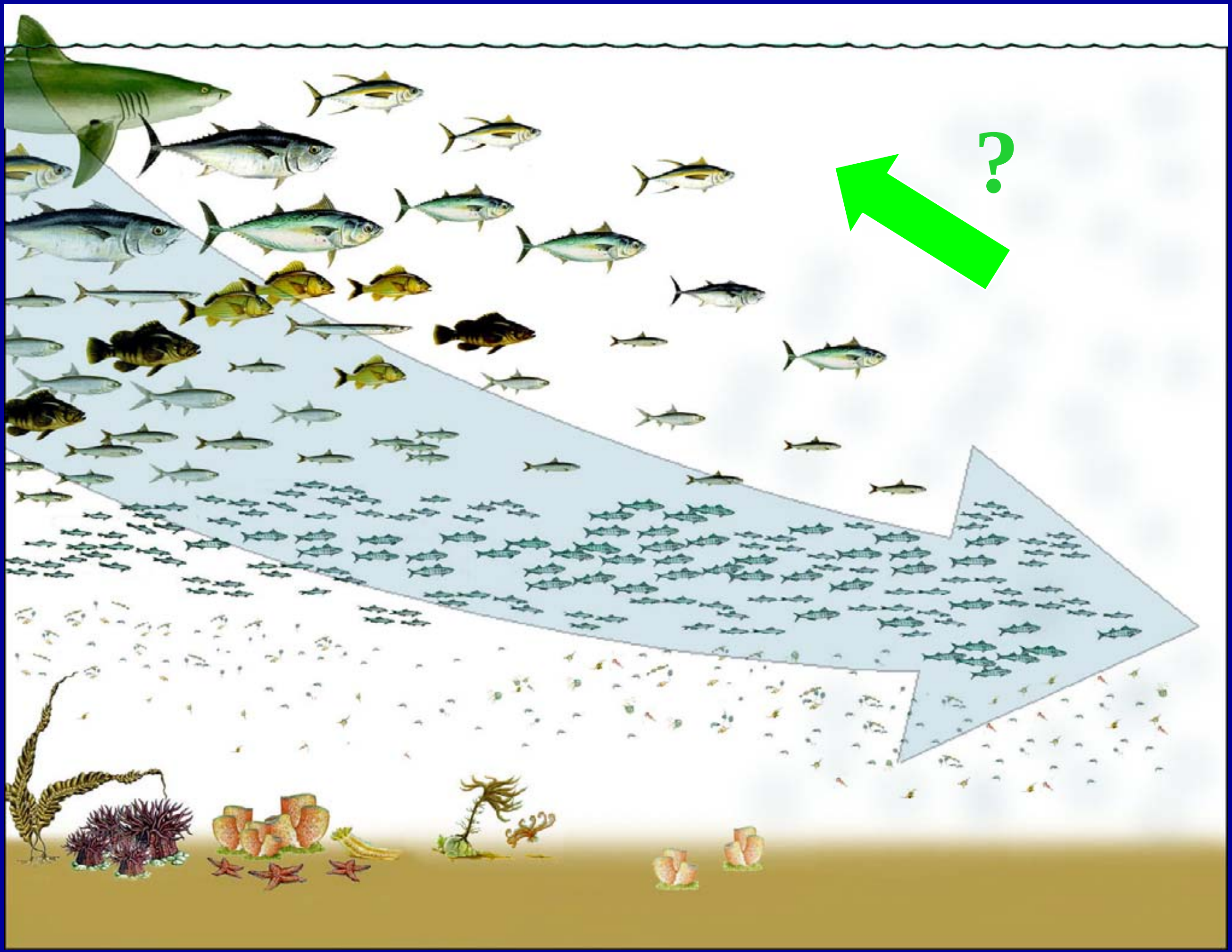
Increased abundance and individual size in reserves



Results from review of over 100 reserves

Halpern 2003

Reverse trajectory of food-web alteration

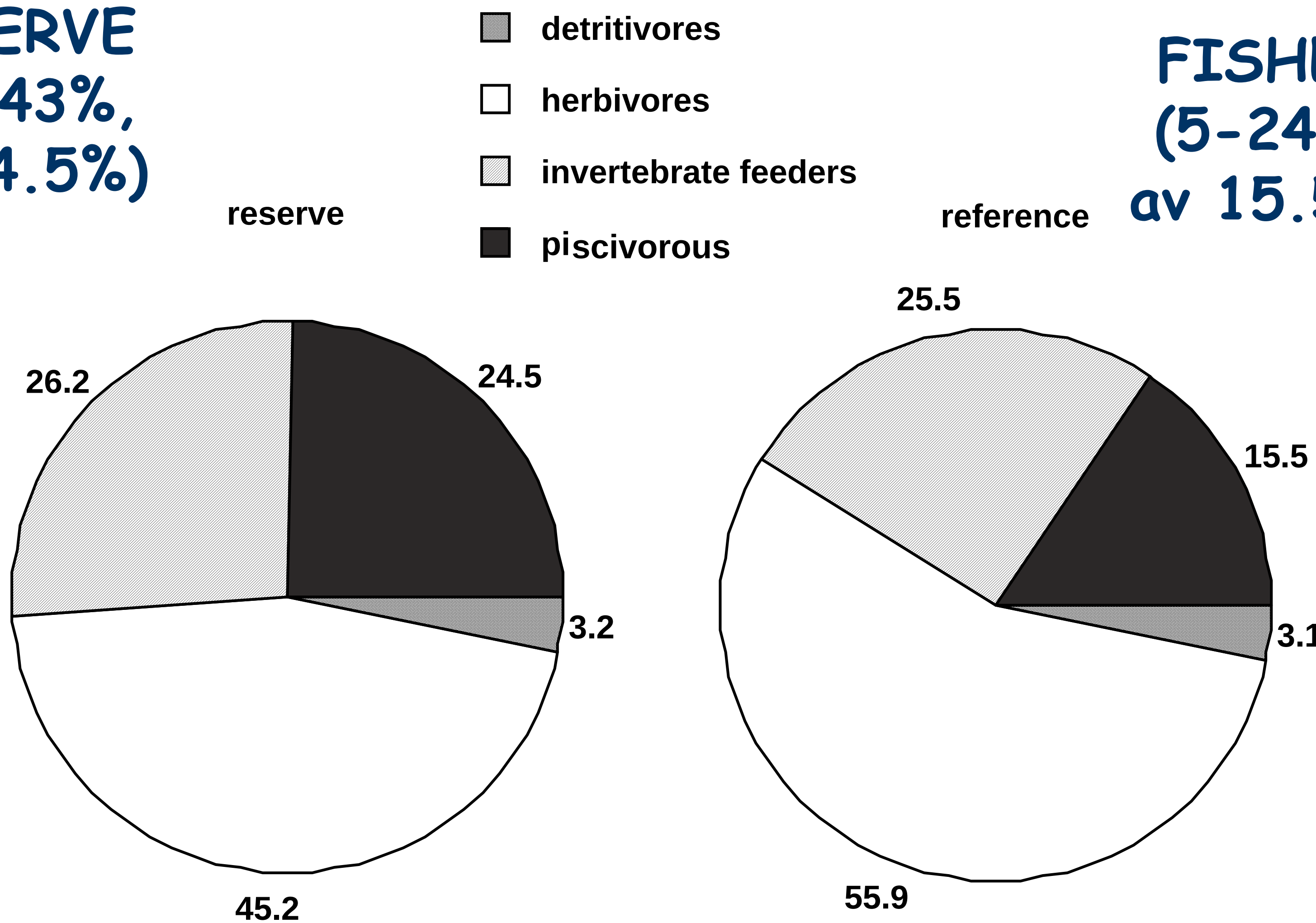


Source: Pauly 2003.

Greater proportions of piscivorous fish biomass in no-take reserves (N=10)

RESERVE (10-43%, av 24.5%)

FISHED (5-24%, av 15.5%)



Slide courtesy of Fiorenza Micheli

Spillover of larvae?

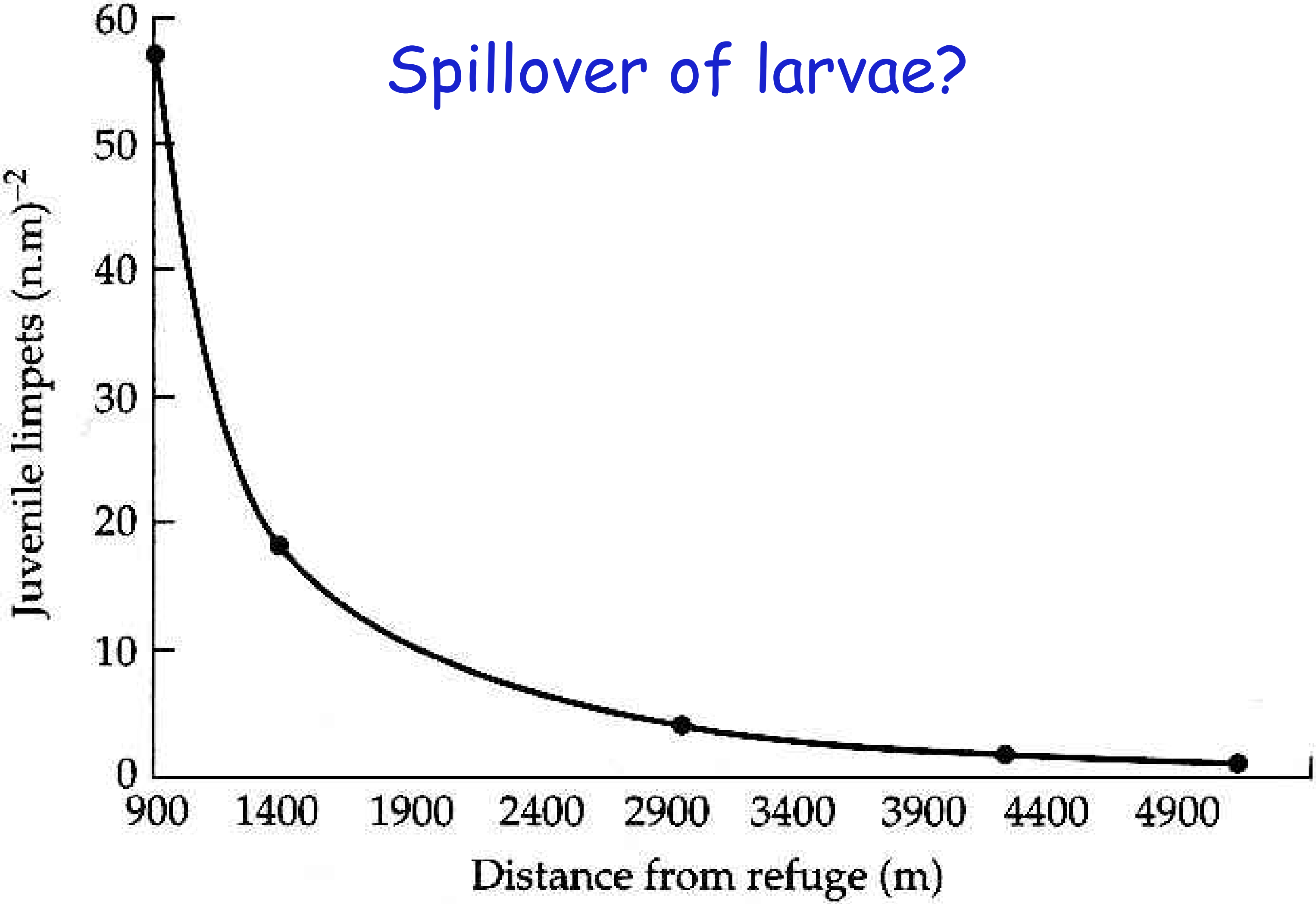
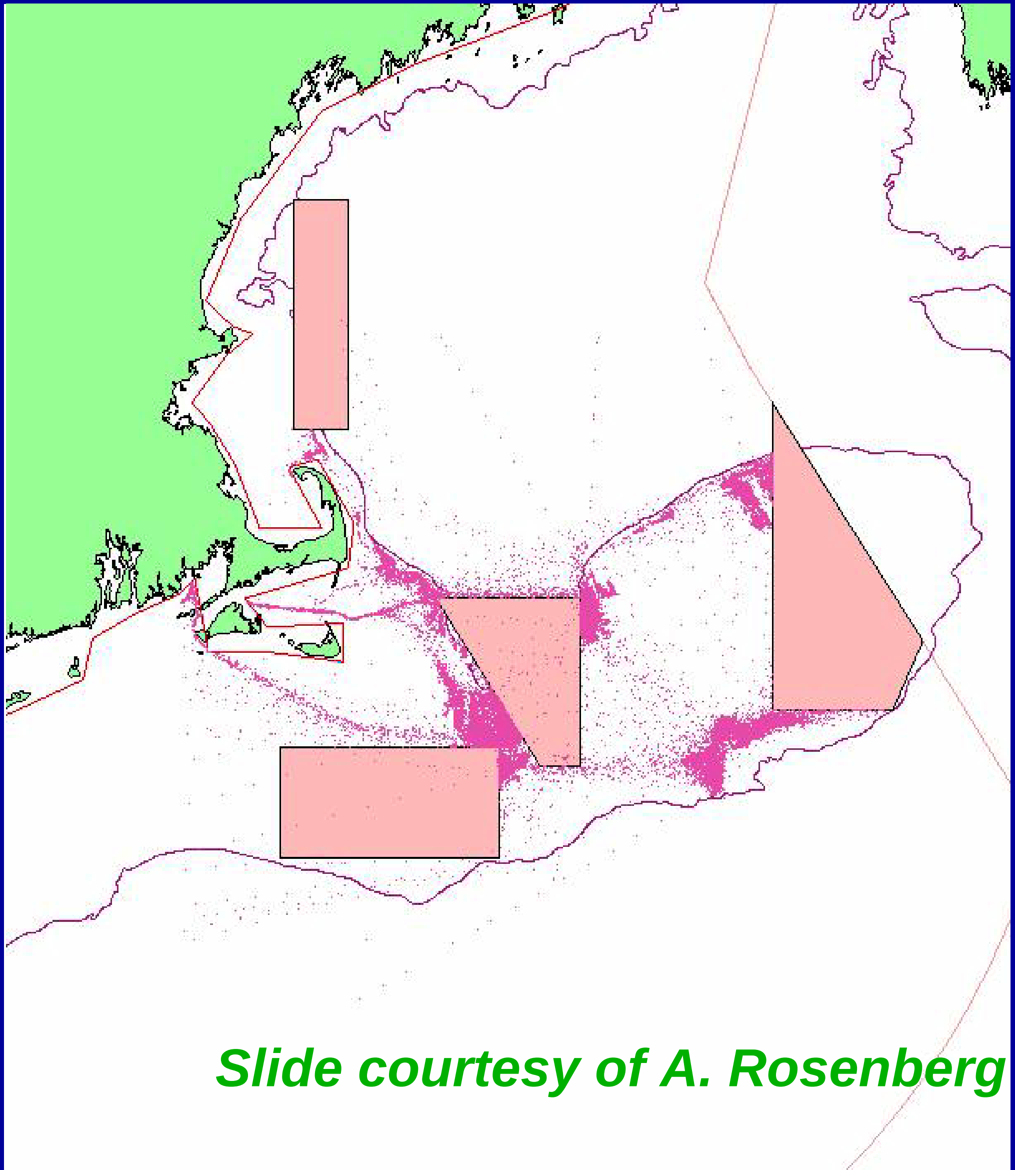


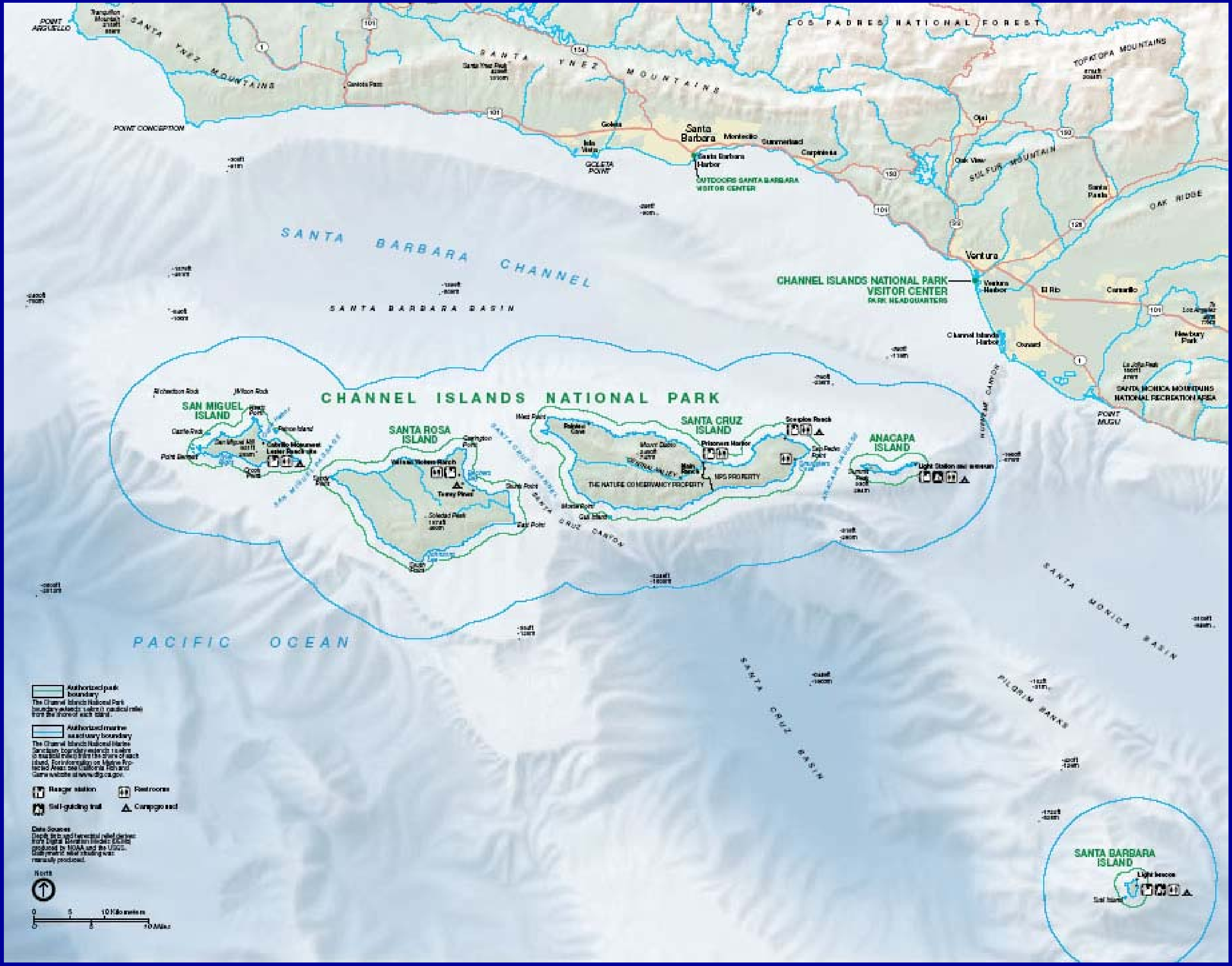
Figure 19.4 Density of juvenile limpets declines exponentially away from the boundaries of a marine refuge in the Canary Islands, suggesting spillover of larvae is occurring. (After Hockey and Branch 1994.)

Spillover and local fisheries enhancement

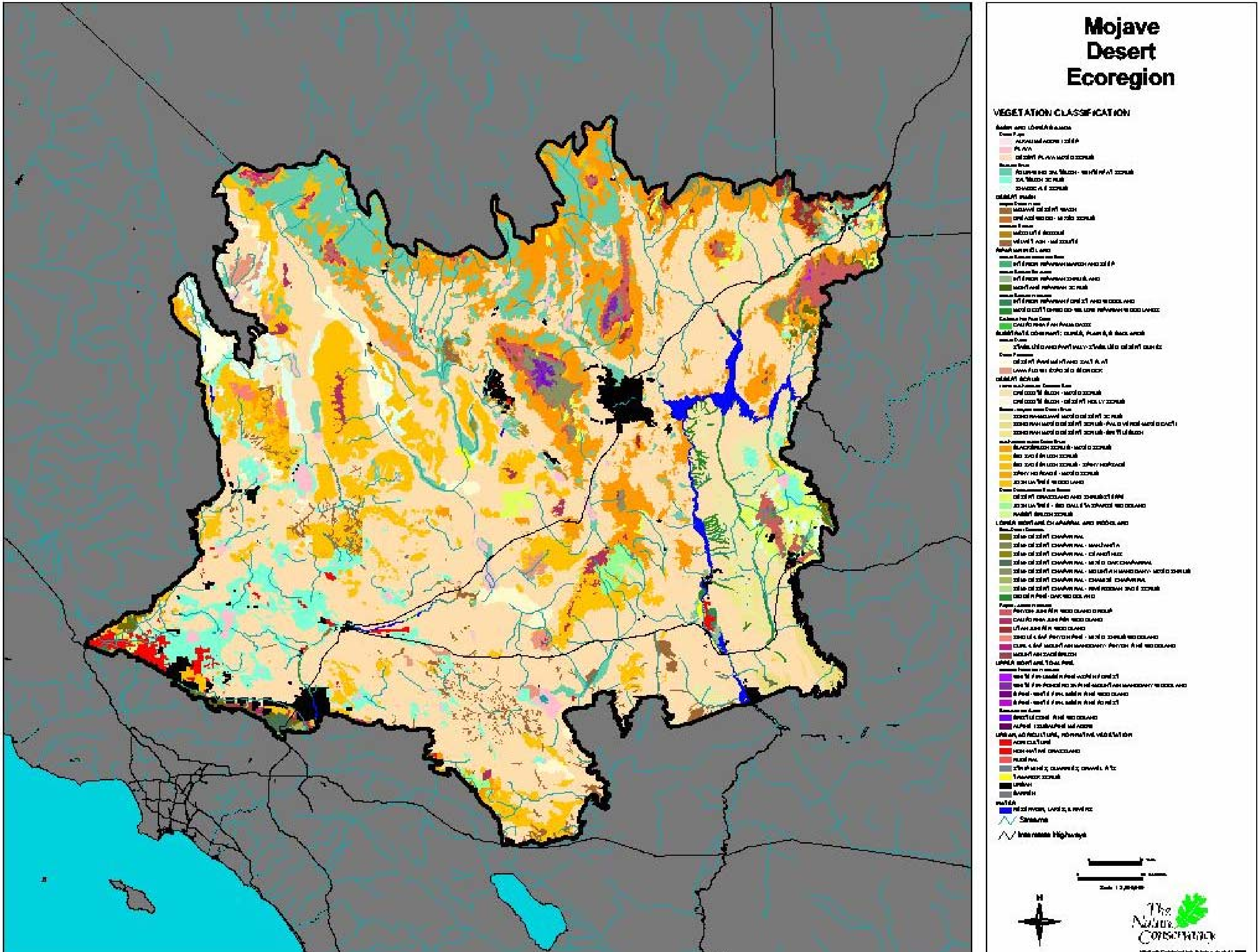
- Tagging studies
- Increased catch per unit effort close to the boundaries of many reserves
- 'Fishing the line'



Reserve Network Design: The Channel Islands



Taking a seascape approach to reserve network design


Mojave
Desert
Ecoregion
VEGETATION CLASSIFICATION
Streams
Interstate Highways
N

Reserve Network Design

Possingham et al. 2000, Cabeza and Moilanen 2001

- Site selection approaches developed for terrestrial reserves (SPEXAN, MARXAN)

- Basic principle: maximize amount of biodiversity represented in network

- Minimum representation problem: find smallest number of sites that will represent every species (or habitat type)

Reserve Network Design

Possingham et al. 2000, Cabeza and Moilanen 2001

Start with MAP of biologically important features divided into planning units

Set CRITERIA:

- Comprehensiveness
- Representativeness
- Adequacy
- Economic objectives
- Spatial design obj.

Set CONSTRAINTS:

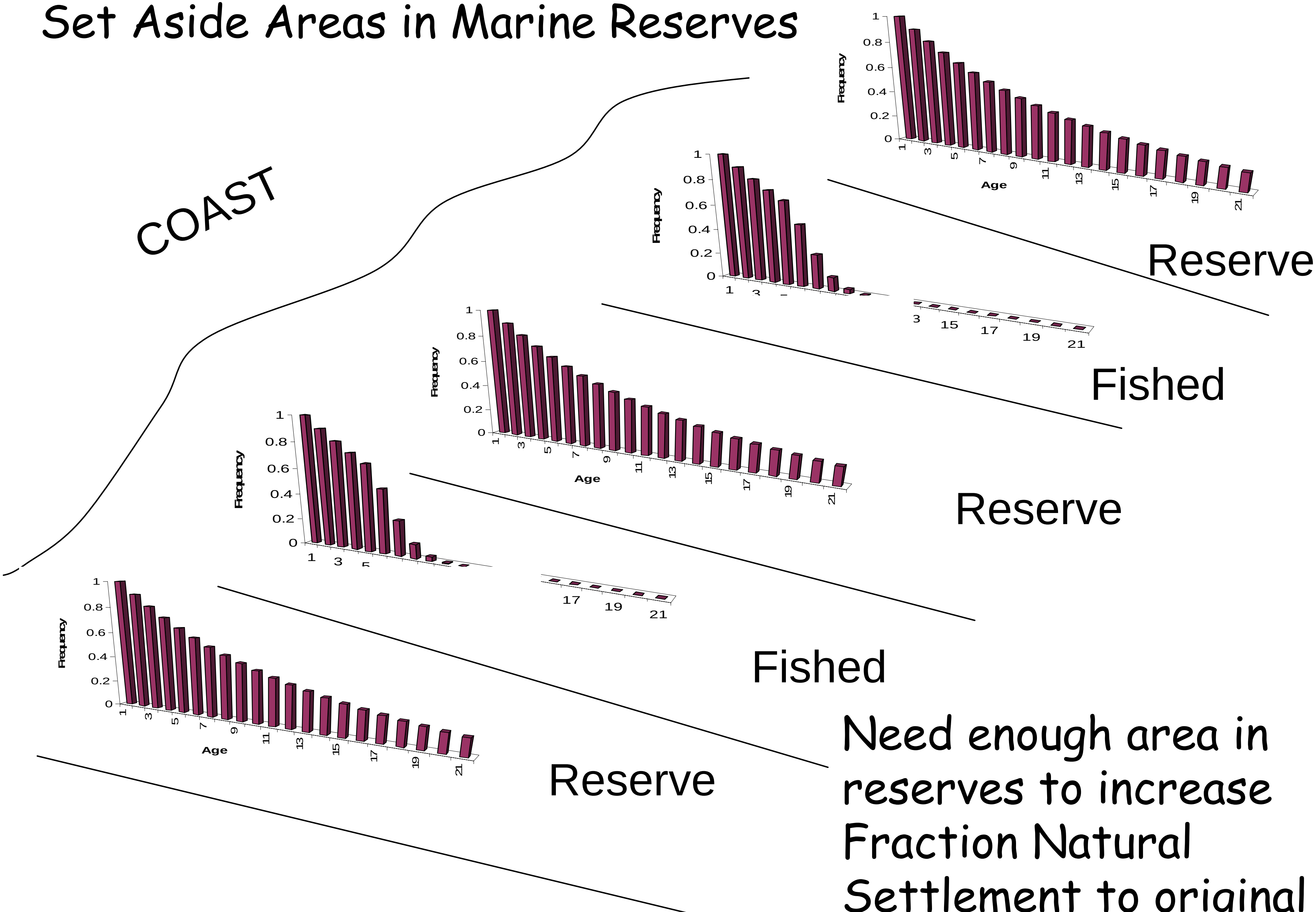
- Adjacency
- Target % in reserve
- Representation in multiple reserves
- Existing reserves

Slide courtesy C. Kappel

Criteria for Channel Islands Marine Reserve Network Design

- Percentage to set aside in reserves (30-50%)

Set Aside Areas in Marine Reserves



Need enough area in reserves to increase Fraction Natural Settlement to original level

Slide courtesy Botsford et al.

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- Biogeographic representation

Criteria for Channel Islands Marine Reserve Network Design

- Percentage to set aside in reserves (30-50%)
- Biogeographic representation
- Habitat representation & heterogeneity
  - Coastline characteristics (e.g. beaches)
  - Substrate type & depth
  - Other physical features (e.g. seamounts)
  - Dominant plant communities

Criteria for Channel Islands Marine Reserve Network Design

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- Species of special concern & critical life history stages (eg. Seabirds & pinnipeds)

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- Exploitable species

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- Ecosystem services (not really incorporated)

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- Existing reserves
- Cost of Reserve system (Based on boundary length)

Reserve Network Design

Approaches:

- "Greedy" algorithms: Starts with site with highest species richness. Maximizes rate of increase of new species - *complementarity.*
- "Rarity" approach: Targets sites containing rare species first.
- Optimization approaches: First generate random reserve systems. Random addition / deletion of sites

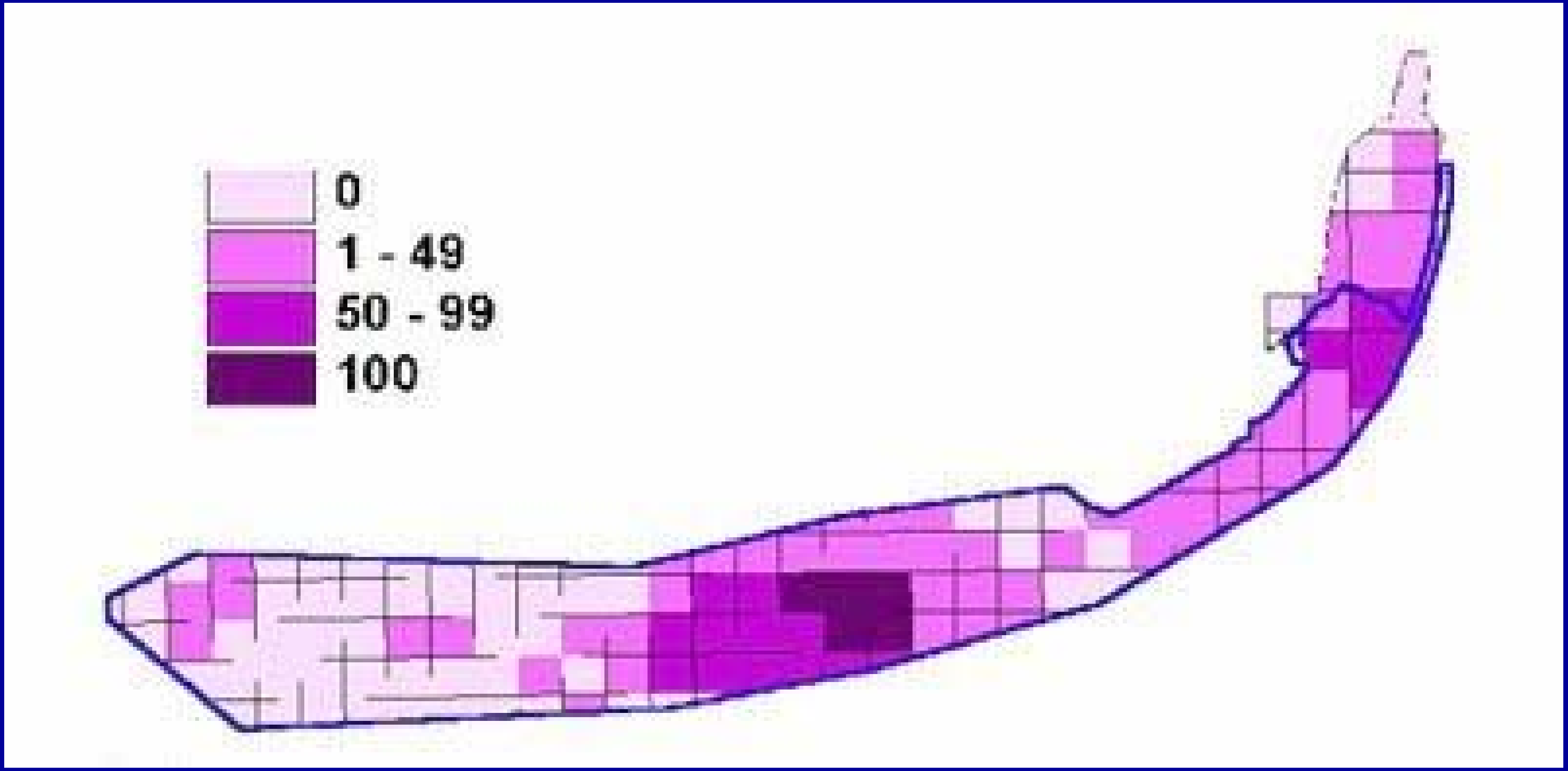
Slide courtesy C. Kappel

Reserve Network Design

Site selection generates alternative networks:

- **Different sets of criteria and constraints produce different outcomes.**
- **Optimization finds *local maxima* and is dependent on starting configuration.**
- **Sites prioritized by examining *irreplaceability*.**

Slide courtesy C. Kappel



Example of SPEXAN's 'summed irreplacability' capacity. Shading represents number of times a 10 km x 10 km block of the Florida Keys was chosen in 100 relatively efficient solutions. Goal: 20%representation of each habitat type (from Leslie et al. 2003).

Final Decisions of SAP

- Determined a range of solutions (ecological perspective)
- Considered economics & political expediency
- Evaluated several potential reserve scenarios including socio-economic information (commercial & recreational activities)
- Made recommendations to the Working Group