Comments
Draft HAP 7-24-07
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First, some comments about issues raised in the Public Contact session of 8-4-07

There was an issue raised concerning: how can we reduce hypoxia if there continues to be high or higher discharge. The example was given of the area off the Brazos River. That high flow was a 100 year record (or record for period of recordings). It is not expected every year. There has been hypoxia off the upper Texas coast over the years that is related to the Atchafalaya River plume. An answer to the what if high discharge continues and nutrients are reduced will we still have hypoxia? The paleo records show that the discharge has been high in the past and there has been no hypoxia. In fact, there was tremendous discharge of the Miss River over the prior 100 years and there was no hypoxia. Justić's work and others also shows that the flux increase is 80% increased concentration and 20% increased discharge. Climate change is also predicted to create more and more intense hurricanes in the Gulf. This would mix the water column,--a 'solution.'

I will do some line by line suggested changes or make comments

P 10, l 17, add….or about 30% saturation in the northern Gulf of Mexico
P 10, l 21, change maximum to 22,000 km^2
P 10, l 23, there is inconsistency in capitalizing Northern or northern. I think the northern is better
P 10, l 27, ….temperature and salinity induced …. Change from density. Density is a result of temperature and salinity

P 11, l 10, …continental shelf for much of the year.
P 11, l 18-19, Osterman is not the only reference. The Rabalais et al. Ecol Appl summarizes many of these ideas.
P 11, l 22 …..nutrient loads (needs a reference). See above.
P 11, l 24-25, …there can be modeling exercises that can tease the components to some degree.

P 12, l 8, the EPA was not necessarily the establisher of the Task Force. It was a joint push by NOAA, Don Scavia, and EPA, Chuck Fox that pulled this together. Funding came from multiple agencies to fund the integrated assessment and the meetings, but I think the bulk at that time was NOAA.
P 12, l 15, should be 'inter-agency' if considering several
P 12, l 24 …six peer-reviewed reports
P 12, l 25 …These included characterization

P 13, l 20, the Task Force may have recognized the need to…. But, the Action Plan had a definite 5-yr reassessment of the goals, progress, and status to work back into the adaptive management process.
P 13, l 21, ….*Action Plan*, including more recent science…
P 13, l 22, change semi-colons to commas

P 16, l 33-34, delete double 'that'
P 16, l 40-41, suggest ….in one part of a system would be reflected on the interrelationships…

P 17, l 17, ….management of hypoxia in the northern Gulf of Mexico and nutrients within the MARB…. As written, says that there is hypoxia in the MARB.

P 18, l 10, The new revised annual average (that includes the 2007 estimated size) is 13,500 km^2. This went up over the prior long-term average.
P 18, l 11, …westward well into Texas coastal waters
P 18, l 13, ….coastal regions with buoyant river plumes and includes…
P 18, l 15, ….temperature in summer, sustained winds from frontal….
P 18, l 17, … the Dimarco et al. (2006) is just a manuscript
P 18, l 19, …since the release…the extent of hypoxia has averaged 16,500….[this is now a 7-year average, including 2001 through 2007
P 18, l 20, here you have the correct estimated maximal size 22,000 km^2
P 18, l 29, .it would be good to list the URL for the IA and the 6 reports again here
P 18, l 38-39, ….widespread hypoxia was first documented on a systematic basis beginning in the mid-1980s. [There were some surveys that documented some larger extent areas, although smaller than current ore even 1985 areas, but there were some data prior to the beginning of the systematic mapping in 1985.
P 18, et seq. inconsistent use of 1980s versus 1980's. Preferred is 1980s
P 18, 43, …proxy studies, dating of cores, and the location of the cored sediments.

P 18 – P 19, l 1, ….need to be more specific than 'recent' …concomitant with increases in nutrient loading from the Mississippi River beginning in the 1960s that caused increasingly sever hypoxia on the shelf (ref would be good, suggest Turner and Rabalais 1994 Nature article and the Rabalais et al 2007 Ecol Appln article)

P 19, l 2 …The limited spatial distribution of reliably… [There is limited core data from the SW LA shelf, shelf break. The ability to get cores that can be dated is limited by the nature of the sedimentology of the continental shelf. I.e., we know enough about accretion to not waste time trying to get more cores from areas that they cannot be dated.
P 19, l 13, …sediment cores, primarily within the Louisiana bight, have provided.
P 19, l 24-26, this is an attack on these papers. However, the point of the paper is that the trends of increase are consistent over time and space.
P 19, l 35, [disagree, I would say that the variations in the sediment cores are quite consistent over space and time and consistent with nutrient load changes]

P 19, l 38, suggest add Rabalais et al. 2007 to these references. This review paper included the trend for *Quinqueloculina*, which shows presence before 1900 and no presence after that date. The original data were in Rabalais et al. 1996 *Estuaries*

P 19, relevant to include the PEB index, BUT the A-E index developed by Sen Gupta et al. (1996) has been verified by oxygen concentration values and applied to other hypoxic areas, e.g., Chesapeake Bay, Long Island Sound, and nearshore bathymetric low areas off Mississippi and Alabama. It is a travesty not to include his seminal work.

Sen Gupta, B. K., R. E. Turner and N. N. Rabalais. 1996. Seasonal oxygen depletion in continental-shelf waters of Louisiana: Historical record of benthic foraminifers. Geology 24(3): 227-230.

Other indices do not necessarily carry with them actual oxygen concentrations

P 20, key findings, see comments above about suitable sediment cores.

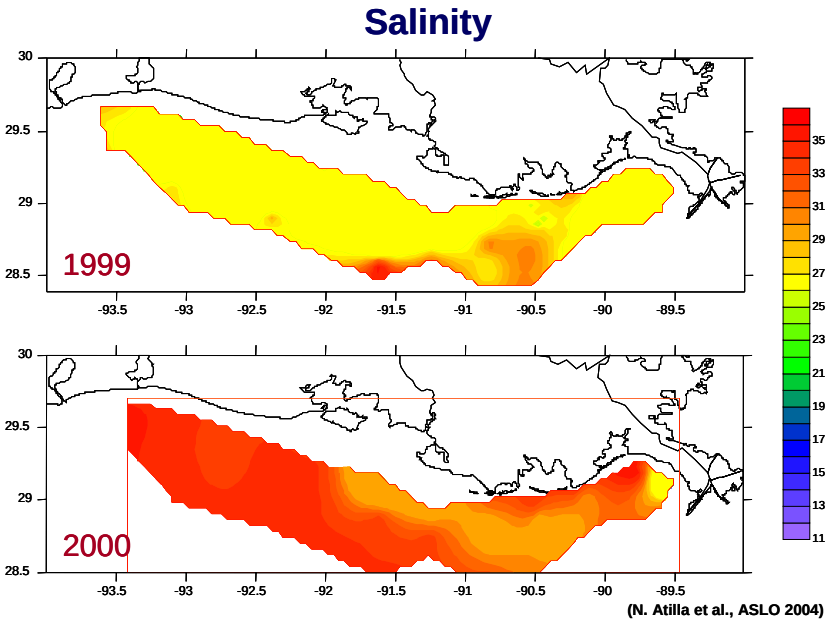
P 21, object to the term ..reliable…with regard to the chronologies. This is an attack on the many peer-reviewed papers that have all come to similar conclusions.

P 21, box, comments above on spatial distribution of 'datable' cores should modify this statement. Perhaps a study just to see what is 'datable' or not before going into the paleo indicators. Although this was certainly stated in Turner et al. 2004 Mar Pollut Bull

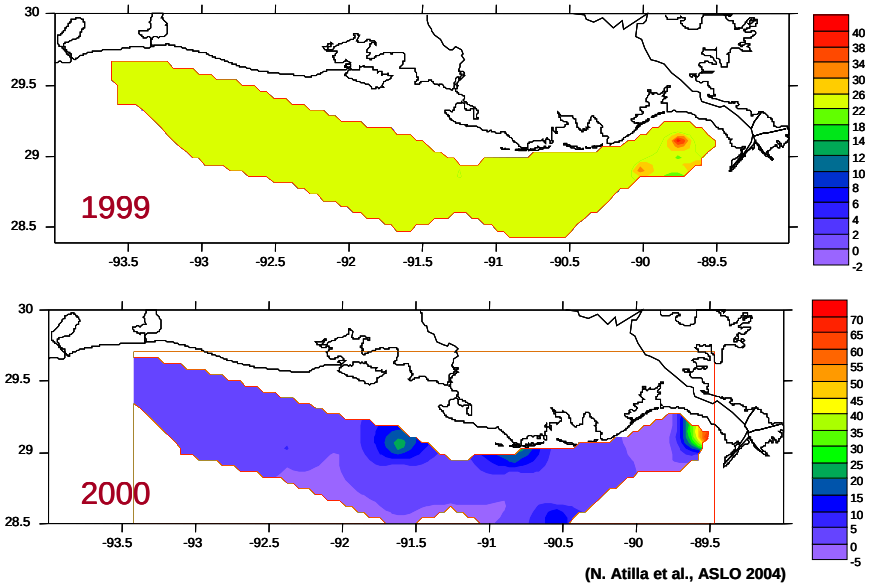
P 24, another factor is the increased flow of the whole MARB combined, but that increase in flow has occurred primarily in the fall months, which is a time least likely to lead to the formation of hypoxia. The data are in Bratkovich et al. 1994

P 25, et seq. The proper terminology for the "bird's foot" delta is 'birdfoot delta'

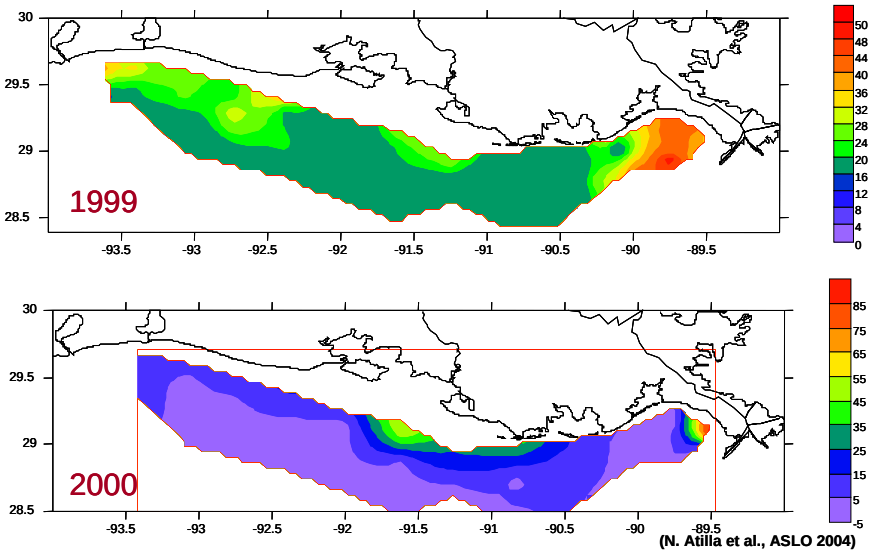
P 25, l 31-34, it is just not the salinity signal in surface waters, and the difference in density from surface to bottom, but also the nutrients in those plumes. For example, see figures below from a high flow year and a low flow year.



NO_3 Distribution in the Gulf (µmole L^{-1})



SiO_3 Distribution in the Gulf (µmole L^{-1})



P 25, l 31, this is not a major finding, already known and printed in peer-reviewed publications

P 25, l 34, …on stratification and nutrient delivery (Rabalais et al. 2002a)

P 25, end, it is unfortunate that the physical oceanography is so separated from the biological processes, because they go hand in hand.

P 26, fig 5 is modeled, suggest use real data such as that provided above

P 26, l 19, not just the EPA or the Task Force. Several agencies are considering how different outputs of the Miss R discharge would affect hypoxia. NOAA, USACoE, LaDNR.

P 27, l 21-22, there is no way that the Rowe and Chapman 2002 Commentary considered the Rhoads et al. 1985 conceptual diagram. They did not even cite it. Figure 7, NO longer represents the concepts in Rowe and Chapman. It appears to be a synthesis of several inputs of information, the Rhoads model and as stated later on p 28 information provided by Boesch. This was the problem with the Rowe and Chapman Commentary—it did not consider realistic options.

P 27 et seq. Zone 1 is NOT nutrient limited. There are very high nutrient concentrations in this zone. This zone is primarily light limited for phytoplankton growth.

P 28, l 5, zone 1 and nutrients are sufficient; very high…There are several publications (Lohrenz et al. and Rabalais et al., respectively) that show the peak in primary production and chlorophyll biomass in 15 to 25 psu salinity waters that meet the improved water clarity and sufficient nutrients conditions
P 28, l 10-12, is there a reference to this statement, or is this conceptual?
There is a paper in press by Quinones et al. in MEPS that shows across the shelf where hypoxia is found:

> "Model estimates indicated that during a summer 2001 shelfwide cruise, stratified surface waters were very productive with an average calculated production/respiration (P/R) ratio of 1.22 and average gross and net primary productivities of 0.60 and 0.11 g C m^{-3} day^{-1}, respectively. In bottom waters, summer oxygen depletion was predominantly due to benthic respiration, accounting for about 65% of the total oxygen loss. In the most hypoxic summer waters, the importance of benthic respiration declined, consistent with low oxygen conditions slowing the rate of benthic oxygen consumption."

Quiñones-Rivera, Z. J., B. Wissel, D. Justić and B. Fry. In press. Partitioning oxygen sources and sinks in a stratified, eutrophic coastal ecosystem using stable oxygen isotopes. Marine Ecology Progress Series.

P 28, l 15, ….into the Rowe and Chapman (2002) three distinct…. [the antecedent and thoughts have been lost after the intermission of description of Figure 7]
P 28, l 19, I don't think I would say that Rowe and Chapman (2002) stimulated new research…. This area of research has always been a focus of NOAA, COP, research programs, IN CONJUNCTION with the biological processes.

P 29, Figure 7, the concepts are much better here, however, the figure would be more reflective of the area of influence and easier to see the areas of the shelf, if the area west of 95°W was omitted, and the area north of 31°N was omitted, and the area of influence of the hypoxia was limited to the 100 m isobath and the deeper portions of the Gulf of Mexico south of 27°N was omitted. Then the focus would be on the area of hypoxia and not lost in the larger figure. Hypoxia so far has been documented only to 60 m depth. (several references)
P 29, l 14-16, the idea that dissolved oxygen should be included in the GCOOS backbone is commendable and correct, except that some of the Ex Bd members are very resistant to this. I plan to work on this at the Sep Ex Bd meeting NR

P 30, l 6, please don't forget the biological processes
P 30, l 20-24, this information should have been included in the section concerning stratification, as well as here.
P 30, l 33, and also alongshore and offshore during downwelling favorable conditions, which predominate through the year (see Wiseman et al. 2004).
P 30, l 35, …map of hypoxia frequency in mid-summer [not an occurrence map]
P 30, l 36-38, duplication of material
P 30, l 40, …strategies for coastal restoration…

P 31, box, while this section is on Physical Oceanography, there still needs to be token mention of the interaction of physics and biology.
P 31, second bullet, last sentence …as that shown in Figure 6, while also considering the effects of nutrient-rich Mississippi River waters discharged into local bays and estuaries.
P 31, last bullet, agree, but see statements above.

P 32, re atmospheric deposition on the Gulf of Mexico hypoxic area. The 13% is attributed to a Pearl reference that is not cited (need reference) versus the estimate from Goolsby et al. that the amount of atmospheric deposition on the area likely to develop hypoxia was 1% of the total nitrogen load of the Mississippi River to the northern Gulf of Mexico (Goolsby et al. 1999).

P 33, l 15, an example of the variability can be seen in the figure below, published in Rabalais and Turner 2006

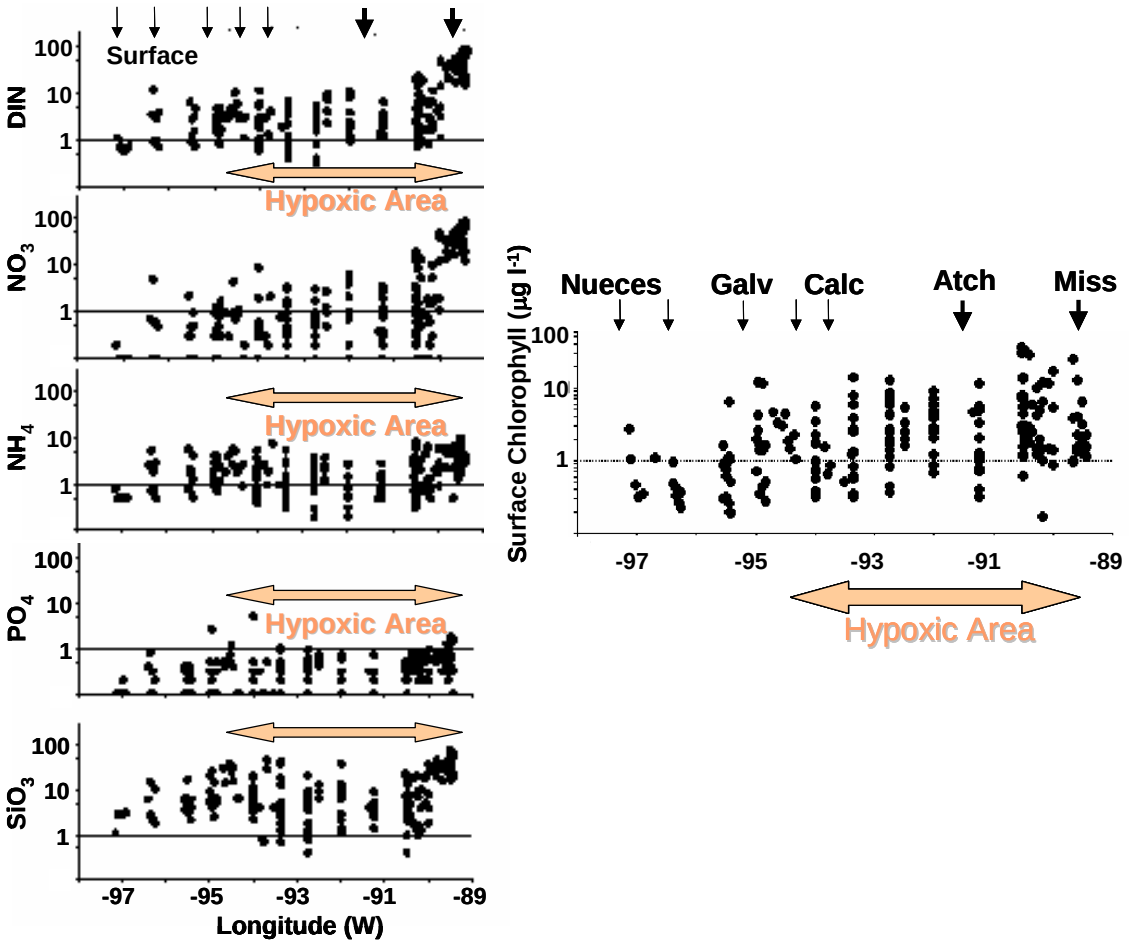
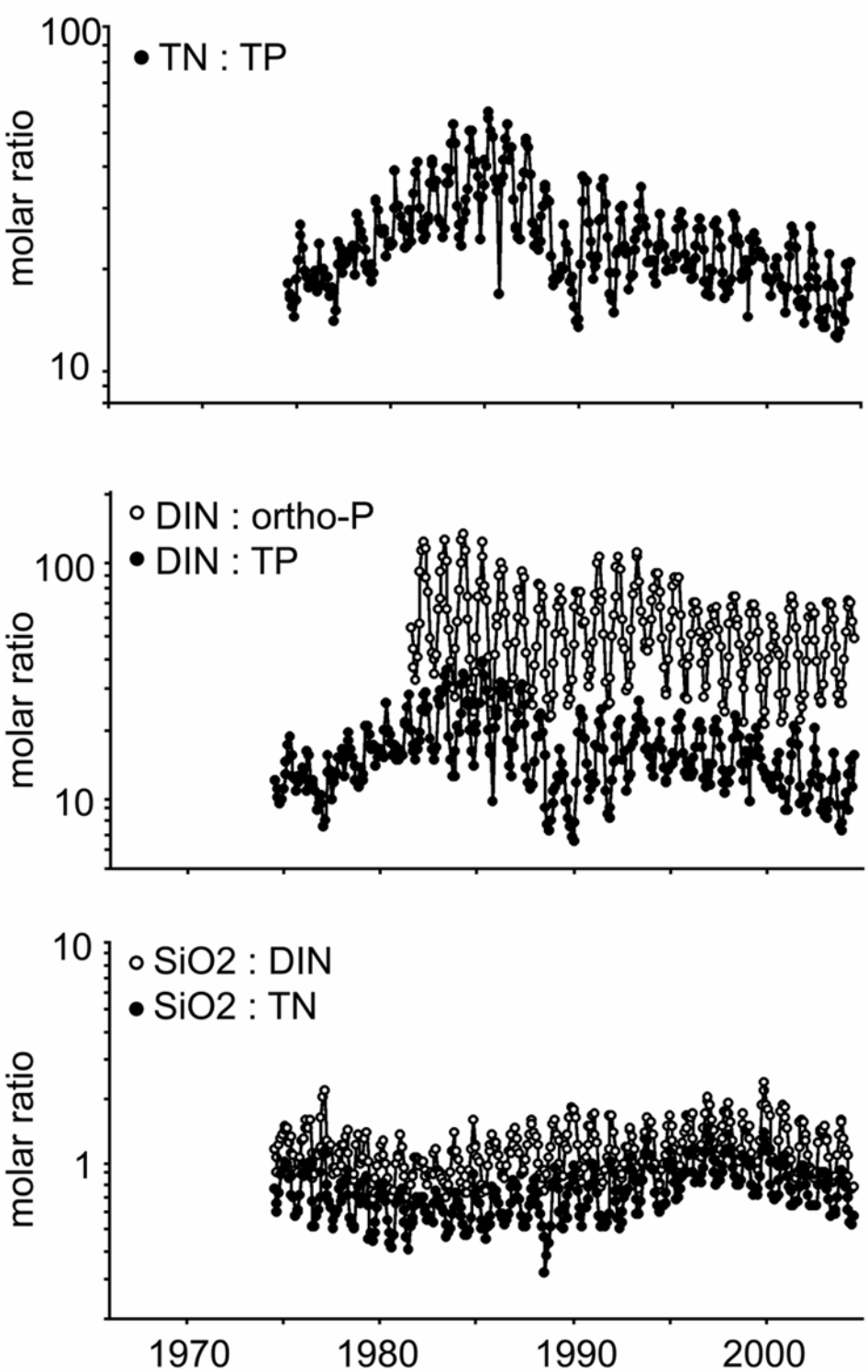


Figure 4. Concentration of surface water nutrients (µM) and chlorophyll biomass (µg l^{-1}) on the Louisiana/Texas shelf for multiple seasons in 1985-2002 (modified from Rabalais et al. 2002a). The black arrows indicate the large inputs of fresh water and nutrients from the Mississippi and Atchafalaya Rivers, and minor contributions from the Calcasieu, Galveston, Nueces and other estuaries. The shaded horizontal arrows indicate the typical distance alongshore for the mid-summer hypoxic zone.

P 33, l, 20-21, this is a pretty benign and general statement.
P 33, suggest that the Turner et al. 2007 in press from the hypoxia symposium now in *Estuaries and Coasts* be cited, which shows that the data since the Goolsby et al. 1999 report shows a range of about 160 down to < 16:1 (Redfield).



Turner, R. E., N. N. Rabalais, G. McIsaac and R. W. Howarth. Accepted 2007. Characterization of Nutrient and Organic Matter Loads from the Mississippi River to the Gulf of Mexico. *Estuaries and Coasts.*

P 33, l 37, word offshore, is this part of the new clearly defined nearshore/offshore continuum?

P 33, l 43-44, I think that there has been equal emphasis among different research groups, doing different studies for different reasons, in the waters overlying the hypoxic zone versus the immediate plume.

P 34, limitation of studies to area of hypoxia. Not really. See embedded figure 4 above.
P 34, l 8, more rapidly than P loading. Has there been any definitive evidence so far that P loading has increased, in any form?
P 34, l 18, 'river plume-influenced' …would be good to provide a salinity range.

P 36, l 34, fix 19929
P 36, l 41-43, this sentence is the correct description of zone 1. It is not nutrient limited.

P 37, l 1-5, these two ideas should not be combined. Of course, water column bioassays do not account for sediment processes. Suggest start paragraph with "Sediment-water column P cycling in the shallow….
P 37, l 5, possible, although unlikely….What is it?
P 37, l 14-16, this is a duplicate of the first l 1-5 and can be deleted, of course they don't.
P 37, l 17-18. Meaning or relevance or contribution of this sentence?

P 38, l 2, suggest delete "interestingly"
P 38, l 5, suggest delete 'quite' The quantitative qualifier is given later.
P 38, l 26, …depends on knowing C production, transport and storage.
P 38, l25-26, the figure 4 from Rabalais and Turner 2006 above addresses this overlap, which is consistent over the long-term and across variability.
P 38 box, …are P limited at peak discharge….
….during summer periods and outside of the plume in Spring???? The sequitor is not logical.
P 38-39 box, think this should take into account the Bode and Dortch article about N recycling on the continental shelf where hypoxia occurs.

Bode, A. and Q. Dortch. 1996. Uptake and regeneration of inorganic nitrogen in coastal waters influenced by the Mississippi River: spatial and seasonal variations. *Journal of Plankton Research* 18: 2251-2268.

P 39, suggest qualify bullet 1 in box ….and the fate of C produced in each zone throughout the year.

P 39, bullet 2, Justic et al. 1996 indicate that 50% of the production in the overlying waters in the area of station C6 off Terrebonne Bay in the area of frequent hypoxia reaches the bottom on an annual basis and contributes to the formation of hypoxia.

P 40, l 30, ..as well as heavily silicified diatoms versus lightly-silicified diatoms E.g. Dortch et al. 2001.

Dortch, Q., N. N. Rabalais, R. E. Turner and N. A. Qureshi. 2001. Impacts of changing Si/N ratios and phytoplankton species composition. Pp 37-48 in N. N. Rabalais and R. E. Turner (eds.), Coastal Hypoxia: Consequences for Living Resources and Ecosystems. Coastal and Estuarine Studies 58, American Geophysical Union, Washington, D.C.

P 40, l 40-43. T&R91 did NOT identify dams as the trapping mechanism, e.g. particles. They indicated that dams that created reservoirs with longer residence times allowed for the P-stimulation of diatom populations, their sequestering and subsequent slower regeneration of Si from the sediments than the uptake of Si in P-enriched freshwater systems. The decline in the Si concentration in the Miss R was gradual, indicating a biological process, rather than abrupt (i.e., drop in suspended sediment load) that would indicate a physical mechanism.

P 41, l 2, add Dortch et al. 2001, see above

P 41, l 18, the scenarios presented in Turner et al. 1998 were more complex than presented here. There is a matrix of low [Si] and high [Si] versus Si:N>1 and Si:1<1. There are multiple scenarios in this matrix.

P 42, l 5, 'coloniality" meaning? Jargon?

P 42, l 11-15, duplication of material presented earlier

P 42, box, suggest add to end of bullet ….limiting factors and when considering nutrient management scenarios.

P 43, top, duplicative material
P 43, l 13 (2), not sure this can be attributed to Rabalais et al. 1999a. There is only one Rabalais et al. 1999 in the References and it is 1999d. I think all the alphabets can be deleted from the 1999, and just refer to the Topic 1 report for the Integrated Assessment.
P 43, l 28, the increased flux of organic N likely during land clearing was seen in the Turner and Rabalais (1994) and Turner and Rabalais (2003) paper as increased biogenic silica indicating increased diatom production in the overlying waters, but this was NOT accompanied by foraminiferal indicators of low oxygen (e.g. A-E Index of Sen Gupta et al. 1996).
P 43, l 44, the work of Turner and Rabalais (1994) Nature also shows that the terrestrial signal in the form of stable carbon isotopes is very near the delta and the near shore, and the remainder of the shelf C in the sediments is indicative of *in situ* produced marine phytoplankton carbon.

P 44, l 13-15, don't really see the relationship or the strong analogy.
P44, l 19-22, meaning?
P 44, l 10-33, this is not a particularly useful addition to this section.
P 44, l 44, sand POC, but Kesel indicates that sand fraction is relatively lower now than in the 1950s compared to the silt fraction. So the relevance is lost.
Kesel, R. H. 1988. The decline in the suspended load of the lower Mississippi River and its influence on adjacent wetlands. *Environmental Geology and Water Science* 11: 271-281.
P 44, l 44, Bianchi et al. 2007 should be a great addition to the literature, has it been posted on the SAB site for public consumption?

P 46, l 2, see also Turner and Rabalais 1994 Nature
P 46, l 7, relevance to formation of hypoxia?
P 45, l 14, see also Turner and Rabalais 1994 for BSi distribution and explanations in text.
P 45, this list of bullets and discussions of organic matter sources is informative, but the relevance to the formation of hypoxia on the continental shelf is missing. E.g. bullet 7 about shunting of organic matter into the Miss R Canyon. This has nothing to do with hypoxia formation.
P 46, l 27, is the Dagg et al. 2006, probably 2007, posted on the SAB site for public review?

P 49, key findings, first paragraph YES!

P 49, bullet 2, should include ….and the relationship of N and P and Si, phytoplankton communities and trophic transfer.
P 49, bullet 3, this seems counter to the body of the text.

P 50, l 21, suggest delete 'careful' Prior studies were not 'careful'?
P 50, l 41 ….hypoxic events, especially when the dissolved oxygen concentrations were low (Rowe….)

P 51, see rates derived from continuous oxygen measurements in bottom water in Rabalais et al. 2007 in press (this has been sent to SAB EPA oversight)
P51, l 27-28, but it was stated earlier that work of Childs et al. indicates a decrease in denitrification rates where oxygen concentrations are low

P 52, l 2 'lower' is contradictory to l 4 'potentially increased'
P 52, l 6-7, strongly agree
P 52, as in section on physical oceanography, the biological processes need to be studied in the context of the physical system, currents, mixing, residence time, etc.
P 28-30, there is no evidence from multiple depth profiles of P concentrations that higher P concentrations in low oxygen bottom water are manifested in higher P concentrations in the water column or in the upper water layer.
From Rabalais and Turner 2006:

> "The regeneration of nutrients in the lower water column or from the sediments could contribute to further nutrient-enhanced production in the upper mixed layer, if they diffuse or mix in significant amounts across the strong pycnocline present much of the year. The rates of these processes, if they occur, are not known, nor have they been estimated. Preliminary examination of vertical nutrient profiles does not indicate a transfer of high nutrients in hypoxic bottom-waters into the overlying water column on the Louisiana shelf (N.N. Rabalais et al. unpubl. data). Wind-induced mixing turned over the water column and introduced higher nutrients from the bottom into surface waters in shallow nearshore Louisiana shelf waters for a temporary enhancement of production (Dagg 1988). The significance of bottom nutrient introduction to surface waters following mixing events in the hypoxic zone is not known."

P 53, l 1-2, this is the denitrification viewpoint of inhibiting N2 gas production. Need to resolve the contradictions. This viewpoint seems to weigh heavier than the other.
P 53, l 11…..smaller, surface-dwelling species have…
P 16-18, citation and relevance to topic at hand
P 53, l 22, suggest that Hagy et al. would be an excellent reference to cite here Hagy et al. 2004 *Estuaries* 27:634-658.
P 53, l 43, …or conditions of concentration or intensity.

P 54, l 1-2, agree
P 54, l 13-14, marine mammals are important, but not likely to be affected by hypoxia
P 54, l 25, suggest add the Rabalais and Turner 2001a book with all the included chapters.
P 54, l 38, Science News article, not a peer-reviewed article for which the peer-reviewed literature is probably more important.

P 55, l 1, perhaps for planktonic recruits, but not for direct development organisms, such as pericaridean crustaceans.
P55, box, agree
P 55, l 14 …timing, severity and extent of…
P 55, lo 16-17 contradicts earlier statements about increases, but is consistent with earlier statements about no statistical change.
P55, l 21, need to define 'others' or delete this word
P 55, l 23, what about the areas away from the plume that are high biomass, but where P is not limiting, e.g. primary production and chlorophyll biomass peaks in 15-25 psu salinity, where N is more likely to be limiting.
P 55, l 24-25 agree

P 56, l 2, dual removal stategies….Yes, needs to be said more than once.
P 56, l 11-15, awkward construction and not parallel structure or thoughts.
P 56, l 17, delete 'also' OR see below
P 56, l 18, delete 'as well' OR see above
P 56, l 18-19, if this is true, then why work towards overall N and P reductions to the Gulf/

P 56, box, l 2…..of the nGoMx and at certain times.
P 56, box, l 5-6, same comment as above. If P reduction won't make a big difference in the Gulf, then why the emphasis on P limitation and dual N and P reductions?

P 57, bullet, agree but is contradictory to prior page
P 57, the Nixon relationship was a log:log plot and, of course, looked linear.
P 57, l 16-18, correlation NEVER implies cause and effect. It is the cumulative strong relationships among factors that lead to hypoxia that provide cause for developing conceptual models and management scenarios. Deductive vs Inductive reasoning.
P 57, the Turner et al. 95 continues to get ragged. Why not just leave it out as non-existent? However, just as Scavia and Donner have submitted a paper to ES&T during

the June SAB panel meeting, Turner et al. have submitted a paper to ES&T (7-2-07 into the editorial queue) entitled "Gulf of Mexico Hypoxia: A Regime Shift and a Legacy" that further defines the Turner et al. 2006 model and provides a biological productivity surrogate for the 'year' term. These two manuscripts are equally viable or non-viable as peer-reviewed publications.

P 58, zero values deleted in ES&T submission
P 58, l 6-7, see above about biological indicator of 'year' factor
P 58, again I see a lot of effort going into showing why this model should not be used (even though it was the only model used by NOAA to predict the 2007 hypoxic area size) than dealing on 'productive' lines of inquiry.
P 58, l 23-24, see above comments about other 'viable' submissions.
P 58, but no time frame just yearly mass balances. Other models have temporal aspects
P 58, l 38, and has a time function
P 58, l 43, a further report by Limno-Tech, Inc. 1995 shows that the response to N reduction is higher than P in increased oxygen concentration in waters below the pycnocline.

Limno-Tech, 1995. Estimated Responses of Water Quality on the Louisiana Inner Shelf to Nutrient Load Reductions in the Mississippi and Atchafalaya Rivers. U.S. Environmental Protection Agency, Gulf of Mexico Program, Stennis Space Center, Mississippi, 48 pp. Plus appendices.

P 60, et seq. The cost of research and modeling and monitoring may be high as noted by a Public Comment on Aug 8, 2007, but it is not the job of this panel to weigh the costs of various recommendations.