SEDAR

Southeast Data, Assessment, and Review

SEDAR Episodic Events Workshop
for Gulf of Mexico Fisheries

November 13-15, 2012
New Orleans, LA

Workshop Summary Report

SEDAR
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1 Introduction

1.1 Workshop Time and Place

The Southeast Data, Assessment, and Review (SEDAR) Episodic Events Workshop for Gulf of Mexico Fisheries was held in New Orleans from November 13, 2012 at 1:00 PM to November 15, 2012 at 12:00 PM, Central Time.

1.2 Statement of Purpose

Many entities (federal, state agencies, private sources) supply funding for Gulf of Mexico research. A common requirement for receiving funds is that researchers must provide their data to a central parent database in a timely fashion (i.e. after a specified amount of time, project completion, or publication). In some cases researchers may contribute willingly to a parent database to make their data widely available to the public. Developing a better understanding of the utility of such databases will be beneficial in conducting stock assessments, and in attempting to identify the impacts of potentially significant episodic events. Colloquially defined as "non-fishing mortality above and beyond the baseline assumed natural mortality level", the formal definition and identification of episodic events in the Gulf of Mexico (like the *Deepwater Horizon* oil spill) will allow fisheries analysts and other scientists to separate identified non-fishing mortality from natural and fishing mortality to better understand the effect of an episodic event on the population abundance of a particular species or group of species.

1.3 Participants

Presenters

Name	***Affiliation***	***Name***	***Affiliation***
Steve Bortone	GMFMC	John Quinlan	NMFS
Jeff Rester	GSMFC	Donna Bellais	GSMFC
Russ Beard	NMFS	Dave Reed	FWC
Bob Muller	FWC	Sean Powers	DISL
Will Patterson	DISL	Read Hendon	GCRL
Adyan Rios	NMFS	Andrew Goodwillie	LDEO
Marcus Drymon	DISL		

Contributors and Observers

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1.4 Acronyms and Abbreviations

DISL	Dauphin Island Sea Lab, University of South Alabama
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute, FWC
GCRL	Gulf Coast Research Laboratory, University of Southern Mississippi
GMFMC	Gulf of Mexico Fishery Management Council
GSMFC	Gulf States Marine Fisheries Commission
LDEO	Lamont-Doherty Earth Observatory, Columbia University
LUMCON	Louisiana Universities Marine Consortium
MCCSC	Mary C. Christman Statistical Consulting
NMFS	National Marine Fisheries Service, National Oceanic and Atmospheric Administration
SEDAR	Southeast Data, Assessment, and Review
UW	University of Washington

2 Abstracts of Presentations

The following abstracts are contributions from presenters who shared their database knowledge, research, or other pertinent material to the workshop's participants. Abstracts are presented in the order in which their associated presentations were given. For additional information regarding research or data presented, please contact the corresponding author.

An Approach to Establishing Fish and Fisheries as In Situ Environmental Bioindicators of Natural Hazards

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Natural hazards and extreme events (hereafter termed “episodic events”), as environmental forcing factors, can have significant effects on the life history features of fish species and their associated fisheries. Exposure to these factors can result in changes to a variety of biological parameters that have spatial and temporal ramifications relative to the extent, degree, and duration of the event. Examination of a variety of life history features can enable researchers to ascertain the relative impacts that episodic events can have on the functionality of the ecosystem. Offered here is a ten-step process to identify, evaluate, and determine those biological attributes of fish and fisheries that allow an evaluation of the environmental impacts of episodic events. In summary, these steps help identify the biological features that are associated with various scales of response to episodic events with regard to broad time and space scales. In brief, the time (e.g., sec., min., days, years) and space (e.g., mm, m, km) units in orders of magnitude that are potentially impacted by specific episodic events should be identified. Subsequently, biological features should be rated relative to their response according to a range of time and space scales. Aligning these features (i.e., biological attributes and episodic events responses relative to time and space) will allow researchers the option to select biological attributes to investigate a full assessment of the range of time and space scales most likely to be encountered owing to an episodic event. Efficiency in sampling design can be gained by fostering broad-based monitoring of a few, but all encompassing, biological attributes associated with fisheries. This would enable a full assessment of the meaningful impact of such events.

The Value of Ecological Sampling in Response to Episodic Events

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Deepwater Horizon discussions should always lead with the acknowledgement that 11 people died. Seventeen were directly injured, and many, many thousands or millions were impacted in

the Gulf region and nationally. The region experienced everything from direct kills due to contaminants to closed areas that either shifted or eliminated fishing. The ecological implications must be viewed from the perspective that the northern Gulf of Mexico was subject to an ecosystem insult that was simply unprecedented. The ecosystem response to this challenge will be explored by academic, industry, and public interests for many years to come. However, management requires immediate action and the region must decide on how it will monitor, analyze, and manage the region's natural resources. This presentation indicates that information collected by 'resource surveys' is more than relevant to broader interests – including energy development. I suggest that inadequate data is costly with respect to time, uncertainty, and the kinds of questions that can be answered. Next generation surveys should carefully consider all the ways that the ecosystem is being exploited – including the potential for episodic events - and should construct effective, efficient survey protocols that address current needs, and those anticipated twenty to thirty years out. Living marine resource surveys such as SEAMAP supplied significant baseline data for assessing the impacts of the Deepwater Horizon episodic event, thus underscoring the fact that these surveys are valuable well beyond the stock assessment arena. Perhaps support for future surveys should be supported more broadly given the value to this broader set of end users.

Southeast Area Monitoring and Assessment Program

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The Southeast Area Monitoring and Assessment Program (SEAMAP) is a State/Federal/University program for collection, management, and dissemination of fishery-independent data and information in the southeastern United States. SEAMAP is a cooperative program whereby Texas, Louisiana, Mississippi, Alabama, Florida, and the National Marine Fisheries Service jointly plan and conduct surveys of economically significant fish and shellfish and the critical habitats that support them. The main goal of SEAMAP is to collect long term, standardized, fishery-independent data on the condition of regional living marine resources and their environment. SEAMAP has sponsored long-term (1982 to present) and standardized research vessel surveys that have become the very backbone of fisheries and habitat management in the Gulf of Mexico. The long-term dataset obtained through SEAMAP surveys provides the only region-wide mechanism for monitoring the status of populations and habitats. Through its cooperative nature, SEAMAP has the ability to sample the entire coastline from Florida through Texas during the same time period and describe the distribution and abundance of fish populations throughout their range in order to better evaluate the status of recreational and commercially utilized fish stocks. SEAMAP currently conducts a Winter, Spring, and Fall Plankton Survey; a Summer and Fall Shrimp/Groundfish Survey; a Vertical Line Survey; a Reef Fish Survey; and an Inshore Bottom Longline Survey.

Gulf Fisheries Information Network (GulfFIN)

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The GulfFIN is comprised of coordinated data collection activities of commercial and recreational data in the Gulf of Mexico, an integrated data management and retrieval system, and procedures for information dissemination. The GulfFIN Data Management System (DMS) is broken up into Commercial and Recreational Landings, with both non-confidential data which is available to the public and confidential data requiring permissions for access contained within each section. The GulfFIN "Commercial Landings" database stores Gulf landings data captured by state "Commercial Dealers", via the Trip Ticket Program, which are reported by state "Commercial Fishermen". The data used in the GulfFIN DMS for Recreational Catch, Harvest and Effort estimates are based on the National Marine Fisheries Service, Marine Recreational Fisheries Statistical Survey (MRFSS). Non-confidential data include yearly summary landings, marine recreational fishery catch and effort estimates, and biological samples. Yearly summary landings are comprised of Commercial Dealer Reports by YEAR, STATE, and SPECIES. Any data within this set deemed confidential has been modified wherein the totals have been removed and replaced with the wording "Confidential Data". Marine Recreational Fishery Catch and Effort Estimates consist of estimated numbers and pounds of sport fish caught and harvested, along with estimated numbers of angler trips from recreational fishing activity in the Gulf of Mexico and off the Atlantic Coast of Florida. Biological Samples include species related biological data from the Gulf States for both Commercial and Recreational landings. Confidential Data include monthly summary landings from Commercial Dealer Reports, State landings detailing all commercial landings data sent by each Gulf State, and subsets of each States commercial landings data.

The NOAA Gulf of Mexico Data Atlas- Digital Data Discovery

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Based on traditional atlases, the Gulf of Mexico Data Atlas website is a data discovery and access tool that allows users to browse a growing collection of datasets, visualized geospatially as map plates. The Atlas provides updated, long-term assessments of Gulf of Mexico ecosystems that indicate baseline conditions and assist restoration and monitoring efforts in the Gulf. The Gulf Atlas is a result of collaborations between over 30 federal, state, non-governmental, and academic partners who provide data and expertise. All geospatial data are accompanied by Federal Geospatial Data Committee (FGDC) and ISO standard metadata. Download links to the original data are also provided, allowing users to create their own products and analyses, and the ArcGIS Server supplies WMS, REST API, and KML formats, enabling use of the map layers in other platforms. These capabilities support federal agency goals as outlined in the FGDC's Geospatial Platform Modernization Roadmap and NOAA's Next Generation Strategic Plan.

A summary of the Gulf of Mexico GAME, GOMAPortal, and GRIIDC data management projects

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GAME

Spatial frameworks (the mechanics of studying a specific area) based on ecological characteristics, called ecoregions, are very powerful tools in environmental protection. Environmental resource managers have recognized the need for management approaches that are based on an ecosystem perspective. The Geospatial Assessment of Marine Ecosystems (GAME) is a project that aims to define and describe marine ecosystems to assist management of coastal and marine waters. The goals of the Gulf GAME project are to identify, inventory, and catalog existing data sets and information related to coastal and marine habitats of the Gulf of Mexico, both in U.S. and Mexican waters. This is in support of the Gulf of Mexico Alliance Governors' Action Plan. There are over 5,000 data set records contained in the GAME catalog.

GOMAportal.org

GOMAportal.org is a metadata catalog and data repository for Gulf of Mexico related geospatial datasets. Funded by the Gulf of Mexico Alliance (GOMA), GOMAportal.org houses the results of a multi-year project by the GOMA Ecosystems Integration and Assessment (EIA) Priority Issue Team (PIT) to improve the state metadata for geospatial datasets for the Gulf of Mexico. Lead by EIA PIT members at the Harte Research Institute for Gulf of Mexico Studies (HRI), EIA PIT state partners collected geospatial datasets and metadata records, and upgraded them to be compliant with the Federal Geospatial Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM) standard, preserving as much of the original character of the metadata as possible. Where possible, the original datasets were also obtained and renamed to have meaningful file names. Finally, available data were packaged with the upgraded metadata, and made available for download via FTP.

GRIIDC

The Gulf of Mexico Research Initiative Information and Data Cooperative (GRIIDC) is the vehicle by which the Gulf of Mexico Research Initiative (GoMRI) Administrative Unit is implementing the Research Database and will help to address the data and information needs of the GoMRI. The GRIIDC will serve the GoMRI by assisting researchers with data archiving and ensuring data interoperability among GoMRI and other datasets. The mission of the GRIIDC is to ensure a data and information legacy that promotes continual scientific discovery and public awareness of the Gulf of Mexico ecosystem. GRIIDC will be designed to receive and process data from various data sources and from various scientific disciplines. These include data from remote sensing activities, oceanographic and atmospheric observing stations, gliders or AUVs and research vessels, market and field research, laboratory and from mathematical modeling. As part of its effort to encourage data sharing, not only among its scientists but to all scientists and researchers interested on the data collected in the Gulf of Mexico, GRIIDC will maintain a registry of data sources used, collected and generated by GoMRI scientists. It will also have web services to allow for a direct access or machine-to-machine communication to it repository. Data providers will be given facilities to allow easy submission of data and corresponding metadata, and advanced query of the system. A catalog to present the data in the registry will also be developed to cater to the needs of the general public.

Evaluating Environmental Effects on Snook

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Both fishery independent and dependent standardized catch rates showed a major decline in 2001 and 2010 and could likely reflect the cold kills in those years. This raised the question of whether the effects of cold kills could be incorporated into the 2011 stock assessment. FWRI's Fishery Independent Monitoring program sets 183 m haul seines at randomly selected locations in Tampa Bay and Charlotte Harbor and these catch rates were standardized with generalized linear models using a binomial distribution for the proportion of positive trips and a gamma distribution for the number of snook caught on positive sets. Potential explanatory variables included year, month, and zone. Standardized catch rates were calculated for recreational intercepts from NMFS's Marine Recreational Fisheries Statistical Survey (MRFSS) and from Everglades National Park Creel Survey (NPS) in a similar manner. The generalized linear model approach with binomial and gamma distributions for the proportion positive and the total number of fish caught on a recreational trip was applied to both surveys. Potential explanatory variables for these catch rate analyses included year, month, area, number of anglers, hours fished, and avidity. When examining the catch rates for the different indices, it was noticed that in addition to 2001 and 2010, there was a decline in 2005 which was a year with a large red tide bloom. The Coastal Marine Assessment Network (C-MAN) has stations along Florida's Gulf coast, and the one at Venice Pier has reported hourly water temperature data beginning in 1986 through the present and Venice is located midway between Tampa Bay and Charlotte Harbor. Snook are sensitive to cold temperatures and sub-adult snook (265-380 mm TL) cease feeding at 14^{o}C and die at 9^{o}C. Therefore, the hourly temperatures were used to estimate the annual proportion of temperatures below 14^{o}C with a logistic regression. Two years stood out high proportions of cold water temperatures, 2001 and 2010. Similarly, several snook were killed in 2005 along Florida's Gulf coast and snook that were being monitored in Sarasota Bay with acoustic tags all died in July 2005 when red tide entered the bay. The Harmful Algal Bloom (HAB) monthly sampling data set also was analyzed with a logistic regression for the annual probability of cell counts exceeding the serious bloom threshold of 100,000 cells/liter. The years with high proportions of cell counts exceeding the threshold were 2001, 2005, and 2006. Because the snook assessment is for Florida's entire Gulf coast, proportion of snook in the impacted area was estimated using the acreage of mangrove as a proxy for the spatial distribution of snook along the coast and the area of red tide was taken as the area between Pinellas and Lee Counties or 47.2% of Florida's Gulf coast mangrove area. Ages of the fish killed by the events came from otoliths that were taken from fish samples from the 2005 red tide event and from the 2010 cold kill. The idea was to estimate the age-specific mortality using an environmental "fishery" in Age Structured Assessment Program version 2 from the National Marine Fisheries Service's Stock Assessment Toolbox and then add these environmental mortality rates to natural mortality. The environmental fishery was set up as a pulse fishery that operated in 2001, 2005, 2006, and 2010. This "fishery" had no landings because all of the fish were considered discards with 100% release mortality. The resulting model fit the indices better than the base model and fit the fisheries the same as the base model. The model fit 2001 and 2010 of the environmental fishery very closely but slightly underestimated the number of fish killed in 2005 and 2006. Because the directed fishery catches remained the same, with the extra mortality, the population sizes were smaller and so including the environmental effects in the population model raised the fishing mortality rates and reduced the spawning biomass by approximately 20% in 2010. The management goal for snook is to maintain the transitional spawning potential ratio (tSPR) at or above 40% and the inclusion of the environmental effects increased the variability in the tSPR and raised the values because including extra natural mortality lowered the unfished spawning biomass per recruit.

Responding to Episodic Events: the Value of Time Series Data

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A multi-gear, fishery-independent survey was initiated in 2010 to monitor populations of commercially important reef fish and apex predators in Alabama's artificial reef permit zone. Data from the trawl, vertical longline and bottom line surveys were used to examine the impacts of episodic events on red snapper (*Lutjanus campechanus*). In addition, data from the bottom longline were used to examine changes in catch characteristics for tiger shark (*Galeocerdo cuvier*). Fishes from the trawl, vertical longline, and bottom longline surveys were sampled following standard SEAMAP protocols for each gear type. Catch from the trawl was dominated by sparids and sciaenids, yet also contained red snapper. Red snapper CPUE (fish/minute/trawl) was higher in 2010 and 2012 compared to 2011, ranging from 0.5 in spring 2010 to 0.02 in spring 2011. Vertical longline gear was more efficient at sampling red snapper, where the species composed greater than 85% of the catch during 2010 and 2011; however, catch trends for vertical longline were less clear than those observed for the trawl. No clear interannual pattern in CPUE was observed, with highest values seen in Spring 2010, Summer 2011 and Fall 2011 (~0.4 fish/hook/soak). Lowest values were seen in Spring 2011 (0.18 fish/hook/soak). Age composition from vertical longline gear indicated red snapper mean age increased from 3.5 y (n=558) in 2010 to 4.7 y in 2011 (n=445). Catch data for red snapper from the bottom longline showed a pattern different from those identified by trawl or vertical longline. Red snapper CPUE was uniformly low in 2010 (less than 1 fish/100 hooks/soak) and showed a seasonal pattern of increased abundance in 2011 (4.0, 2.0 and 0.5 fish/100 hooks/soak in spring, summer and fall, respectively). This trend continued in 2012, with red snapper CPUE calculated at 7.0 and 6.0 fish/100 hooks/soak in the spring and summer, respectively. Age composition from bottom longline sampled red snapper showed a pattern similar to that seen in the vertical longline. Mean age was 6.5 y (n=48) in 2010, 6.1 y (n=39) in 2011 and 8.3 y (n=96) in 2012. Catch data from the bottom longline also demonstrated higher CPUE (fish/100 hooks/soak) and smaller mean size for tiger sharks in 2010 relative to 2009 and 2011. While primarily used for stock assessments, fishery-independent time series data are a critical tool for evaluating the effects of episodic events on fishery resources.

Shifts in Reef Fish Community and Trophic Structure Following the Deepwater Horizon Oil Spill

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Northern Gulf of Mexico (longitude 86.6^{o}W to 88.4^{o}W) natural reefs (n=16) were studied between May 2009 and Aug 2012. Fish communities were sampled with an ROV and fish were collected to examine growth and trophic ecology. Liver and bile were sampled following the Deepwater Horizon Oil Spill (DHOS) to assess exposure to polycyclic aromatic hydrocarbons (PAHs). Fish community shifts occurred as early as summer 2010, with the greatest effect occurring in small demersal planktivores, many of which declined by 100% following the DHOS. Large fishes (e.g., snappers, jacks, and triggerfish) also declined. Trophic shifts within communities included declines in demersal planktivores and piscivores but increases in pelagic planktivores. Muscle stable isotope ratios indicated a shift toward more benthic versus pelagic prey sources in several species. High liver PAH concentrations were rich in alkyl homologs, thus indicating a petrogenic source. Presence of PAHs and induction of enzymes that catabolize PAHs indicate community structure and trophic shifts were most likely due to toxicological effects of the DHOS.

An Overview of Gulf Coast Research Laboratory Sampling Programs Applicable to Identifying Episodic Events in the North-Central Gulf of Mexico

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The University of Southern Mississippi's Gulf Coast Research Laboratory (GCRL) is a research and education institution that focuses largely on the marine and coastal resources of Mississippi and the Gulf of Mexico (Gulf). Many of the long-term and ongoing scientific studies conducted at the GCRL provide critical baseline data for identifying, and often quantifying, episodic events that may impact managed fish stocks. For instance, cooperative fishery-independent monitoring programs such as the Southeast Area Monitoring and Assessment Program, Inter-Jurisdictional Fisheries Assessment and Monitoring, and Mississippi Coastal Sport Fish Studies, continually collect biological catch data and associated environmental metrics. Those databases allow for detection of changes in a system, such as hypoxia events caused by freshwater diversions that can affect fish and invertebrate distribution or abundance. Marine pathogens (*Vibrio* sp.) are also monitored on a local scale to identify bacterial abundance, seasonality, and environmental correlates from water column, bottom sediment, and oyster tissue samples. Similarly, phytoplankton community structure is monitored in state waters to assist in detecting harmful algal blooms (HABs) and establish baseline data for non-bloom conditions. Those datasets can facilitate the detection of episodic events that may impact exploited fishery stocks and could result in seafood safety advisories and/or fishery closures. Contrary to the aforementioned phenomena that may each be sources of non-fishing mortality, potentially beneficial episodic events may also occur. Recent GCRL research has documented that pelagic *Sargassum* is a vital nursery habitat for more than 150 fish species, some of which are federally managed. Periods of high abundance of this alga could result in enhanced larval and juvenile survival for some fish species, which may in turn promote increased recruitment to their respective fisheries. While GCRL research varies on spatial, temporal, and even taxonomic scales, these surveys provide beneficial data on general baseline trends and may serve as a template for future expanded research efforts to better detect and quantify episodic events and the subsequent effects, positive or negative, on exploited stocks.

Effects of Hurricanes and Other Severe Weather Events on Fish and Fisheries in the Florida Keys

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Severe weather events frequently affect important marine fish stocks and fisheries along the United States Atlantic and Gulf of Mexico coasts. However, the effects of these events on fish and fisheries are not well understood. The availability of self-reported data from two fisheries in a region frequently affected by tropical cyclones provided a unique opportunity to investigate short-term responses to past events. This study involved selecting severe weather events, calculating changes in effort and catch-per-unit- effort (CPUE), and analyzing those changes across various temporal, spatial, and species-specific scenarios. Responses in each variable were analyzed within and across scenario factors and explored for correlations and linear multivariate relationships with hypothesized explanatory variables. A negative overall directional change was identified for logbook fishing effort. Based on both correlations and linear models, changes in logbook fishing effort were inversely related to changes in average maximum wind speed.

Severe weather events are more likely to affect fishing effort than catch rates of reef-fish species. However, lack of responses in CPUE may also relate to the ability of this study to detect changes. The temporal and spatial scales analyzed in this study may not have been adequate for identifying changes in effort for the headboat fishery, or in CPUE for either fishery. Although there was no region-wide response in CPUE associated with severe weather events, further research on this topic is necessary to determine if storm-induced changes in fishery data are likely strong, long-lasting, or widespread enough to influence the outcome of stock-wide assessments.

GeoMapApp and Its Utility in Fisheries Science

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GeoMapApp (www.geomapapp.org) is a free map-based data exploration and visualization application developed by Columbia University. Hundreds of built-in data sets and maps spanning a wide range of geoscience topics are displayed in their geospatial context. The multi-resolution base map includes the 10m USGS NED land elevation data set and a large number of cleaned multibeam swath bathymetry files and coastal grids. User-generated data can be imported in a variety of formats - data tables and spreadsheets, shapefiles, grids, images - and manipulated using the full spectrum of GeoMapApp functionality. Short YouTube video tutorials are available.

3 Defining Episodic Events

3.1 Introduction

Prior to this workshop, an "episodic event" was informally defined as "non-fishing mortality above and beyond the baseline assumed natural mortality level." In order to formally define and identify episodic events in the Gulf of Mexico, participants were asked to discuss appropriate criteria for labeling an episodic event, as well as data necessary to appropriately identify such an event.

Discussions began with a focus on aspects of stock assessment models that would be most likely to reflect the occurrence of some unforeseen or abnormal phenomenon. The appropriateness of examining model parameters such as natural mortality, fishing mortality, growth, reproduction, movement, recruitment patterns, and others were discussed. A variety of necessary data were identified, including:

- Aging data before and after the event (k, L_{inf}, t_0), largely to determine the selectivity of affected ages
- Estimates of M by age
- Selectivity of individuals to the event based on quantifiable variables such as age, sex, diet, geographic location, and season; and qualitative variables such as population health before the event
- Changes in catchability over time, with the time period analyzed including periods before, during, and after the event
- Fecundity and recruitment deviations to which multiple vectors/time blocking can be applied to tease apart the event from the rest of the time series

Attention was subsequently directed to the vulnerability of an organism to an episodic event in a given habitat at a given life stage. This point led to consideration of the spatial scale of an event. Participants determined that a localized phenomenon without a population-wide impact may not necessarily be considered for stock assessment purposes, unless the phenomenon had the potential to have a very large-scale effect (i.e., red tide off the west coast of FL, with respect to the gag and red grouper populations). This determination is critical for utilizing episodic event data in stock assessments. Participants acknowledged that such an event would likely not only impact vulnerable species within the geographic range of such an event, but local habitats as well. An episodic event could cause cascading effects through a population resulting from this impact to affected habitat, perhaps also affecting resident species which otherwise would not have been vulnerable. If some portion of the available habitat is lost as a result of an event, then it could be reasonably expected that carrying capacity may decrease on spatial and/or temporal scales with a corresponding increase in catchability.

Analyses conducted to identify episodic events must be quantifiable, testable, defensible, and repeatable, with probable cause necessary for pursuit of inclusion of data in stock assessment models. The consensus of participants was that the burden for the identification of episodic events needs to be placed on the Data Workshop of SEDAR stock assessments.

As a result of these debates, the workshop's definition of an "episodic event" evolved:

"Non-fishing mortality above and beyond the baseline assumed natural mortality level."

"An episodic event is not caused by a management action- it is an irregular, unpredictable, infrequently occurring event that causes a substantial and punctuated change in our perception of what is normal, that can cause an acute or chronic change."

"An event whose effects are beyond normal variation and are not accounted for in the model."

Throughout discussions, several themes were reiterated with respect to identifying an episodic event, including:

- Episodic events occur periodically, yet inevitably
- Anthropogenic influences (i.e., fisheries closures, oil spills), in addition to natural events, may cause episodic events
- Spatial characterization and magnitude of an episodic event is paramount, with an emphasis on high-resolution spatial data coupled to fisheries-independent monitoring and survey data in order to define the significance of an event
- Modeled variables such as natural mortality, recruitment, growth, and reproduction may be candidates for further analysis when conducting model testing for potential population-level impacts of an episodic event

3.2 Tools for Identifying and Defining an Episodic Event

Workshop participants identified two classes of tools for identifying and defining an episodic event. Empirical tools are needed to properly identify and collect data in a standardized and broadly applicable manner. Modeling tools would subsequently be needed to accurately establish relationships between data sources to determine the existence and impact of an episodic event.

Several existing database and data management tools were identified that participants thought would prove useful in identifying episodic events:

- The Environmental Surveillance Network (http://testing2.ncddc.noaa.gov/esn_site/) allows individuals to report events to a searchable database, which also provides relevant ecological sampling data such as fish kills, temperature, conductivity, and more, based on a defined geographic area. Data are provided from both federal and state resources.

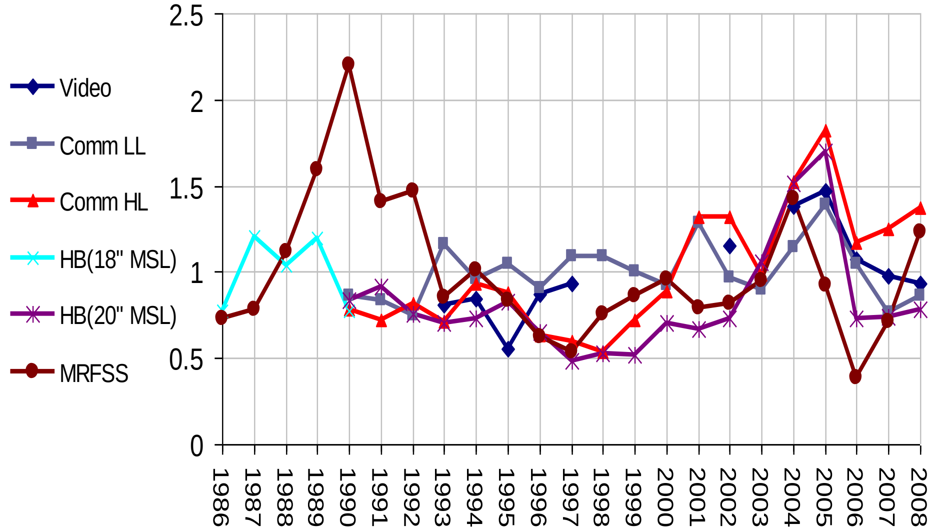
- The National Data Buoy Center (http://www.ndbc.noaa.gov/) was recommended for assessing environmental variability of physical oceanographic variables within a particular system, as they may relate to an episodic event.
- The National Oceanographic Data Center (http://www.nodc.noaa.gov/) serves as a permanent repository for the world's physical, geological, biological, and chemical oceanographic data, which are provided to the scientific community and the public as a searchable database.
- The GeoMapApp (http://www.geomapapp.org/) administered by the Lamont-Doherty Earth Observatory at Columbia University serves as an open-access data repository and data-mining program capable of combining multiple data sets from various sources (federal, state, academic, international) into high-resolution maps.

4 Case Study: Gulf of Mexico Gag and Red Grouper and Red Tide

4.1 Introduction to the Case Study

This case study documented how the 2009 gag and red grouper update stock assessments dealt with an episodic event. In 2009, assessments of gag and red grouper were conducted by staff members of the NOAA Southeast Fisheries Science Center (SEDAR 2009a, 2009b). These assessments indicated a severe decline in all indices of abundance between 2005 and 2006 (Figure 1). This caused models to fit poorly and to fail to recreate historical population patterns (Figure 2). During 2005 there was a severe and prolonged red tide event which led to numerous fish kill reports, beach closures, and documented mortality of reef fish (http://myfwc.com/research/redtide/archive/historical-events/offshore-red-tide-associated-mortalities/).

a. Red Grouper Indices:



b. Gag Indices

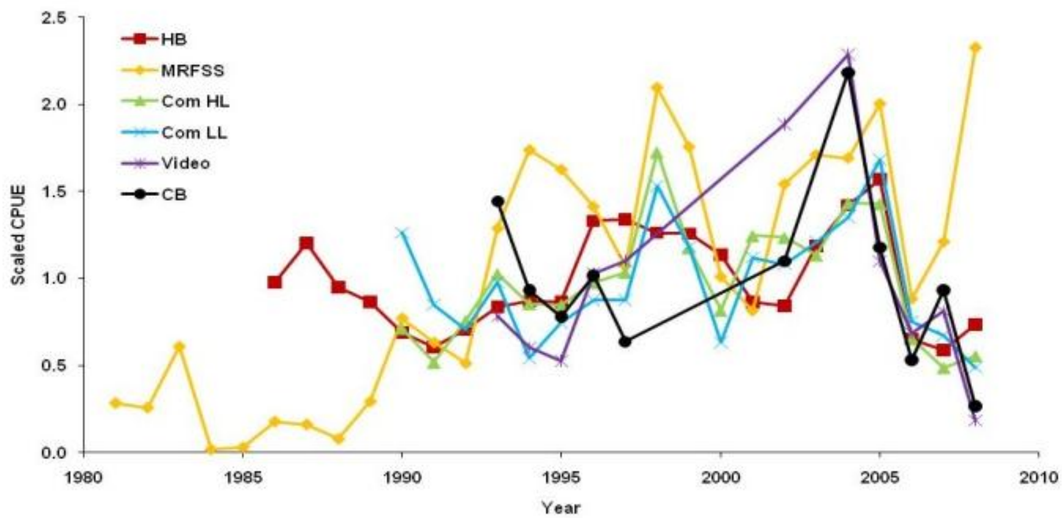
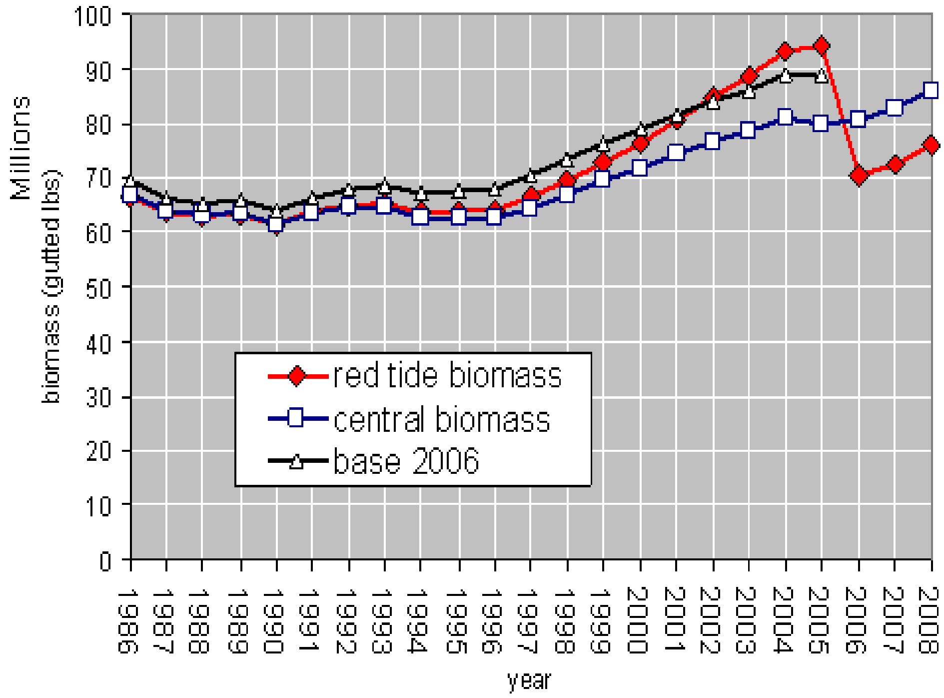


Figure 1. CPUE Indices used in the 2009 red grouper (a) and gag (b) assessments. Video is a scientific camera survey, Comm LL and HL are commercial longline and handline indices, HB is the headboat fishery, and MRFSS is the Marine Recreational Fisheries Statistics Survey.

a. Red Grouper:



b. Gag:

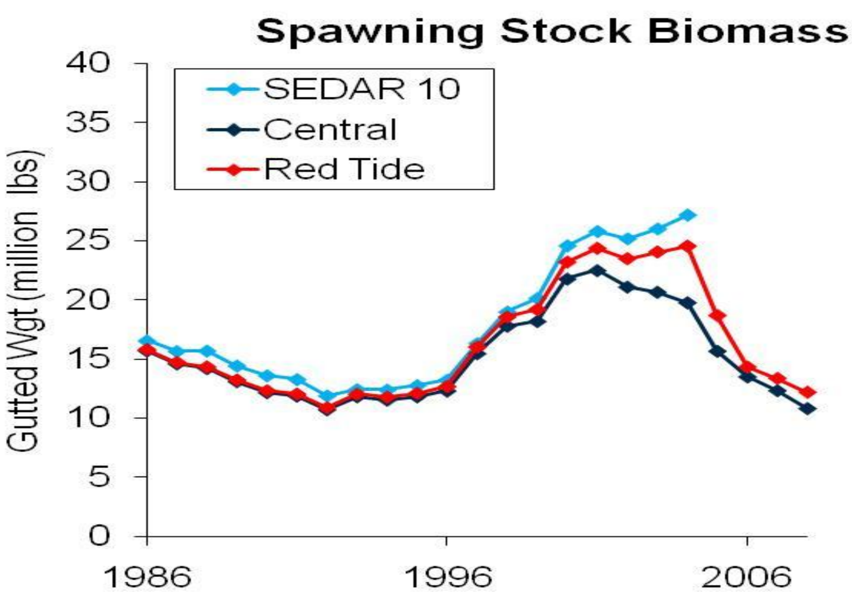


Figure 2. Biomass trajectories from three model runs for red (a) and gag (b) grouper. Base 2006 (or SEDAR 10 model) are the previous models, central are runs without red tide M, and the red tide runs incorporate additional M in 2005. Note that departure of the central models from the 2006 and SEDAR 10 are indicative of the failing to match the 2006 results.

In response to the lack of fit and a desire to incorporate the potential for red tide related mortality, an additional natural mortality term was estimated for 2005. Including the extra natural mortality parameter improved fits to the indices and the resulting M was 0.32 y^{-1} and 0.27 y^{-1} for red and gag grouper, respectively. As the baseline M for the two species was approximately 0.14 y^{-1} and 0.15 y^{-1}, the episodic M estimates for 2005 were twice the baseline M and approximately equal to the sum of natural and target fishing mortality rates. These translated to an estimated 21% and 18% of the population having died as a result of some event in 2005. The Gulf of Mexico Fishery Management Council's Scientific and Statistical Committee accepted the results of both assessments with the additional red tide mortality term as the basis for management advice.

4.2 Development of Indices of Red Tide and Incorporation into Models

Developing the red tide indices for gag and red grouper provided a short-term solution for incorporating the effects of red tide in each update assessment, but did not provide a long-term basis for dealing with these events in the future. To do so requires the development of an index of the environmental factor to determine whether a given year is an outlier in severity versus other years, and to include the data as an index within the assessment model. The goal of this project was to develop an index of red tide severity using FWRI water monitoring data and satellite oceanographic data. FWRI water monitoring data consists of more than 50,000 records of red tide concentration measured over the course of 50+ years. Much of the data are "event-response", in that they are collected during bloom events to characterize the extent of the blooms and as such do not provide an unbiased quantitative measure of red tide severity over time.

To create an unbiased index, we developed a model to predict red tide presence or absence as a function of multiple satellite data products. We then used this model to predict the probability of red tide in space and time for the years 1998-2010 where satellite information was available. Different spatial and temporal partitions of the data then allow one to create multiple indices that apply to different areas and times which will then be tested within the grouper stock assessment models, with the goal of having a best-fitting index of red tide severity for use in the 2013 gag stock assessment (SEDAR 33: sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=33).

4.3 Modeling and Accounting for Episodic Events in Assessment Models

There are several means to account for an episodic event in assessment models. The following list is not exhaustive but represents several possible options if the event has caused mortality:

4.3.1 Direct subtraction

If it is possible to estimate the number or biomass of animals killed by an event, then they can be simply subtracted from the population in a manner similar to landings. It is useful to have an idea of the selectivity of the event (i.e., did the event kill old or young fish, etc). Collection of an unbiased age and size composition during fish kills would allow selectivity to be estimated. Alternatively, it may be possible to use proxies to determine the number of animals killed, and then remove them from the modeled population similar to the FWRI snook stock assessment (Muller 2012, pers. comm.).

4.3.2 Single year estimation of episodic mortality

This is the method applied for the gag and red grouper update assessments, where a single extra parameter ($M_{episodic}$) was estimated in the stock assessment model for a single year. This method was useful as a one-off approach, but is problematic when there may be several episodic events or when it may be difficult to determine whether to allow estimation of this parameter, as it can potentially be confounded with estimation of fishing mortality.

4.3.3 Incorporation of an index of an environmental factor

This is the method that is most preferred for incorporating episodic events and requires that a quantitative index of the event be developed, and ideally an annual variance estimate of that index as well. The index would then trend up or down indicating the severity of the event and informing the model as to how much influence it should have. The methodology of incorporating episodic events is synonymous with incorporating covariates into assessments (Maunder and Watters 2003).

First it needs to be determined to which model parameter the episodic event is linked. Usually it will be natural mortality, but it could be another factor such as recruitment deviations. Then a decision must be made as to whether the event is additive or multiplicative. With regards to M, an additive factor could simply increase the base natural mortality, while modeling the factor as multiplicative means that it could increase or decrease the base M. Then, if the index has no associated variance, it can be incorporated within the model as a scaling factor similar to how CASAL (Bull et al. 2005) models disease mortality and how the ‘model’ method of stock synthesis 3 (SS3) incorporates environmental factors (Methot 2000, Schirripa et al. 2009). These methods do not allow for the variance of the index to be considered and are problematic if the index is highly uncertain.

A second method, the ‘data’ method in SS3 (Schirripa et al. 2009), incorporates an environmental index and its variance and by allowing them to be fit by the model. This method may be preferable, particularly when any environmental index is not known with certainty.

5 Application of Data to Assessment Models

5.1 Introduction

Workshop participants were asked to discuss how to apply data to stock assessment models. Consideration was given both to data which are currently available and data which are anticipated to become available in the future. The resulting framework outlines the product of the discussion and provides an applicable methodology for attempting to assess episodic events.

5.2 Data Integration Framework

1. Has an Episodic Event occurred?
    a. Do multiple lines of evidence for the Event exist?
        i. Anecdotal evidence
        ii. Empirical evidence
    b. Is there sufficient empirical evidence to estimate the magnitude of the Event (e.g., dead fish, mammals, etc)?
2. Is the Event likely to have had population-level impacts?
    a. What is the spatio-temporal scale of the Event (see Bortone 2008)?
    b. What model/biological parameter is likely to have been affected (e.g., growth, recruitment, natural mortality, selectivity, catchability, etc)?
        i. Is the Event likely to affect all ages or specific ages, all areas or localized?
    c. Quantify 'normal' variation in the Event with a time series or proxy for the Event. Which specific Event(s) in the time series is an outlier?
    d. Is the Event likely to have a trend (e.g., effect on steepness or carrying capacity)?
    e. Does our current assessment model already account for the event? For example:
        i. Our models would already account for reduced landings due to a closure
        ii. Does our current estimate of M already account for event?
3. Can the effect of the Event be modeled in plausible ways?
    a. Choice of an appropriate assessment model(s) to use will depend on what parameters/biological processes are affected by the event (see Step 2b) and by what environmental data are available to model the event.
        i. Can the candidate assessment model incorporate environmental covariates, or be coded to incorporate them?
        ii. Do uncertainty estimates for the environmental covariate exist, and if so can the candidate assessment model incorporate those uncertainty estimates?
    b. Hypothesis testing
        i. H_0 = no event
        ii. Test within assessment model

iii. What happens when H_0 cannot be tested or fail to reject (i.e., we know something big happened but the data do not support it at this time)? If an external estimate of the Event effect is available, then the effect can be "forced" in the assessment model.

4. Does modeling the Event change management advice? If yes, then:
    a. Calculate periodicity/probability/duration/severity of Event effects
    b. Incorporate Event effects into future projections
        i. Short vs. long term projections depending on duration of the effect
    c. Include Event effects in benchmark calculations
    d. Determine need for sensitivity analyses of projections/benchmarks to different levels of Event effects

5.3 Additional Data Needs

In addition to the Data Integration Framework, the additional data needs pertinent to the integration of information appropriate for assessing episodic events were identified:

- Better spatial information on commercial and recreational self-reported fishery data
- Habitat distribution data
    - Would determine cell sizes for spatial information
    - Could use Vessel Monitoring System data to identify hot spots, as first cut
    - Could go to Advisory Panels to get information from stakeholders
    - Data exist with respect to where fish are generally located (or where fishing occurs), but can't account for year-to-year changes in distribution
- Spatial information on where fish are found
- Size/age composition of fish kills
- Maximize fishery-independent sampling (e.g., stomach contents, tissue samples)
    - No fish should be wasted: collect all possible data from every fish caught
    - Because surveys are broad, they often are inefficient for any single given species
- Data needs from *Deepwater Horizon*:
    - Fine-scale spatial information
    - Changes in catchability
    - Condition information/indicators
    - Stomach content
    - Disease incidence before/after
    - Prey base information
    - Stable isotopes
    - Oceanographic data
    - Evaluation of surveys and their ability to answer these questions
    - Examination of how to improve our surveys

6 Research Recommendations

- Create a survey sampling matrix that can be completed by multiple partners (state, academic), with each partner focusing on particular aspects of the matrix to build the layers of baseline data needed to assess the effects of an event

- Begin improving data collection by utilizing existing infrastructure to ensure that no sample is wasted through collecting all possible data from each retrieved sample

- Development of high-resolution sampling strategies to capture fine-scale changes in ecosystems as a result of an episodic event

- When SEDAR stock assessments are announced, each participating Fishery Management Council's Scientific and Statistical Committee can begin identifying potential episodic events to be considered by the SEDAR process for each respective species being assessed

- Potential episodic events should be identified as soon as possible (i.e., ideally a year in advance of the assessment), because event-related data must be compiled and assessment models often must be modified to accommodate the event

- Sampling programs should set aside a small portion of their overall budgets for "emergency sea days" to provide sampling teams the capability of responding to episodic events as they occur, as opposed to having an event occur and being forced to wait until funds for sampling become available

- Development of detailed bathymetric data, coupled with knowledge of sediment composition, will allow resource managers to match areas affected by an episodic event with the species likely to utilize local habitats, thereby better characterizing potential impacts to flora and fauna

- The establishment of a single central data hub was not accepted as viable by workshop participants; instead, improved collaboration and communication between existing databases, their managers, and data providers was proposed to facilitate optimal data dissemination between user groups

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