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May 15, 2011

□□Dear Reader,

Please forgive if what is before you is difficult to read and please forgive the grammar and spelling – I will gladly answer any questions concerning what I bring before you.

My history concerning the examination of the biological basis of the □ regulation of the butterfly fishery begins just after the New Year of 2011, quite by accident. □□ Previously, I made was aware of butterfly biology and mathematical □ and statistical models used to make assessments of the butterfly populations in the 1980s □ when I was a Senior Scientist at the Fishery Service, Woods Hole, MA. There, I □ worked on the transmission biology of the timing and size of sexual maturity of □ fishes. I also, by accident of life, had the opportunity read material that crossed the □ desk of the then Director of the USNMFS Lab, Mr. Robert Edwards, so I have had □ some familiarity with the scientific effort at Woods Hole. I made □ various trips in the RV Albatross, (maybe one or two on the Delaware?), the RV Phalarope, and have even, strangely, been □ Chief Scientist of the Albatross in the 1980s due to political wrangling within USNMFS Woods Hole. During the same period 1980s I also worked as an artisanal commercial fisherman in Woods Hole. From 1990 I was fishing out of Monterey □ and running vessels involved in the harvest of squid and sardines and selling fish commodities business that sold this catch, during this period to try out an idea in order to try to make progress on one of the most enduring problems in developmental biology, the transmission genetics of the timing of maturational events,

A few years back late Professor Karel Liem of the Department of Fishes at the Museum of Comparative Zoology and Professor Walter Gilbert of the Department of Cellular and Molecular Biology at Harvard thought that by being a research associate at in the Museum and at the Biolabs Harvard I might find it easier to proceed with my work on the transmission genetics of the timing of sexual maturity. I took advantage of these appointments and spent four or five years trying to wrap up my fishing business in order to devote myself completely to scholarly pursuits in the lab. Finally, I stopped commuting to Cambridge from Monterey and moved to Woods Hole and Boston.

I had been thinking about an experiment concerning fishing with light that might prove interesting and maybe give the inshore bottom a rest so I was looking for a vessel to test my ideas and just after the New Years I visited Seafreeze to see what they had laying around their yards. I had visited with Norpel previously. Soon after New Year, I visited Seafreeze to explore the availability of vessels for my purpose as well as to inspect their catch herring for my commodity business.

At Seafreeze, I met Geir Monson who asked me if I wouldn't mind heading out on one of their vessels and think about what I saw. I don't like to be an observer so I found my place in the crew and spent much the next two months at sea. FV Relentless went to the various usual haunts of the squids, and the herring so we traveled near and about the heads of canyons from North Carolina to George's. When I returned from each trip I had the wonderful opportunity to dive into the Mayr Library at Harvard and read the literature concerning the fishes and invertebrates that made up SeaFreeze's fishery. The most noticeable item about

□the trips offshore was how difficult it was to stay off the butterfish. Though □my interest was squid one might say that that the association of the butterfish□with the squid captivated my attention. The more I thought about the□ butterfish and the more I learned the more I thought that it was an interesting□ biological species that could teach me, in a different way, the value of my studies on the □transmission genetics of the timing of sexual maturity are to fishery science □and the regulation of animal numbers. I asked Geir to send me as much material as □possible that came across his desk concerning this species. □□I would like to take this opportunity to enlighten this audience with what I □have learned, by examining the fishery first hand, but selling the catch, by □fishing the species of interest, by examination of the literature, and by □thinking about the needs of the Council to set up a program that seeks to balance the □rival greeds of conservation and exploitation.

I was re-introduced into the butterfish's world on the first haul back□of the net of the FV Relentless. Sharing the catch with the squids, a few □dogfish, were the butterfish. I had brought with me a copy of Bigelow and□ Schroeder, Fishes of the Gulf of Maine, (an the old edition) and re-read the □chapter on the butterfish. It was interesting for me to note that despite□ their understanding that the butterfish are important in many obvious ecological□ ways there was very little biology that was done on the butterfish. They noted □that even the taxonomy of the butterfish was interesting and somewhat□ perplexing. □□I did note while onboard that no matter how hard Captain Greg Bray tried to avoid the □butterfish by the use of sonar, sounders, fishing in particular locations, on □particular tides, at particular times, in particular winds, the FV Relentless had □a hard time to not catch them as by-catch – one wonders what the deck would look like if Captain Bray hadn't been trying to avoid them (later

I would learn that the Bigelow cannot avoid them either as they make up 4% of its catch as well I think in more abundance than any other teleost). When I asked him about this he said that he spoke to other vessels who were fishing in the area because the goal was to avoid the butterfish as they had no economic utility and if they were caught and had to be separated from the Illex and the Loligo and become a by-catch statistic, as well. These butterfish as by-catch had sadly only one duty, that was to feed the seagulls that followed the vessel. Separating butterfish from squid is non-trivial in a sea and tires the crewmembers, thus adding to weariness and lack of attention to details. The abandonment of butterfish as seagull feed Captain Bray considers the lack of a particular shame of his fishery. Captain Bray also informed me that he has seen the different morphologies that were mentioned in the slight scientific literature that we had available.

When I returned to Harvard in late January 2011, I found not one but two Ph.D. theses done under Giles Mead's direction in the Department of Fishes. Dr. Robert Collette another associate of Harvard's Department of Fishes, with the Smithsonian and the UNSMFS Systematics Laboratory had worked on these species years ago (1963) – working out the complicated taxonomy of this group. I understood that the taxonomic status of the three forms may or may not be understood - and certainly that the opportunity for using modern methods for helping to diagnose the taxonomic status and possible stock status of the different butterfish from different regions had not been explored at all in almost 40 years. Like Bigelow and Schroeder I found that there were vast holes in the knowledge base even at the taxonomic level and certainly at every other level of biological thinking. Biological places where the knowledge base is slight where there is a great level of ignorance of the

biological object of interest is a very nice home to someone who is ignorant like myself. You don't sound so foolish because no one else knows anything deep about the subject anyway.

Obviously, we found the association of butterfish and Loligo – they seemed as inseparable as Porgy and Bess. Though obvious that the two species are associated with each it was also nice to be able to validate this association in time and space by statistical means - this has been done using very standard Principal Component Analysis by Zhang, et al. (J. Northw. Atl. Fish. Sci., Vol. 43: 47–64), who note that, "The ability to rebuild the productivity of important exploited stocks in the Gulf of Maine also depends upon the understanding and functioning of their spatial structure." So, by capture data, collected by the USNMFS analyzed, and by natural history observations made by Captains during fishing operations we can easily claim that the squid, particularly Loligo and the butterfish either live very close to each other in separate schools or mixed with each other in a single location or both depending.

While ashore, I also discovered two very carefully done studies of the cohort analysis of the butterfish, one of the Gulf butterfish, *P. Burti* (Murphy and Chittenden, Fishery Bulletin, U.S. 89:101-116 (1991) and the other of the butterfish off North Carolina, *P. triacanthus* (Rotunno and Cowen, Fishery Bulletin 95:785-799 (1997). And note here that Rotunno and Cowen found a protracted spawning season and they concluded that their "study adds to our current knowledge of the early life history and spawning seasonality of butterfish, *P. triacanthus*. Our finding of a more protracted spawning season and of a seasonal difference

between spawning locations should be of value in reassessing management plans for this species. Current management plans are based on conclusions that *P. triacanthus* spawns during summer months only."

Another area of biology that I was able to examine while on shore was the maturational history of the butterfish. It is general knowledge that the butterfish reproduces when it is about a year old. Obrian, Burnett and Mayo (NOAA technical Report NMFS 113 (Maturation of Nineteen Species of Fish off the Northeast Coast of the US. 1985-1990)) present data that indicates that 50% of a butterfish cohort are sexually mature at 9 months of age and almost 100% at 18 months. Making them the earliest maturing species of any fishes in our commercial catch.

Along with a collection of scientific papers dealing with butterfish and squid which I thought relevant, Geir Monson brought together for my reading pleasure many recent unpublished papers concerning the attempts by the USNMFS to produce an assessment based on trawl and landings, determination of the parameters of fishery models, reviews of the scientific efforts to calibrate changes in net design, vessel, and deployment – reviews, critics, the comments all sorts of Monday morning quarterbacks concerning the strategies of scientific work.

I took aboard the vessel various recent articles and scholarly texts on the history of the use of mathematical models for the projection of fished populations at the theoretical level, in particular the last ten years of papers by Jon Shnute. I thought these papers would help me place the models employed for dealing with the butterfish in historical context.

I also attempt, while on board the FV Relentless, to try and identify in our catch what Mike Horn and others had identified as a separate group of butterfish, those with a different shape and few or no pigmentation. The variation in pigmentation between different strains of fish and their association with different body shapes has been of interest to me as the genetics of the timing of sexual maturity has association with the genes involved affecting shape and pigment (or so it seems).

The time at sea could be spent productively examining the information on the butterfish and thinking about how the butterfish biology might shed some light on my research goals. I was lucky to have brought as much literature as I did as the fishing was very poor and we searched and traveled more than fished. I dug into the regulatory literature, summary reports of the 49th Northeast Regional Assessment Review, SARC this and SARC that, and earlier Assessment reviews. I had opportunity to think about the studies on the lack of continuity of the fish surveys. The lack of larval surveys. I tried to compare the effort of scientists here to done by CalCofi (sp) reports of which I had read frequently while fishing in the Pacific.

I imagined before I began that some of the unanswered questions raised by Murawski and Waring in 1979 would have been answered by 2011. For instance, Murawski and Waring were trying hard to work with a disorganized data set to answer questions concerning fishing and natural mortality - they knew then how difficult it would be to provide objective measures for these forces of mortality - obviously the study of the forces of mortality

needed to be understood in order to make the mathematical models work. But I failed to find any evidence that any of this biology has taken place and it is certainly true that if it has it has not entered into use in the mathematical modeling. In fact, it seems that the disorganized data set that Murawski and Waring used due to the nature of collections during the North Atlantic Treaty Organization period has not improved due to frequent inconsistencies in survey applications and the inability to provide accurate calibration between changes of gear, research vessel, and time that the net fishes. Furthermore, entire survey programs that might have led to understanding the forces mortality and oceanographic transport of not only butterflyfish larvar and fry but many other species had been abandoned. The Fishery Service has prided itself on the importance of its survey yet it appears that the Service has abandoned that belief by not paying sufficient attention to ensure confidence in continuity. The actions of here speak louder than any words or calibrations. There is a mess. And I thought then that the mess will continue.

That fishery scientists know the value of consistency in collection methods is illustrated by Rogers et al., Climate and population density drive changes in cod body size throughout a century on the Norwegian coast, (www.pnas.org/cgi/doi/10.1073/pnas.1010314108). From their methods section:

“The data are 91 years of length measurements from beach seine surveys for juvenile cod conducted for scientific purposes by the Norwegian Institute of Marine Research, giving us the advantage of high-quality, long-term fishery-independent data on a pre-recruit life stage. Sampling is conducted every autumn at an average of 110 stations spread across 250 km of the Norwegian Skagerrak coast (Fig. 1) (18) and targets cod hatched the previous spring

(referred to as age 0). The Flødevigen surveys are especially remarkable for their consistency: only three scientific personnel have led the surveys since 1919, each of whom overlapped with another for at least 5 y to ensure consistency in methods, station locations have been marked exactly, and the wooden boat used today is a replica of the one used in 1919. The near-century time frame of this study includes extended warm and cool periods in Northern European climate".

While sorting butterfish from squid I wondered who shot the Albatross? As I pitched butterfish overboard as by catch I thought about how the fishery service could provide good information based on its modeling efforts and the data that was going into them. What a shame it was that each butterfish picked was to be building better seagull brains rather than human. I found it really curious that problems with the model and the data have been known for some many years, but nothing has taken place to improve it (meaning the data base) or abandon the effort. I also discovered that reviews population status of a species that is actively breeding by year one and that few 3 and 4 years olds are present takes place every four or five years. By doing an assessment every four years or so meant that regulations were being made for the past conditions and not the future. This seems strange to me but perhaps this is the way of the regulatory world. After a few days of reading this vexatious literature I needed a break – the acronyms where making me seasick. In order to help myself I made little flash cards with NAFO on one side and its name on the other, or BRP, or ABC,

I did have a few papers on the basic biology in this case the population genetics of Loligo with me so rather than read any of the regulatory information that Geir had provided for me would just relax and read the squid literature. I had with me the work (Mar Ecol Prog Ser

310: 263–270, 2006) of Roger Hanlon's lab of MBL at Woods Hole, MA paper attempting to delineate different stocks of the squid and open the possibility that squid, might perhaps, could or maybe return to the place of their birth. This sure would have been interesting if there were enough samples taken at multiple time points but the sample size was pretty small for the size of the generalizations about populations of squid. Although Hanlon's group had very limited sample sizes they drew the conclusion that "The implications of population structure in *Loligo pealeii* for current fisheries management are 2-fold. (1) Separate inshore spawning groups should not be treated as a single unit stock. (2) The intensive offshore fishery may be impacting the inshore fishery as well as the genetic composition of discrete spawning stocks. If squid are travelling in discrete, related groups when migrating from offshore canyons to inshore spawning sites (whether showing spawning site fidelity or not), then targeted, intensive winter fishing in specific off-shore canyons could potentially impact or even eliminate specific local summer stocks. Fishery managers must consider these potential interactions when planning for separate stock quotas. There is much to learn about the migratory and reproductive strategies of mobile loliginid squids, which play a central role in most coastal marine ecosystems."

It is possible that squid return to the natal breeding grounds may be correct for the squid, but the demonstration is based an examination of say 400 individuals in a population of over a billion squid at one particular time and a few places in the sea, and luckily Hanlon's idea of regulations did not get acted upon. Dear Reader please forgive me as I was trying to fill travel time on the FV Relentless and not re-read the regulatory information that Geir had deposited with me and just try to enjoy some population genetics when the ugly head of making bold statements on almost no data reared.

But I am a lucky man, and as luck would have it I had another squid genetics paper with me written by Shaw et al (Mar Ecol Prog Ser 408: 117–127, 2010) with Lisa Hendrickson of NMFS Woods Hole, MA as a co-author was onboard the Relentless. This time with increased numbers the authors claim that Hanlon's lab results may be due to artifact created to correct for the null alleles (a technical term that we are not going into here) and that the data when correctly corrected indicate that there may be no stocks of squid, no natal homing, just a large homogenous population of squid with lots of gene flow. While Shaw and Hendrickson might be right its certainly is hard to prove a negative – but they're paper does point out that how much more careful and alert about how one would have to be to prove the opposite. To my great relief did not go off into how regulations would be set. Hopefully, Dr. Hendrickson will not be fired from the Service for doing basic rather than applied research

I had with me two additional papers on squid one written by Macy and Brodziak which (Macy WK, Brodziak JKT (2001) Seasonal maturity and size at age of *Loligo pealeii* in waters of southern New England. ICES J Mar Sci 58:852–864)

This paper was quite enjoyable to read and its too bad that we do not have published information every year on the squid growth and maturity - but that is my prejudice – of course one would like to have domesticated *Loligo* which probably would teach us a great deal about squid and squid habitats. But it seems that there are no strains of our squid maintained in aquaculture as far as I know. How nice it would be to know something about critical stages and mortality even under cultured conditions. And this goes for the butterfish as well? Does the fishery Service say in Sandy Hook or at the shore-side facilities have a secret culture of butterfish going one for pollution studies? And if doesn't, why not? How can one understand the forces of mortality by not studying the timing of mortality even under artificial

but controlled conditions? I like papers that make you think about how to fill the holes in the knowledge base.

The last paper that I had with me was by Hastings and Cadrin (Fish. Bull. 200–213 (2002.)) focusing on temporal spatial distribution and breeding patterns of the squid. They actually noted that there were deep water spawning grounds and these grounds were active during the winter. Which winter we aren't sure of, how often we do not know - but they do exist, and far from being unknown they are well known to the fishermen who contributed to the study. And these winter breeding grounds are important in many ways but they are not taken into account in terms of population models or population persistence.

It didn't really hit me until I got out on deck and was sorting butterfish from Loligo again that maybe the observations of the fishers and the analysis by Hastings and Cadrin concerning winter and spring or summer breeding aggregations meant clearly that the work by Shaw, Henrickson, et al. and that of Hanlon's group were not right and not even wrong. It was clear to me then and is clear to me now that in order to test any hypothesis concerning return to natal breeding grounds or possible stock differentiation (they may not be the same thing) one must be able to identify a squid as being spawning at a particular location. Both genetic studies assumed, with limited sample size, that squid captured offshore in the winter were not on their natal grounds and spawned along the shore (perhaps the data exists and GSI might be examined by genotype). The work of Hastings and Cadrin provides an important caution. When you are out on deck or working on the conveyor seeing thousands of squid and butterfish pass before your eyes one realizes just how limited the sample sizes are that the geneticists were playing. More modern robotic, high throughput, DNA chip methods must be

applied was my conclusion – as both genetic studies showed that gene frequencies of the squid may vary spatially (from region to region) and temporally (from year to year) – it would be just fanciful if they did not. I wondered if anyone had studied the butterfish population genetics, as the squid genetics was being actively studied, whether for the purpose of management or as basic research. And as I threw butterfish to seagulls and watched the squid slide down to the packing room I wondered how to factor the information and the misinformation in a better conflation that would have higher predictive power with respect to the affects of fishing or not on these two species.

Returning to our homeport I met with Geir again and he suggested that I listen in to a webinar concerning the Loligo/Mackerel/ Butterfish regulations being examined. I must tell you that I was a webinar Virgin. The acronyms stalled me pretty bad – but the flash cards helped and I had been reading this material for over a month. The mix of statute, biology, theoretical concepts, practical constraints, legal constraints, economic information, inability to decide basic biological questions and what philosophical and governmental role the Council could and should or would play made for some really challenging listening. But, I knew, that by listening to the webinar of regulatory decisions being made so to speak at the “grass roots level”, so it was a challenge worth taking – I came away convinced by the discussions at that webinar that the butterfish and the squid were to be thought of together – they cannot be studied separately as had been done. As the squid is predator to the butterfish and *mutas mutandis* at some stage of development, they breed in same areas, they overwinter in the same regions, they mature at earlier ages than any other fished species in our region – why weren’t they being studied together? And why weren’t they to be regulated not just at the same time

and place and webinar...but as a unit? I also learned for the first time that the VIMS survey inshore survey was reporting data concerning the butterflyfish and squid abundance. I've had the opportunity to read and examine carefully the reports that are being used in the webinar series that I am now participating in.

There are a few areas that I find logically unacceptable with respect to basic management practices. The most basic is the inability to correct errors in analysis. For instance, butterflyfish has an "overfishing" designation that cannot be changed even though from what I made to understand it was done in error. Is it not negligent to not fix. As they always urge at nuclear power plants, "Clean up spills immediately!" I think this spill has to be dealt with before progress is really made in rational regulation of the butterflyfish. Many regulations that are decided will have to please this error. But this is only a minor issue.

The issue that I find to be most disturbing is that none of the analysis is not using a scientific decision making process but it is not using a statute based model either. It seems easy to infer from the discussions or presentations that there is a belief on the part of the group that some of the numbers, some of the trends, some of the statistics might be useful to vary the quota or perhaps not - but almost everything is always up in the air. Nothing is known, or nothing is known for sure, and therefore unacceptable, and only acceptable if the status quo which is an admitted error is maintained. Lee Anderson pointed out in 1977, the "final step is to periodically to reevaluate the fishery and the objectives of management".

The question becomes how to provide scientific guidance to the council so that it can make rational and objective or even biased policy decisions concerning the rival greeds of conservation and harvesting. There is no doubt that we need a better model for the butterflyfish.

The best model for the butterfish is the butterfish itself. But we really don't have the information about the butterfish to use it as a model of itself. So it seems to me that the next best model for the butterfish is a species that has many of the same habits of spatial temporal distribution, a rapid growth rate, early maturity, etc. the species in our fishery that is the best metaphor, model, proxy for the butterfish turns out to be an invertebrate named Loligo. Why not use this species as a proxy for the butterfish in order to set the butterfish quota? Certainly using the species that has the similar life historical features means that we just might be on the right track to provide guidance so that scientific based decision making can take place. Yes it may seem unusual for us to use an invertebrate as a model for a vertebrate. But it really is not. In the study of vertebrate development we biologists use zebrafish and infer physiology of humans. We use the worm *C. elagans* neuronal development and infer the biology of vertebrates. These analogies are not unique to the fields of morphology or physiology. The very basis of conservation fishery biology was founded the use of analogy. Leewenhoek in 1685 discovered how to tell the age of a fish by the markings on their scales used analogy to the rings of trees. In 1759, Hans Hederstrom used analogy to design experiments demonstrating that Leewenhoek's use of analogy was correct and that one could tell the age of fish, measure their yearly growth and understand that important principles of conservation could be applied to protect populations of fishes in streams and ponds and lakes.

How can we apply what we know about the squid to help the council develop a quota that will protect the butterfish and its fishery?

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