**ECOSYSTEM ALTERATIONS (EA) WORKING GROUP**
**New England Aquarium Education Center**

**Boston, MA**
**8:00am to 6:00pm**
**27 April 2004**

## MEETING SUMMARY

*ACTION*: **References for Seafloor Habitat Recovery Monitoring Program (SHRMP)**
Stellwagen Bank National Marine Sanctuary (SBNMS) staff will include references to the information presented by James Lindholm, Pfleger Institute, on SHRMP in the final Mobile Fishing Gear Action Plan.

*ACTION:* **Pollution Presentations**
SBNMS staff will assemble a panel of experts on pollution issues to present information to the Working Group (WG) at the next meeting.

*ACTION:* **Straw-man Biomass Removal Recommendation**
Chris Glass, Manomet Center for Conservation Science (Manomet), Jud Crawford, Conservation Law Foundation (CLF), and Dave Wiley, SBNMS, will draft a straw-man recommendation for biomass removal.

*ACTION:* **Bycatch Reduction Presentation**
The presentation on bycatch reduction techniques by Chris Glass was rescheduled. This presentation will be given at the next meeting.

*ACTION:* **Remaining Action Plan Schedule**
The WG decided that for pollution recommendations, a panel of experts will be assembled for the next meeting, where recommendations will be drafted. Wind farm options will be added to the Cables Action Plan. The WG also decided that for the final meeting, ocean dumping/marine debris and dredge disposal recommendations will be considered.

*ACTION:* **Next Meeting**
The next meeting of the EA WG is set for May 24, 2004, at the Manomet Center for Conservation Sciences.

*AGREEMENT:* **Mobile Fishing Gear Recommendation 1**
The WG accepted the Recommendation 1 as written in Appendix A of this document, with options to be drafted by WG members at a later date.

*AGREEMENT:* **Two Options for Mobile Fishing Gear Recommendation 1**
The WG decided that options would be drafted by WG members to detail impact limitations for mobile fishing and human activities. Options are to be drafted by WG members at a later date.

*AGREEMENT:* **Mobile Fishing Gear Recommendation 2**
WG members decided that site identification for Habitat Areas of Particular Concern (HAPC) designation should be included as a separate recommendation. Recommendation 2 was added. The WG accepted the Recommendation 2 as written in Appendix B.

*AGREEMENT:* **Mobile Fishing Gear Recommendation 3**
As a third recommendation, WG members decided that the SBNMS should establish a research steering committee as a standing subcommittee of the SAC. The WG accepted this recommendation (Recommendation 3) as written in Appendix C.

*AGREEMENT:* **Mobile Fishing Gear Recommendation 4**
WG members decided that items identified by the WG should guide the proposed research steering committee. Recommendation 4 was added as written in Appendix D, to be completed by the WG at a later date.

*AGREEMENT:* **Coastal Activities Removed**
The WG agreed that Coastal Activities should be removed from consideration for Action Plan development. However, Coastal Activities is an important issue and the WG agreed that the Sanctuary Advisory Council (SAC) should be informed about its importance.

***Working Group Attendees (April 27, 2004):***

| **Name** | **WG Seat / Affiliation** | **Attendance** |
|---|---|---|
| Porter Hoagland | WG Chair | Present |
| David Wiley | Team Lead (SBNMS) | Present |
| Ben Cowie-Haskell | Co-Lead (SBNMS) | Present |
| Michel J. Kaiser | Woods Hole Oceanographic Institution | Present |
| Robert Steneck | University of Maine | Not-Present |
| Les Watling | University of Maine | Not-Present |
| Bob Kenney | University of Rhode Island | Not-Present |
| Chris Glass | Manomet Center for Conservation Sciences | Present |
| Frank Mirarchi | Commercial Fishing Industry | Not-Present |
| Russell Sherman | Commercial Fishing Industry | Not-Present |
| Phillip Michaud | Commercial Fishing Industry | Not-Present |
| Mary Beth Tooley | Commercial Fishing Industry | Present |
| Richard Ruais | Commercial Fishing Industry | Present |
| Bruce Munson | Recreational Fishing | Not-Present |
| Jud Crawford | Conservation Law Foundation | Present |
| Geoffrey Smith | Environmental Defense | Present |
| Robert Buchsbaum | MA Audubon Society | Present |
| Rachael Taylor | The Nature Conservancy | Present |
| Stormy Mayo | Center for Coastal Studies | Present |
| Susan Murphy | NMFS | Present |
| Leslie Ann McGee | NEFMC | Present |
| Susan Snow-Cotter | MACZM | Not-Present |
| Luis Ribas | Fisherman, Alternate for Phillip Michaud | Present |
| | | |
| ***Technical Advisors*** | | |
| Richard Taylor | SSWG Alternate for Russell Sherman | Present |
| James Lindholm | | Present |
| | | |
| ***Others Present*** | | |
| Timothy Feehan | PSGS | Present |
| Jennifer Ghiloni | PSGS | Present |
| Peter Auster | University of Connecticut | Present |
| Kathy Lang | NMFS | Present |
| Kate Smuklev | NOAA | Present |

**WELCOME, INTRODUCTIONS AND ADOPTION OF AGENDA**

Porter Hoagland, WG Chair, opened the meeting and welcomed all members of the EA WG. After opening comments the meeting agenda was presented and set for the day.

**OLD BUSINESS AND ACTION ITEMS**
Dave Wiley reviewed the action items identified during the last meeting. WG members were asked to provide input as necessary.

**Fished and Un-fished Area Comparisons**
Alan Michaels was unable to attend the meeting to present information on the issue of fished and un-fished area comparisons. Dave Wiley was able to present some information concerning an area off Gloucester, MA that is considered an un-fished area located 1000 ft off a breakwater. Due to its close proximity to shore and the presence of a sewer outfall pipe, this area has remained un-fished. Sampling has been conducted two times per year over a fourteen-year period and might be considered suitable for use as a non-impacted control site to determine the effects of mobile fishing gear on the benthic environment. This area is similar to the study site presented by Frank Mirarchi at the February 26, 2004 EA WG meeting, and is shallow and exposed to natural storm disturbances. No significant differences have been detected between this un-fished site and fished sites.

**Precedent for Long-term Risk Coverage**
The precedent for the use of bonds or insurance to cover long-term risk has been set by the Army Corps of Engineers. They are currently using this method for wind farm projects of Cape Cod, requiring companies to post a $300,000 bond. This method is also employed for large oil and gas exploration projects.

**Fisheries Information**
National Marine Fisheries Service (NMFS) Fishing Vessel Trip Reports are available for research use. Analysis is currently being done on catch, vessel location, and bottom topography using this information. A presentation on fish populations and the effects of biomass removal by Kathy Lang, NMFS, has been scheduled for this meeting. This presentation can be found in the Presentations section of this summary.

**Natural Disturbances Paper**
Chris Glass has not yet received a copy of a research paper by Joe DeAlteris detailing the effects of natural disturbances to marine environments along the Gulf of Maine. This will be done at a later date. If Chris cannot provide a copy of the paper, Peter Auster, University of Connecticut, has offered to provide one.

**Lindholm and Auster Presentations**
James Lindholm and Peter Auster were scheduled to present their findings on impacted and non-impacted area comparisons within the Gulf of Maine during this meeting. Both presentations can be found in the Presentations section of this summary.

**Changing Coastal Food Webs in the Gulf of Maine**
SBNMS staff will reschedule the presentation by Bob Steneck, University of Maine, on changing coastal food webs in the Gulf of Maine for a future meeting.

**Bycatch Issues**
The presentation on bycatch reduction techniques by Chris Glass was scheduled for this meeting. However, due to time constraints this presentation was rescheduled for the next meeting.

**Stock Assessment**
At this time, the stock assessment process is being revised. SBNMS staff will clear up this issue for the next meeting.

## PRESENTATIONS

**Report on the Seafloor Habitat Recovery Monitoring Program (SHRMP) at SBNMS**
James Lindholm described the monitoring program at SBNMS that is investigating the recovery rates of seafloor habitat and associated taxa after anthropogenic disturbance. SHRMP was started in the Spring of 1998 and is on-going. Results from comparisons of fished and un-fished locations were presented. When studying the affects of mobile fishing gear on the benthic environment it is important to note the severity of impacts for particular types of gear, the frequency of fishing on particular habitat types, the spatial distribution of the gear used, as well as the natural disturbances that occur in the area. Fishing gear such as scallop dredges have more severe impacts than otter trawls, however the spatial distribution of otter trawl fishing is far more extensive in the Sanctuary than is the case for scallop dredges.

Limited data on the spatial distribution of trawl and dredge fishing from 1989 to 1994 (NMFS Sea Sampling Database)shows activity to be heterogeneous across the Gulf of Maine (GOM), with some areas fished many times annually, and others fished less or not at all. However, it is important to note that the data represent only an estimated 5% of the total effort applied to the area during that time period. For natural disturbance, the New England area is subject to severe storms through the year. The effective depth of storm-generated disturbance of the seafloor has been observed to be 60 meters water depth. Within the SBNMS, 64.6 percent of the benthic habitat is below sixty meters in depth. The erosional effects of ocean currents are still being studied.

*Experimental Design*
In the context of alteration from fishing activity and natural disturbance, SHRMP has three main project objectives:

1. Quantifying the diversity and relative abundance of epifaunal invertebrates in piled boulder and gravel habitats inside and outside of the Western GOM Closure Area (WGOMCA).
2. Quantifying the diversity and relative abundance of epifaunal and infaunal invertebrates in unconsolidated mud and erosional sand habitats inside and outside of the WGOMCA.
3. Quantifying the relative abundance of seafloor microhabitats (the scale at which individual fish relate to the seafloor) in each of the four habitats listed above inside and outside of the WGOMCA.

Site selection for the experiment was a top priority. Comparable sites had to be identified both inside and outside the WGOMCA. Unfortunately, fixed gear located at the gravel site outside the WGOMCA caused many observation trials to be aborted. Sampling for this ongoing study was done using remotely operated vehicles (ROV), the SBNMS Integrated Seafloor Imaging System (ISIS), the U.S. Geological Survey (USGS) Seabed Observation and Sampling System (SEABOSS), and side-scan sonar.
*Results to Date*
Species accumulation curves derived from the analysis of hard bottom epifaunal communities in 2001 (3.5 years post-closure) indicated that the “Boulder In” site showed significantly higher levels for species richness and species diversity. Several species of structure forming invertebrate taxa were found in

higher abundance inside the WGOMCA while others had greater abundance outside the WGOMCA. There were no differences observed between the gravel in and gravel out stations with respect to hard bottom epifaunal invertebrates in 2001. Analysis of seafloor microhabitats at the gravel stations from 1998 to 2001 also showed no statistical difference between the sites inside and outside WGOMCA study area.

Cluster analyses were conducted for mud and sand microhabitats comparing fished and un-fished sites from 1998 to 2002. It is important to note that shrimp trawling was permitted within the WGOMCA, and occurs within the mud habitat (though the precise distribution of shrimp trawling in the closed area is not known). For mud, the results are as follows:

- For 1998, no difference in richness, abundance, evenness and diversity between fished and un-fished sites, at the family and species level.
- For 2001, no difference in richness, abundance, evenness and diversity between fished and un-fished sites, at the family and species level.
- For 2002, higher abundance, evenness, and diversity at "Mud In" site (un-fished) at both family and species level.

For sand microhabitats, the cluster analysis results are as follows:

- For 1998, no difference in richness or diversity between fished and un-fished sites at family or species level, but higher abundance and lower evenness at the Sand In site at the family and species level.
- For 2001, no differences between sites with the exception of higher family level diversity at the Sand Out site.
- For 2002, no differences between sites with the exception of higher family level evenness at Sand Out (fished) site.

*Conclusions*
Results differ from habitat to habitat, although it will be important to track recovery progress over time. However, for the past three and a half years since the WGOMCA was created, differences between sites inside and outside the WGOMCA are attributable to fishing activity. Though this project has been beneficial, it was still created as a project of opportunity due to the creation of the WGOMCA. The area was created to reduce fishing mortality for cod, and not specifically for scientific experimentation on habitat recovery. Because of this, the project has two persistent issues:

1. Better data on the spatial and temporal distribution of human activities.
2. Ability to answer questions of utility to Sanctuary and Sanctuary users would be enhanced by a better-designed closed area.

Comparable sites were located in areas that may have been too close to the edge of the WGOMCA. The program has produced robust results, but has been limited by the area of the WGOMCA located inside the SBNMS. Sampling will continue, and plans have been made for further ROV, SEABOSS, and side-scan sonar cruises in the summer of 2004.

*Questions & Answers*

***Question 1:*** In the diagram for species accumulation, why would you get graphs like these showing more species with increasing numbers of quadrats?

> ***Answer:*** This is an accumulation of species. With each new photograph, more species are identified and added to the accumulated number of species. Based on sampling prior to the beginning of the project, it is not clear that additional quadrates would show significantly more species.

***Question 2:*** Do the quadrats correspond to a large area?

> ***Answer:*** Each quadrat is 0.35 square meters, so the area would increase along the transect. The total area for this data is approximately 75 square meters.

***Question 3:*** A study area of 75 square meters is not very large. Things like current speed and the fact that the gravel sites were not the same are issues concerning experimental design. What about factors for randomness, does this mean that more quadrats are needed?

> ***Answer:*** There are many issues with replications and design. However, that is not the only message. An ROV was used for collecting this data. There is a high degree of confidence with what was observed since each habitat type was basically ground-truthed.
>
> ***Comment:*** Members of the WG stated that the design for this study was dictated by the area of the WGOMCA within the SBNMS ("The Sliver"). More sites would be useful, but the current system does not allow this opportunity. If more study sites are eventually created, we must make sure there are enough. Quantifying fishing in the area is also an issue to be dealt with.
>
> ***Comment:*** Given that much work was done to find a number of sites to study, WG members felt that the data answered whether communities respond to different levels of disturbance. Sites in and out of "The Sliver" were similar in community structure in 1998. However, the communities have changed since then. This can suggest that fishing is a major source of disturbance.
>
> ***Comment:*** Other WG members stated that an argument could be made that any fishing can have impacts, even fixed gear. In this case, impacts would be dependant on the density and frequency of the gear used.
>
> ***Comment:*** For some WG members, vessel monitoring systems (VMS) on all boats would be useful to quantify fishing. For vessels that could not use VMS, passive data loggers could be used in conjunction with a third party company that could act as a firewall for data collection.
>
> ***Comment:*** Some WG members stated that a major constraint is that the amount of fishing actually occurring in the fished areas is unknown. However, observer data can provide haul-by-haul information to quantify what gear is used and where fishing occurs.

***Question 4:*** The project as is, was a good project of opportunity. Are there sites within the Sanctuary that would be better to use for future projects?

> ***Answer:*** Yes. Actually, being able to work from East to West through the Sanctuary would offer the best amount of sites with representative habitat types.

***Question 5:*** Can you stratify smaller habitat types within each habitat type?

***Answer:*** That would depend on the question asked. This study could be used as a starting point for other studies to continue.

**Biological Diversity at SBNMS**

Peter Auster presented information concerning biological diversity at the SBNMS. Biological diversity is distributed unevenly across the globe and every biogeographic region contains unique components of diversity. The Northwest Atlantic is split into two main regions: Acadian and Virginian. The Acadian region is split into four sub-regions: Scotian Shelf, GOM, Georges Bank, and Mid-Atlantic. Each sub-region has some unique regional faunas associated with it. The SBNMS, located in the GOM sub-region, is an area of high biological diversity.

*Biological Diversity*

Biological diversity is defined as the total complexity of all life, including not only the variety of organisms but also their varying forms, patterns and interactions. It can be characterized at genetic, species, and ecosystem (or community/landscape) levels. The clearest component of biological diversity to quantify is species diversity. All species can be classified, and all major phyla are represented in the ocean. Within the SBNMS, many species have been quantified, although the exact count is incomplete. For invertebrates the number of species within the SBNMS is:

- Infaunal species – 234 (mud and sand; $<4m^2$; Grannis and Watling).
- Epifaunal species – 82 (gravel and boulder; $\sim 63m^2$;McNaught, unpublished).

For vertebrates the number of species within the SBNMS is:

- Fishes – 66 (demersal survey; Auster, 2002); plus 6 (Auster, unpublished)
- Marine mammals – 17 (Ward ,1995)
- Seabirds – 38 species (Trull, MS 1998)

Genetic diversity is the relative richness of different genes within each species, such that different phenotypes can be expressed under the widest variety of conditions. Such variation allows persistence of populations in variable environments. For example:

- Orange roughy – fishing reduced genetic diversity over a short time-period (off New Zealand).

- Atlantic cod – five genetically distinct populations have been identified with no change in genetic structure over time (off Newfoundland), possibly contributing to the fact that the population is not reproducing quickly.

Ecosystem (landscape/community diversity) can be characterized by variation in attributes of ecosystem, landscape or community scales. For example:

- Characteristic water masses and patterns of primary production
- Spatial pattern in patch characteristics including patch size and adjacencies
- Spatial variation in dominance hierarchies that lead to variable patterns in trophic linkages and patterns in habitat use

*The Undersea Landscape*
The latest technology has enabled us to view the undersea landscape more clearly. Multi-beam imagery provides a level of resolution of landscape features that has been unattainable with lower resolution bathymetric and seafloor geological surveys. Multi-beam imagery provides a highly detailed picture of the seafloor landscape, providing detailed bathymetry and backscatter. This aids in determining bottom type by the strength of acoustic signal reflectance. The undersea landscape also includes surface and deep water current patterns, as well as stratified levels of water mass through the water column. Surface current patterns can identify bio-physical regions in Massachusetts Bay.
The species composition of seafloor communities is highly correlated with the grain size of benthic sediments and water mass. Larger, highly mobile species tend to favor large grain size bottom types, while smaller, more sessile species favor smaller grain size bottom types. At the scale of Stellwagen Bank and Stellwagen Basin features, fish community distributions have been correlated with distinct groups of habitat types including:

- Sandy shell beds, sandy gravel, muddy sand, muddy gravel with attached sponges and partly buried boulders.
- Mud, sandy silt.
- Cerianthid anenome forest, burrowed mud.
- Gravel and scattered boulders, sandy gravel ridges.
- Piled boulders.

Trawl survey data has been used to determine the affinities of fishes for particular habitat types. High-density samples of most species occurred in a narrow range of habitat types.

*GOM & SBNMS Species Richness*
High-density areas of species richness can be found around the perimeter or the GOM and Georges Bank. The SBNMS is located in this GOM perimeter region with high species richness. Classification of species into the categories of resident, annual migrant, summer migrant, winter migrant, slope, mesopelagic, and coastal for both the GOM and the SBNMS shows that 1/3 of the total species in the GOM can be found in the SBNMS. The Alpha diversity index shows a constant diversity between the GOM and the SBNMS over time while both the Shannon and Simpson indices show some change; however, there is no clear trend in diversity for any particular landscape feature.

*Representation of Seafloor Communities*
The SBNMS currently has a problem with identifying study sites that are representative of all the seafloor habitats within the Sanctuary, while minimizing impacts to users. One way to minimize area would be to identify the smallest set of sites that contain sufficient amounts of representative habitats. This represents a type of mathematical optimization problem, for which certain computer algorithms are ideally suited. One such method is simulated annealing (MARXAN) to delineate representative habitats based on set goals. The basic MARXAN objective function is:

$$\text{Total Cost} = ? \underset{\text{sites}}{\text{Cost}} + ? \underset{\text{species}}{\text{Penalties}} + \text{BLM} ? \underset{\text{sites}}{\text{Boundary}}$$

Where the total cost is equal to the trade-offs (Cost + Penalties) for the number of habitat types represented plus some function to account for the number of adjacent areas that are represented by the boundary length modifier (BLM). With MARXAN a target can be set for a percentage of habitat types

represented, and the calculations can be made to identify areas within the specified parameters. The model can be run to identify a specific number and total area of study sites within the Sanctuary that contain the percentage of representative habitats types. For any given percentage of represented habitat types, the total area of a study site increases with a decreasing total number of sites within the Sanctuary. In other words, to have one site, the total area is larger than having four separate sites that encompass the same percentage of representative habitat types. This could become a question for management, since one area can be regulated easier than many, but the area would be larger. MARXAN is a powerful tool that can be used to identify areas that would contain representative habitat types for study within the SBNMS. It can assess trade-offs and show a range of optimal solutions which can be used as a starting point for discussion on study sites within the SBNMS.

*Questions & Answers*

***Question 1:*** So, with MARXAN, are you changing the BLM?

***Answer:*** Yes. These are preliminary runs intended as an example of the process. You start with a set of conditions and let the computer provide a range of options.

***Question 2:*** In the diagram, what does the 28.3 percent represent?

***Answer:*** This is the percent of the Sanctuary area contained in the solution.

***Question 3:*** Can MARXAN be brought to meeting and be done on the fly?

***Answer:*** No. The program needs to make multiple runs which take too much time.

***Question 4:*** Do you think that a majority of commercial fishing areas correspond to species poor areas in terms of species richness?

***Answer:*** Commercial fishing spans the entire range.

***Question 5:*** With MARXAN, can the model include the cost of displaced activity?

***Answer:*** This is a model that comes out of Australia for terrestrial conservation and has only recently been applied to the marine environment. It could be possible.

***Question 6:*** What is the biological reasoning behind changing the BLM?

***Answer:*** There are a variety of reasons. It can be a management reason. There is a trade-off of study area size and number in order to meet a representation target of habitat types. Altering the BLM can be useful for adaptive management.

***Question 7:*** Can the distance from particular ports be included in the model?

***Answer:*** Yes. Every square could be given a distance value and use it in the analysis.

**The Effects of Biomass Removal: Altering Marine Ecosystems**

Kathy Lang provided information on how marine ecosystems can be altered by the removal of biomass. In an ecosystem, a strictly top down alteration (such as biomass removal) will result in an overall smaller population while a strictly bottom up alteration (such as increased nutrient availability) will result in an overall larger population. In an ecosystem under the influence of both top down and bottom up effects (such as typical marine populations), the net result can be:

- Balanced such that there is no change in the population size.

- A reduction in the population size.
- An increase in the population size.

The end result depends on the relative magnitude of the various effects on the population. Bottom up and top down alterations can have effects on the trophic levels within an ecosystem. Where altering influences are strictly bottom up, the effect on each trophic level is progressively reduced so that the overall effect is smaller on higher trophic levels. In an ecosystem where the altering influences are top down, the effect on the various trophic levels is staggered.

*Populations*
For a single species in a given area, individuals are added through immigration. Individuals of this species are removed through emigration, natural mortality, or fishing harvest. Within the population, there is a distribution of individuals that vary by sex, size and age. Some reproduction also occurs. In addition to a single species population dynamics model, any one species can have various interactions with other species in the same ecosystem. Most often, these interactions involve consumption. When two species consume each other, this interaction it is called a cycle. In some species members of the species may be eating other smaller members of that same species. Cannibalism is not uncommon with marine species. In very complicated interaction webs, effects of alteration on a single species can have implications on many other species within the ecosystem and these implications are difficult to predict.

*Biomass*
When looking at total biomass for all finfish collected by the North East Fisheries Science Center (NEFSC) from 1963 to 1999, biomass appears to be constant; however, there has been a significant change in the composition of this biomass. When separated by groundfish species versus pelagic species, an overall decrease in the abundance of groundfish such as cod and flounder species, and an overall increase in the abundance of the pelagic species such as herring and mackerel can be observed. Elasmobranchs, such as dogfish and skate, have also increased in biomass. Records also indicate that the average length for all species together has decreased, although this may be biased by the biomass increase in herring and mackerel, which are small in body size.

The total weight and revenue of otter trawl landings in New England can indicate changes in populations. With weight, the composition of the landings has changed rather dramatically with an increase in landings of non-groundfish species. Cod, haddock and yellowtail now make up a much smaller percentage of the landings by weight. Monkfish and skates are making up a much larger percent of the landings in this fishery. A decline in revenue has occurred as the number of vessels in this fishery has increased. With declining revenues being divided among a larger number of participants, profitability is even further reduced.

Over time, energy flow through populations has changed. In the Northwest Atlantic in 1977, prey items were relatively unique for particular predators. These prey items and their predators were:

- Sandlance – spiny dogfish, cod, winter skate and summer flounder.
- Squids – spiny dogfish and summer flounder.
- Herring – spiny dogfish and monkfish.
- Mackeral – spiny dogfish.

However, in 1987 a decrease in stock size of cod and the increase in the stock size of the elasmobranchs, which were then consuming more of the prey species, caused all predator species to feed on additional prey species. By 1997, the energy flow was similar to 1987, but the stock size of herring had increased while the stock size of sandlance had decreased. Over time, the percentage that the pelagic species comprise of the diets of some the major predator species has changed. The overall trend between decades indicates that pelagic species comprise more of the diets of predator species.

The total amount of food items consumed by predators has also decreased. The ecological implication is that the amount of energy flowing within the system has changed. As an example, the linkage density of silver hake shows that the number of interactions with other species has increased significantly from 1973 to 1998. This indicates that the relative importance of this species in the ecosystem has increased so that any alteration in the population of silver hake will now have an impact on an even greater number of other species. Another example is sculpin, where scallop viscera make up a high percentage of the diet of this species. Also, the abundance of sculpin in the ecosystem has been increasing in recent years. In this case, it appears that the influence of humans in this ecosystem may be maintaining, or even increasing, the abundance of this species. As traditionally landed groundfish (such as cod) are less prominent in the ecosystem, we need to know what is taking their place in terms of ecology and economics, and be prepared to deal with those organisms.

*Guild Model Structure*

One step towards modeling the tradeoff in biomass of different groups (or guilds) could be the use of a model such as the original Schaefer production model, which states that biomass growth is equal to natural growth minus the harvested biomass. In order to consider ecological interactions with other species, mathematical terms can be added to account for competition and predation. This model can predict four scenarios:

- Scenario 1 – A base model where the species composition within a guild may vary, but the biomass of a given guild remains constant over time.
- Scenario 2 – The demersal species have been selectively removed and the result is not only a change in the amount of biomass within each guild (favoring planktivores), but also a significant drop in the carrying capacity of the ecosystem which therefore limits the potential yield of the system. This version of the guild biomass model is the closest to what has been observed in the Northwest Atlantic.
- Scenario 3 – The pelagic species have been selectively removed and while the biomass in the other guilds remains fairly constant, the carrying capacity of the ecosystem is still reduced due to the removal of a food source.
- Scenario 4 – The piscivores are removed which is essentially a predator release, and there are some slight shifts in the amounts of biomass of the remaining guilds. However, the carrying capacity of the ecosystem remains quite high.

Therefore, at equilibrium, the species within a guild may vary in numbers, but the overall biomass of the guild will remain constant as will the carrying capacity of the ecosystem. Removing significant amounts of biomass from one guild can result in changing the relative biomass of the other guilds in the ecosystem, alter the energy flow within the system, and can also alter the carrying capacity of the system. Finally, while internal variations do occur within the guilds, external factors have a much more significant effect over time.

*What We Know*
Looking at the guild structure within the ecosystem from an energy flow perspective, in a demersally oriented system, most of the energy flow is vertical and thus stays within the system. This situation is closest to what was observed in the Northwest Atlantic in the late 1960's and early 1970's. In an ecosystem in which pelagic species dominate, the energy flow is mostly horizontal, meaning that more of the energy moves through the system than the amount maintained through vertical input. This depicts the current situation in the Northwest Atlantic.

What is known about the ecosystem today is:

- Notable amounts of biomass have been removed from the North East U. S. Continental Shelf ecosystem.
- There is a general decline in long-term landings and value if removal rate exceeds production rate.
- Economic implications are generally positive in the short term, but negative in the long term due to foregone yields.
- There is understanding of the general concepts and processes acting within the system.
- Top-down effects can alter how a system functions or is structured.
- The biotic components (targeted and non-targeted) of the ecosystem respond to removals, particularly:
    - We see a shift in community biomass to smaller species.
    - We see a general shift in community biomass from demersals to pelagics.
    - Undesirable species become more prominent, with fisheries often then initiated for those species.
    - Energy flows within the ecosystem are altered.
    - Scavenger populations tend to do well.

*What We Need to Know*
Even with the current level of knowledge, there are still issues that need considerations such as:

- We can conceptually model the system to mimic what we observed, but how well?
- What are the general and specific ecosystem responses, or suspected responses, given particular management alternatives that address biomass removal?
- Can we address biomass tradeoffs, even generally, with any degree of confidence (i.e. can we influence the system to be how we want it to be)?
- What is the probability of obtaining a desired response, even generally, given particular management alternatives that address biomass removal?
- What are the indirect or unintended effects of a trophic cascade?
- Magnitude of the effects of removals at different trophic levels
- Forage base issues for charismatic megafauna
- Bycatch/discard associated issues

*What We Can Not Know*
There are also issues that may be impossible to understand such as:

- Precisely how trophic cascades will "trickle" through a system given food web complexities.
- Specifically (magnitude and sometimes not even the direction), the response of populations in the biotic community to biomass removals, particularly removals at different trophic levels and in conjunction with other processes extant in the ecosystem.
- Whether system resilience is linear or non-linear as a function of various levels of overall systemic removals.

*Questions & Answers*

***Question 1:*** What is meant by the change with piscivores? Is it because piscivores eat less fish or is it because there are less prey items available?

***Answer:*** It could be less prey items. It could also mean there are less predators to eat them.

***Question 2:*** With the consumption graph, is this the consumption of each sample for each year?

***Answer:*** Yes.

***Question 3:*** In terms of the keystone species like the silver hake, as the abundance increases, basically they eat more prey items and more predators eat them?

***Answer:*** Yes.

***Question 4:*** What drop in biomass may come from human activities? Is it possible to tell if the whole system is simply slowing down?

***Answer:*** This is information that is currently beyond what we can calculate.

***Comment:*** WG members expressed that historical data could be helpful. It is possible to look back and see that in the past ten years, groundfish biomass has increased three fold. However, it depends on how far back one looks, since looking way back in history shows a spawning stock biomass that was orders of magnitude higher.

***Question 5:*** Having modeled the complicated interactions between species, the likelihood of a trophic cascade by the removal of one species is unlikely. Is there greater jeopardy for an ecosystem that is dependant on fewer species?

***Answer:*** Yes.

***Question 6:*** Is it possible that we are compromising the GOM ecosystem with our actions?

***Answer:*** We are definitely altering the ecosystem, but as to compromising it, that is uncertain.

***Question 7:*** Is there an effort to look a decadal shifts, natural cycles and if so, how much is natural variation?

***Answer:*** Our data goes back only to 1960.

***Comment:*** WG members stated that knowing what the natural biology of the system, knowing natural cycles, is important. Recent work by a Russian researcher has indicated that a cycle of sixty years may be occurring and that we are currently experiencing a low point in that cycle.

***Question 8:*** Is there a level of selective removal that you think is acceptable?

***Answer:*** In the conceptual model, no real level is analyzed. Real time numbers have not been available.

## ECOSYSTEM ALTERATION IMPACTS OF MOBILE FISHING GEAR: AGREEMENTS, RECOMMENDATIONS OR OPTIONS

### Proposed Mobile Fishing Gear Recommendations

The Chair opened discussion on the proposed recommendations for mobile fishing gear. It was explained to the WG that Sanctuary staff, as an attempt to blend proposed recommendations from the last meeting, drafted this document. As Recommendation 1 was discussed, it became apparent that more recommendations needed to be added. These became Recommendations 2 through 4. The proposed recommendations can be found in Appendix A - D at the end of this document. All additions suggested by the WG are marked in **BLUE** and deletions are marked in ~~**RED**~~ font. Issues raised for each section during this discussion are noted below.

***Issue 1:*** **Recommendation 1**

In an attempt to blend recommendations for past meetings, SBNMS staff drafted a straw-man recommendation for the WG to discuss. The WG was concerned that the statement needed to be broader in terms of activities to be restricted and that research goals should be identified. The time-scale for research areas was also a topic of discussion. The WG decided that options would be drafted by WG members to detail impact limitations for: 1) mobile fishing; 2) human impacts. After amendments were made, the WG accepted the Recommendation 1 as written in Appendix A of this document, with options to be drafted by WG members at a later date.

***Discussion:*** WG members discussed details on how research areas should be created. Research areas should be representative of habitat types found within the Sanctuary. Wording was changed to incorporate areas "…representative of habitat types and depths within the Sanctuary." For designating Habitat Areas of Particular Concern (HAPC), WG members agreed that areas should be identified within the Sanctuary and be recommended to the New England Fisheries Management Council (NEFMC). However, this should be added as a separate recommendation. Wording was developed and added as Recommendation 2. It was important that the any new research areas needed to have the proper scale at which to operate and attain research goals. Such areas should be used for a variety of research topics that are relevant and pertinent to the biological needs of the Sanctuary. However, the spatial scale should be minimized to reduce impacts on all stakeholders. WG members were also concerned that the time-period should be stated in such a way as to not define a study area as permanent. To address these issues, "These area(s) should be set aside for a period that is identified by the research needs, commitments, long-term monitoring and recommendations as identified by a Sanctuary research committee" was added. The idea for a Sanctuary research committee was then identified as a recommendation, and was written as Recommendation 3. To address user needs, the recommendation was edited to reflect this issue. WG members also wanted research areas to be located "… to the greatest extent feasible within the existing Western Gulf of Maine (WGOM) Habitat Closed Area, where it overlaps the SBNMS…" and that if additional areas within the Sanctuary was needed, such an action "…would be compensated for by a reduction of comparable area elsewhere in the WGOM Habitat Closed Area or other area and/or measure." Wording was also added to specifically identify "The Sliver". The WG agreed that members

would be tasked with providing details concerning options for restrictions on mobile fishing and human impacts.

***Comment:*** WG members expressed that recommendations must be backed by robust justification providing specific scientific reasons for presentation to the SAC.

***Comment:*** In terms of research to be conducted within the Sanctuary, WG members stated that certain ecological experiments could not be done in areas that are impacted. Impacts needed to be controlled. If an area was closed to fishing, it should be closed to all human activity to enable scientific experiments to be conducted.

***Comment:*** WG members stated that specific tow data on fishing within the SBNMS should be collected to determine when, where and how much fishing is conducted.

***Comment:*** Some WG members cautioned that research itself could be a source of impact. Too much research sampling in an area could cause un-wanted impacts. Areas should be able to be used for a wide range of research options.

***Comment:*** WG members stated that some justification for research areas should be given. If the areas are to be used to answer questions that are specific to the Sanctuary, then they should be located within the Sanctuary. If other research options are to be utilized, areas outside the Sanctuary may be more appropriate, depending on the question asked.

***Comment:*** For closing an area for research, WG members expressed that options should include all types of fishing. Closures should not be limited to a specific gear type only.

***Comment:*** Some WG members suggested that areas currently outside the Sanctuary would be useful for research. The SBNMS should consider the potential of boundary changes.

***Issue 2:*** **Recommendation 2**

While discussing Recommendation 1, WG members decided that site identification for HAPC designation should be included as a separate recommendation. Recommendation 2 was added and the WG accepted the Recommendation 2 as written in Appendix B.

***Discussion:*** The WG decided that HAPC designation would not preclude HAPC identified by the NEFMC. The SBNMS should investigate areas within its borders to recommend to the Council as HAPC pursuant to NEFMC designation. The wording was added and the Recommendation was approved.

***Issue 3:*** **Recommendation 3**

While discussing Recommendation 1, WG members decided that the SBNMS should establish a research steering committee as a standing subcommittee of the SAC. Recommendation 3 was added and the WG accepted the Recommendation 3 as written in Appendix C.

***Discussion:*** The WG was in agreement that a subcommittee should be established in conjunction with all stakeholders to decide research goals and objectives. The committee would identify the research needs, commitments, long-term monitoring and recommendations needed for research areas. The WG altered the wording accordingly and approved the recommendation.

***Issue 4:*** **Recommendation 4**
While discussing Recommendation 3, WG members decided that items identified by the WG should guide the research steering committee. Recommendation 4 was added as written in Appendix D, to be completed by the WG at a later date.

> ***Discussion:*** The WG decided that it could anticipate potential research needs for the SBNMS and add them as guidelines for the recommended research subcommittee. These guidelines should be established to provide direction to the subcommittee based on items identified by the assembled expertise of the WG.

**NEW BUSINESS**

**Remaining Action Plans**
The WG decided that due to time constraints for the creation of Action Plans, a straw-man recommendation on biomass removal should be created for the next meeting. Chris Glass, Jud Crawford, and Dave Wiley will draft a straw-man recommendation for biomass removal. For pollution recommendations, a panel of experts will be assembled for the next meeting. The WG decided that wind farm options will be added to the Cables Action Plan. The WG also decided that for the final meeting of the WG, ocean dumping/marine debris and dredge disposal recommendations will be considered.

**Bycatch Reduction Methods**
Due to time constraints, the presentation on bycatch reduction techniques by Chris Glass was rescheduled. This presentation will be given at the next meeting.

**Next Meeting**
The next meeting of the EA WG is set for May 24, 2004, at the Manomet Center for Conservation Sciences in Manomet, MA.

**FINAL COMMENTS**

Meeting adjourned at 6:00 pm.

## Appendix A

Additions are marked in **BLUE**
Deletions are marked in ~~**RED**~~

**Recommendation 1:** The Sanctuary should work with the New England Fishery Management Council (NEFMC) **and other appropriate agencies and stakeholders** to set aside an area(s) ~~**indefinitely from mobile fishing**~~ within SBNMS that allows for research on **topics including** habitat recovery, biological succession and community ecology. **These area(s) should be set aside for a period that is identified by the research needs, commitments, long-term monitoring and recommendations as identified by a Sanctuary research committee.**

The area**(s)** should **be** ~~**comprise an equitable inclusion**~~ **representative** of habitat types and depths ~~representative of~~ **within** the Sanctuary. ~~**The area could simultaneously serve as a Habitat Area of Particular Concern (HAPC) pursuant to NEFMC designation.**~~ The area should be located to the greatest extent feasible within the existing Western Gulf of Maine (WGOM) ~~**Closure**~~ **Habitat Closed** Area, where it overlaps **the** SBNMS and **thus** would not increase the total area already ~~**closed**~~ **restricted** to fishing by the WGOM ~~**Closure**~~ **Habitat Closed** Area **where it overlaps the SBNMS (i.e., "The Sliver").** Any additional area closed to fishing within the SBNMS in the exercise of this action would be compensated for by a reduction of ~~**equal**~~ **comparable** area elsewhere in the WGOM ~~**Closure**~~ **Habitat Closed** Area **or other area and/or measure**.

**For a fixed period, as identified by the research need, with renewable potential from 1) mobile fishing; 2) human impact**

## Appendix B

Additions are marked in **BLUE**
Deletions are marked in ~~**RED**~~

**Recommendation 2: The SBNMS should investigate areas within its borders to recommend to the Council as Habitat Areas of Particular Concern (HAPC) pursuant to NEFMC designation.**

## Appendix C

Additions are marked in **BLUE**
Deletions are marked in ~~**RED**~~

**Recommendation 3: We recommend that the SBNMS establish a research steering committee as a standing subcommittee of the SAC that will be charged with specific activities or goals to address issues pertinent to the SBNMS including those raised during scoping as well as issues pertinent to the Councils. The research steering subcommittee should be comprised of approximately 10 members from SBNMS staff, NEFMC research steering committee, academics, fishing industry, recreational fishing, and conservation organizations.**

## Appendix D

Additions are marked in **BLUE**
Deletions are marked in ~~**RED**~~

**Recommendation 4: We recommend that the research steering committee….**

*Gerry E. Studds* **Stellwagen Bank National Marine Sanctuary**
Management Plan Review

**Ecosystem Alteration Working Group – Draft Agenda**

**Date**: 27 April 2004
**Location**: New England Aquarium, Boston MA –Education Center

| TIME | TOPICS AND OBJECTIVES |
|---|---|
| 8:00-8:15 | Welcome, Adoption of Agenda and Minutes from last meetings. Porter Hoagland |
| 8:15-8:30 | Review: Action Items Porter Hoagland |
| 08:30-9:00 | Report on the Seafloor Habitat Recovery Monitoring Program at SBNMS; James Lindholm Pfleger Institute |
| 9:00-9:15 | Questions |
| 9:15-9:45 | Peter Auster, National Undersea Research Center |
| 9:45-10:00 | Questions |
| | |
| 10:15-10:30 | **BREAK** |
| 10:30-12:00 | Recommendations and Option for the SAC |
| 12:00-12:30 | **LUNCH** |
| 12:30-1:00 | Ecological Implications of Biomass Removal; Kathy Lang & Jason Link NMFS |
| 1:00-1:15 | Question |
| 1:15 – 1:45 | Biomass Removal and Bycatch Reduction; Chris Glass, Manomet Center for Conservation Sciences |
| 1:45 – 2:00 | **BREAK** |
| 2:00 – 5:30 | Discussion on recommendations to SAC & Action Plan Development |
| 5:30 – 6:00 | Next meeting plan |