# NSF OCE: MPAs and more

**Basic Science for Sustaining Living Marine Resources**.

In harvesting the sea's living resources, it is not disputed that we are overstressing our marine resources at alarming, sometimes devastating rates. Through harvesting and habitat change. It is up to debate whether we can bring them back.

One crucial note is that **we need far more and better attention to the basic science surrounding the questions of how we conserve, preserve and restore our marine resources to know even if we can.**

*No Initiative yet, but emphasis in core programs past five*
*From the website:*

## POPULATION CONNECTIVITY IN MARINE SYSTEMS

**The Biological Oceanography Program, in partnership with Physical Oceanography, currently supports continued discussions and research concerning priorities in this area. Specific areas of interest include:**

- **Population and community ecology: Determine how different kinds and strengths of inter-specific interactions affect the dynamics of open versus closed populations.**
- **Evolution: Compare degrees of isolation with rates of genetic divergence.**
- **Biogeography: Evaluate the extent to which range limits are set by barriers to dispersal rather than physical tolerances of adults or biotic interactions.**
- **Management, conservation and biodiversity: Evaluate the efficacy of extant reserves as determined by regional dispersal patterns**

**Paucity of understanding of these complex systems is in part because the scales are too large for single/small group of investigators to study.**

**Critical need to study intra-population linkages by:**

**(1) determining dispersal paths of propagules,**

**(2) characterizing the physical/ biological mechanisms underlying this dispersal,**

**(3) gaining a better understanding of the relevant characteristics of coastal circulation from the near-shore to the outer shelf, and**

**(4) assessing the population and community consequences of the consequent intra-population linkages.**

**Envision a developing this as a strong emphasis within Core Programs**

**- inter-disciplinary, mid to large sized research projects**

*Example: Recent Mid-sized Award from PhysOCE and BioOCE*

**Linkages between larvae and recruitment of coral reef fishes along the Florida Keys Shelf: an integrated field and modeling analysis of population connectivity in a complex system**

- Su Sponaugle and her collaborators (U. Miami) - larval fish ecologists, physical oceanographers, and modelers. Includes new *in situ* sensor technology.
- Looking at whether marine systems are "open" versus "closed, " one of the central questions in biological oceanography today.
- Looking at the interaction of biological and physical factors influencing larval survival and condition at settlement.
- Examining species of fish with different life-history characteristics in the Florida Keys.
- Integrating a three dimensional hydrodynamic model with a Lagrangian particle tracking model to connect the pathways between observed ichthyoplankton distributions, larval condition, and larval settlement.

- Speaks to the sustainability of populations of organisms, our abilities to accomplish population recovery, and the applicability of Marine Protected Areas. Florida Keys, second largest MPA in the US. In part, recovery is dependent on the degree to which populations of marine organisms are connected via the dispersal of larval propagules.

*Example:* **Biocomplexity - BE/CNH: Coupled Natural and Human Dynamics in Coral Reef Ecosystems: The Effect of Marine Reserve Network Design and Implementation**

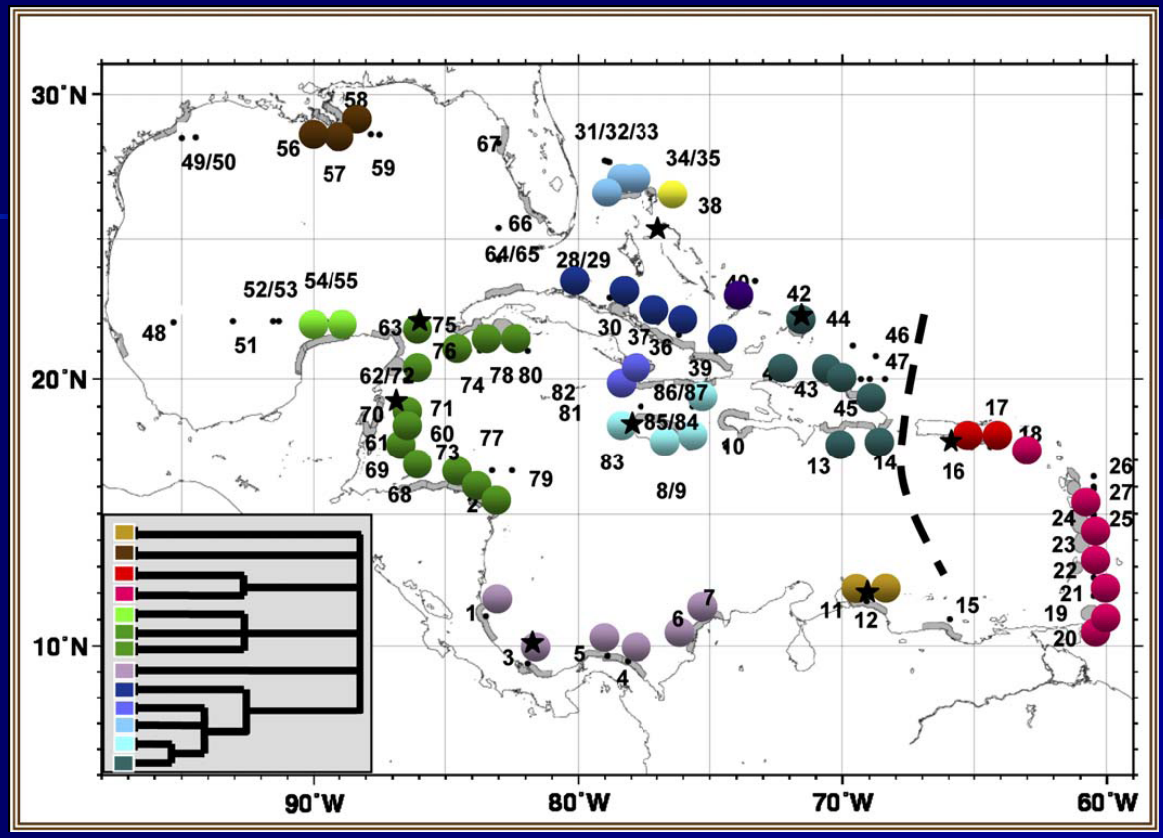
**Dan Brumbaugh, Don Olson, Fiorenza Micheli, Steve Palumbi, John McManus, and others**

**This project's Connectivity Working Group (CWG) is studying how the Bahamian archipelago is ecologically connected with the rest of the Caribbean, as well as how internal parts of the archipelago are linked to each other.**

**The degree of such connections, including how much they vary over time, plays a pivotal role in understanding the functions of a network of MPAs in The Bahamas.**

**In particular, the performance of an MPA network for fisheries will largely depend on whether reproduction and replenishment of populations tends to be fairly local, or whether larvae are dispersed widely by current patterns.**

# Coupled Natural and Human Dynamics in Coral Reef Ecosystems: The Effect of Marine Reserve Network Design and Implementation

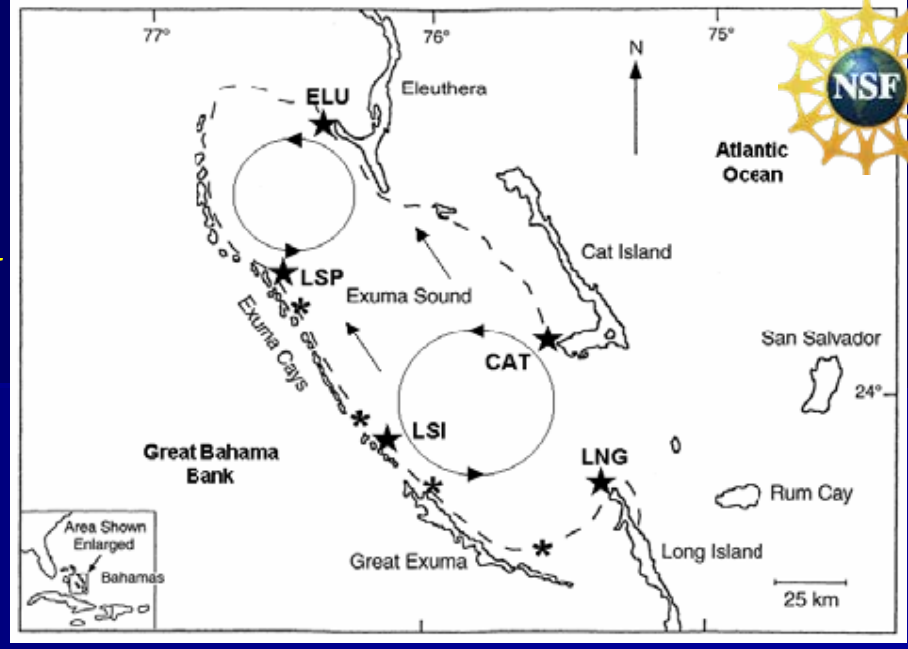



Colored circles indicate arrival locations with genetically similar populations as determined by the consensus dendrogram (insert) from PRIMER.

From: Galindo, H.M., D.B. Olson, and S.R. Palumbi. 2006. *Seascape genetics: A coupled oceanographic genetic model predicts population structure of Caribbean corals. Current Biology 16:1622-1626.*

# *Synthesis of Local Demography and Regional Connectivity in a Marine Fish Metapopulation*

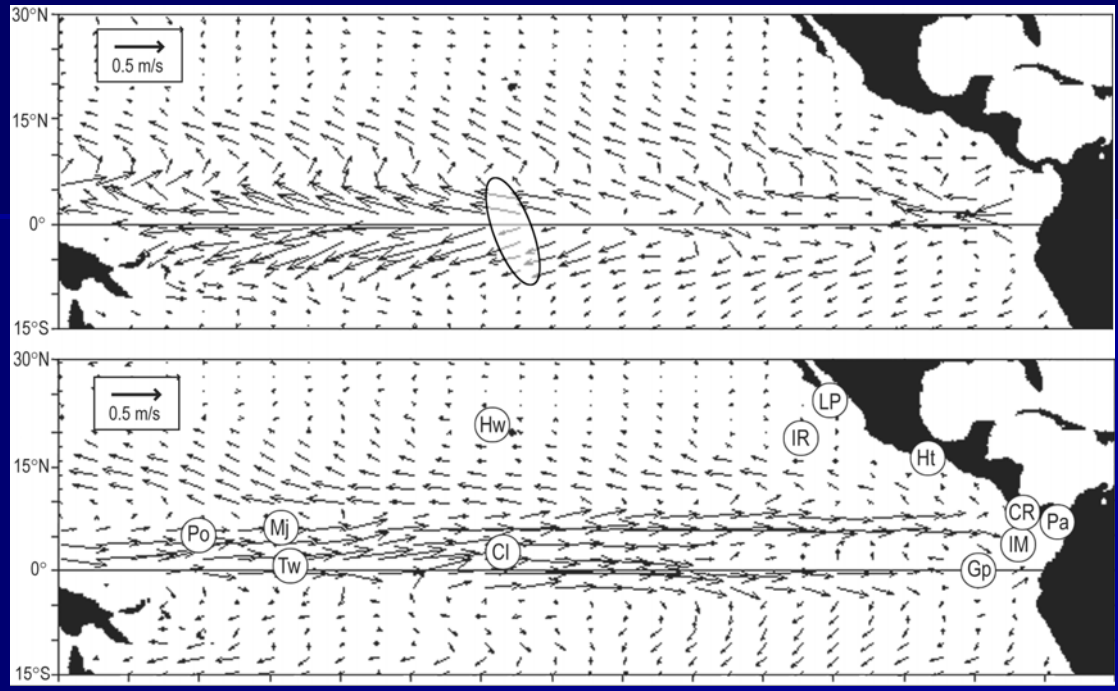
*Mark Hixon, OSU*




**Fundamental knowledge needed**:

(1) the degree of larval connectivity among local populations,
(2) the extent of self-recruitment of larvae back to their natal populations,
(3) the physiological condition of recruiting larvae,
(4) the relative demographic rates (including recruitment, growth, reproductive output, and death)
(5) sources of direct density dependence,,
(6) the level of synchrony of variation in abundance among local populations, and
(7) the environments of local populations (predators, competitors, habitat structure.

***New project from OCE. ENSO-enhanced gene flow across the Eastern Pacific Barrier, Michael Hellberg, LSU and Iliana Baums, Penn State***




1) Have any central and eastern Pacific populations of the coral *Porites lobata* experienced prolonged isolation?
2) Are any eastern Pacific populations of *P. lobata* presently in genetic contact with central Pacific populations?
3) Do routes of genetic exchange between populations follow the patterns of currents during ENSO events?
4) Have eastern Pacific populations of *P. lobata* suffered genetic bottlenecks?

## Other advances in Population Connectivity:

New and better technologies to identify origin and trajectories of early life history stages

- Trace metal geochemical methods,
- Isotope geochemical methods,
- Physical-Biological models (including the US GLOBEC models used in management considerations for scallops around Georges Bank)

Researchers like Lisa Levin, Simon Thorrold, Cynthia Jones, Cisco Werner, Don Olson, Lauren Mullineaux, Andreas Thurnherr, Craig Lewis, to name a few.

Systems from coral reefs, to estuaries, to shelf seas, to hydrothermal vents.

**Within the NSF's Integrative Graduate Education and Research Traineeship Program (IGERT)**

IGERT goal: to develop U.S. Ph.D. scientists and engineers who will pursue careers in research and education, with the interdisciplinary backgrounds, deep knowledge in chosen disciplines, and technical, professional, and personal skills to become, in their own careers, leaders and creative agents for change. This program provides educational opportunities for Undergraduate Students, Graduate Students.

**Steve Gaines et al. U.C Santa Barbara**

**Global Systems Biology: Linking Life, Physical and Social Sciences in Large Marine Ecosystems**

**- Significant emphasis on science and training related to resource conservation and marine protected areas.**

# Beyond Population Connectivity and MPAs

Pew Foundation ***American's Living Oceans; Charting a Course for Sea Change. A Report to the Nation; Recommendations for a New Ocean Policy*** (May 2003).

>>> Critical need for much more basic and applied research on ocean ecological systems, and monitoring of ocean environments, in order to improve the knowledge base and use of knowledge for the sustenance of living marine resources.

President's ***U.S. Ocean Action Plan***, Sept 2004 (formal response to the U.S. Commission on Ocean Policy)

>>> Calls for: (1) protecting and restoring healthy marine ecosystems more effectively; (2) improving ecosystem-based management of natural resources; and (3) using peer-reviewed science in management decisions.

Pew Foundation ***American's Living Oceans; Charting a Course for Sea Change. A Report to the Nation; Recommendations for a New Ocean Policy***

and the

President's ***U.S. Ocean Action Plan***

- Increased investment and action in science is needed because while we have a sound scientific understanding of the reasons for problems in current management approaches, we do not have the much greater knowledge basis on which to reliably build better and sound policies for the sustainable use of living marine resources in most systems.

- This challenge is made even greater because of the fundamental need to bring together generally separated sectors of the basic research community to meet the needs: marine ecology and physical oceanography, fisheries ecology and oceanography, evolutionary biology, and the social/economic sciences.

# Fundamental Science to underpin the Management of Living Marine Resources – A Supreme Challenge at the Cross Roads of Ocean Ecology, Fisheries, Physical Oceanography, Climate Science, Politics and Economics.

**In the Biological Oceanography Program this is considered the most important challenge and priority today in its purview.**

# Science for Managing Living Marine Resources

**Just as scientists had ideas and have given warnings about the overexploitation of fisheries, scientists have ideas and hypotheses to test about:**

- how the harvesting of marine resources impacts the target populations,
- how those populations can evolve in time,
- how those impacts cascade through the other parts of the complex ecological systems,
- the degree to which changing climate systems drive or exacerbate population sustainability and the ecosystems supporting them,
- how it all fits together with the human economic, social and political systems.

**But these ideas need to be <u>explored, broadened, tested and challenged with research</u> in order to give our society the understanding upon which to base more rational and enlightened policy on the harvesting and sustaining of resource populations**

## Themes: Populations

- What is needed to sustain the populations we harvest?
- How are the populations we harvest connected internally in space and time?
- How does the physical oceanographic context matter for sustainability?
- Are there set geographic features in the fluid ocean that influence sustainability?
- Is the biological diversity within populations that influences the resiliency of populations?
- Are there thresholds for population size that influence sustainability by way of reproductive success or predator-prey interactions? What are the resiliencies and resistances to changes?
- Is there pattern with regard to population responses that relate to life-history characteristics of the species? The phylogeny of the species targeted? The ecological system in which the target species lives?

## Themes: Ecosystems

- What are the consequences in the ecological system of harvesting large numbers from a single species within it? How are predators of the target species, and the prey of the target species impacted first order, and what second order responses follow?
- What are the resiliencies and resistances to changes?
- Are their non-linearities, critical thresholds, emergent properties with the heavy exploitation and target population decrease? Via ecological compensation? Do these compensations restructure the ecosystems or the human use of the ecosystem?

## Themes: Evolution

- Is there direction change in the genetic structure of the harvested population caused by the fishing pressure? How fast is change occurring?
- What is the selective agent causing evolution? What features are selected for and against (growth, age of reproduction, fecundity/age, etc.)?
- How does change inter-relate with management practices? Is this reversible? At what time-scale?
- What would be the management practices that could be employed to “improve” a change trajectory?

**Themes:**

**Climate Systems Interactions**

- **How does normal climate (atmosphere, ocean) variability translate into ecosystem and population variability?**
- **How does this impact population sustainability, resilience, resistance?**
- **What are the possible positive/negative synergisms between climate induced dynamics and harvesting/over-exploitation?**

**Coupled Human/Natural System Interactions**

- **A wide open array of fundamental science at the cross roads of ecology, oceanography, politcal and social science, and economics.**
- **NOT How do managers use ecologists data and knowledge, BUT science where social, behavioral and economic questions are fundamentally integrated with natural science.**

## What is needed for us to achieve success is?

- the attention of the NSF on the fundamental importance and urgency of THIS science;
- the recognition that this is not a "NOAA problem," NOAA cannot do this alone, and can be facilitated by partnership with NSF and the academic science establishment it supports;
- the recognition that academia, which NSF supports, is required for (1) the expertise now, and (2) the development of the expertise needed for the future.
- the attention to the multi-faceted and complex array of ecology, oceanography, evolution, fisheries science, economic, social and political science.

CAMEO - First steps will seek to link the data obtained through integrated ecosystem assessments, with research that seeks to understand how human and other pressures on the system change important ecosystem state indicators.

- development of advanced modeling frameworks that extend existing approaches in novel ways and extend the theory of ecosystem dynamics modeling;
- application of common modeling frameworks to a set of representative marine ecosystems to compare and contrast how ecosystem organization and productivity interact with anthropogenic change;
- comparison of existing marine protected areas as a management tool, focusing on key unresolved scientific questions underpinning their use.

## CAMEO Steering Committee established

***The key initial tasks*** **for the steering committee will be to:**

- **develop a series of key research questions for each of the thematic areas,**
- **develop research priorities for addressing them,**
- **select two or three candidate regions with which to focus research efforts (e.g., for the MPA task MPAs),**
- **develop specific RFPs to inform the funding agencies and organizations.**
- **outline a structure and operating principles to oversee the program and effectively allocate resources.**

**(Cowan, Micheli, Hixon, Houde, Steele, Werner, Essington, Fogarty, Hollowed, Levin, Polovina, Rosenberg, along with science managers from Moore, Packard, USGS, MMS, NOAA and NSF)**