Sea Around Us

Understanding impacts of the Gulf of Mexico oil spill: How will fisheries fare?

by Ashley McCrea-Strub

As devastating images of oil in the Gulf of Mexico streamed across virtually every media outlet during the months following the explosion of the Deepwater Horizon on April 20th, 2010, many experts in the fields of marine ecology and fisheries science have found themselves faced with the question, "What will be the impacts of this disaster?" As a native of South Florida with memories of family vacations to Gulf-coast beaches and an appreciation for delicious Gulf seafood, I have been eager to participate in any efforts to better understand the problem.

Attempting to answer this question is no simple task. Estimates of the quantity of oil, natural gas and associated methane, and chemical dispersants released into the Gulf of Mexico are plagued by uncertainty. The U.S. government-appointed team of scientists, a.k.a. the Flow Rate Technical Group, estimated that a total of 4.9 million barrels of oil were released from BP's Macondo well [1] while an independent study suggested between 4.16 and 6.24 million barrels [2]. According to BP's records, approximately 1.8 million gallons (i.e., about 6.8 million litres) of dispersant were applied at the site of the leak as well as the sea surface, though the validity of this amount has been questioned [3]. Complex oceanographic processes have made it extremely difficult to determine the current and future distribution of these toxic substances from the surface to the sea floor, and the duration of their persistence in the marine environment. Most importantly, there are no immediate answers to questions concerning short- and long-term impacts on habitats and marine organisms in the path of this disaster. This uncertainty is particularly troubling for fisheries dependent on economically valuable species.

Despite the geographic distance separating the Fisheries Centre from the Gulf of Mexico, the databases developed by the

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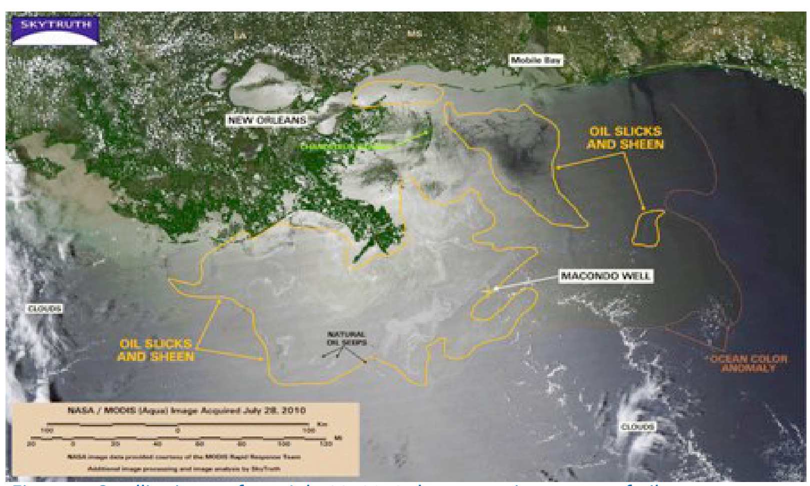

Figure 1. Satellite image from July 28, 2010 demonstrating extent of oil on sea surface. (www.skytruth.org).

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From 2000 to 2005, an average of 850,000 tonnes of fish, crustaceans, molluscs and other invertebrates, were commercially caught in the Gulf of Mexico.

Sea Around Us Project provide a unique opportunity to explore potential effects of the spill on commercial fisheries in this Large Marine Ecosystem (LME). While these databases supply detailed information on a global scale, they may be easily queried to understand trends occurring in smaller geographic regions, such as the Gulf of Mexico. Using data detailing the location and quantity of species reportedly caught by fishers throughout the Gulf [4], in addition to information regarding the price that they receive when they sell their catch [5], spatial maps illustrating recent trends in catch and landed value were generated for this study. From 2000 to 2005, an annual average of approximately 850,000 tonnes of fish, crustaceans, molluscs and other invertebrates, primarily inhabiting the highly productive continental shelf area, were commercially caught in the Gulf of Mexico. The majority of this catch originated within the 200 nautical mile limit of the United States' Exclusive Economic Zone (EEZ), followed by landings within Mexican waters. The total landed value of this catch was estimated at approximately $1.38 billion US.

As oil slicks visible on the sea surface grew in size following the spill (Figure 1), the U.S. National Oceanographic and Atmospheric Administration (NOAA), as well as the States of Florida, Alabama, Mississippi and Louisiana, declared portions of federal and state waters closed to commercial fishing in an effort to promote seafood safety and ensure consumer confidence. The location of this closed area in relation to mapped average catch and landed value was analyzed to provide clues regarding potential economic losses to commercial fisheries in the region (Figure 2).

As of July 22, 2010, over 10% of the total surface area of the Gulf and nearly 25% of the US Gulf EEZ was closed to commercial fishing operations. Figure 2 demonstrates that this closure overlapped with highly productive and economically valuable shelf habitats accounting for 18% of the total annual value of reported commercial landings within the Gulf of Mexico. This represents a potential annual loss of

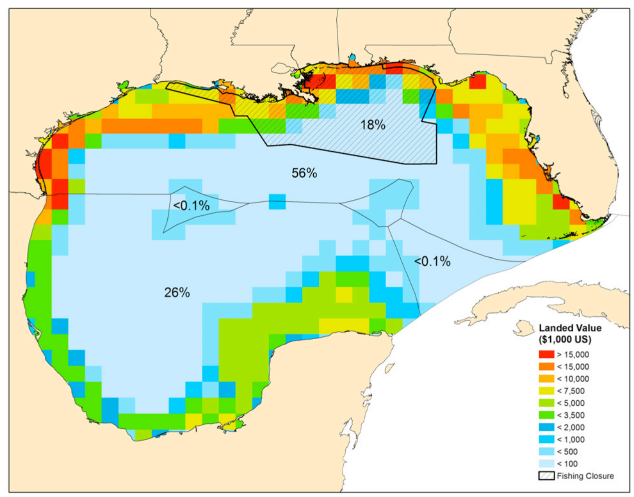

Figure 2. Spatial distribution of the average (2000-2005) annual landed value of reported commercial fisheries catches in the Gulf of Mexico. The area closed to commercial fishing (including both federal and state within the US EEZ as of July 22nd 2010) accounts for approximately 18% of the total value of landings within the LME. The remainder of the US EEZ still open to fishing accounts for 56%, while Mexican waters account for 26% of total landed value. Less than 0.1% of the annual landed value is derived from the two High Seas areas and Cuban waters.

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The *Sea Around Us* website may be found at www.seaaroundus.org and contains up-to-date information on the project.

The Sea Around Us project is a scientific collaboration between the University of British Columbia and the Pew Environmental Group. The Group supports nonprofit activities in the areas of culture, education, the environment, health and human services, public policy and religion. Based in Philadelphia, the Group makes strategic investments to help organizations and citizens develop practical solutions to difficult problems. In 2000, with approximately $4.8 billion in assets, the Group committed over $235 million to 302 nonprofit organizations.

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$247 million to be suffered by U.S. commercial fishers. While the majority of US catch within the closed area during 2000 to 2005 was composed of Gulf menhaden, landings of brown and white shrimp generated the greatest value (12% of the annual US total in the Gulf, combined) due to high consumer demand and associated prices, followed by blue crabs (4%), Gulf menhaden (3%), and eastern oysters (1%). Potential impacts on valuable invertebrate fisheries may be compounded by the fact that relatively immobile, benthic organisms are likely to suffer higher rates of mortality as a result of the toxic effects of oil compared to more mobile fish species [6]. In addition, the capacity of habitats and species to recover from the effects of oil, methane, and dispersants may have already been compromised due to pre-existing sources of stress, including nutrient-laden freshwater discharge from the Mississippi River resulting in periodic oxygen-depleted 'dead zones', and bottom habitat destruction due to extensive shrimp trawling.

While this study does not attempt to address the full range of biological and economic consequences of the Deepwater Horizon oil spill on fisheries in the Gulf of Mexico, it does provide a preliminary perspective on one aspect of the puzzle, given pre-oil spill trends. It is evident that the oil spill has clearly impacted an area of crucial economic importance within the Gulf of Mexico. Missing from the situation presented here are the values to recreational fishers, an important sector in the region.

During the months following the spill, my head has been filled with nostalgic thoughts of flour-like sand squeaking beneath my feet while playing on the beaches of Seaside, Florida, hours spent searching the seashore in Captiva for the beautiful shells that still sit in a bowl in my living room, and devouring a 10 lb bag of steamed clams bought from a fishers by the side of the road in Cedar Key. How will future generations of vacationing families, Gulf-coast residents and fishers remember this region? Hopefully, expectations of environmental resilience along with a continued dedication to clean-up operations will facilitate a swift recovery.

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Oil dispersants: The easy way to clean house

by Leah Biery

At the end of August, I moved to Vancouver from Sanibel Island, Florida. Sanibel is a tiny island in the Gulf of Mexico, where millions of litres of oil have spilled since the Deepwater Horizon explosion on April 20, 2010. When people learn that I am from the Gulf region, they usually ask how much oil I saw on nearby beaches. Surprisingly, the answer is none.

Oil has washed ashore in the northern region of the Gulf, closer to the spill, but southern Florida's coast appears largely oil-free. The absence of visible oil in southwest Florida is probably due to a combination of natural and anthropogenic factors. The Loop Current flows relatively far offshore, so it has not played a significant part in carrying oil or tarballs to SW Florida's coastal areas (see figure). Also, major storms with the potential to push oil inland have bypassed the area so far this hurricane season.

Despite the pristine beach conditions in SW Florida, it is important to remember that the lack of visible oil does not necessarily indicate a lack of presence. Chemical dispersants played a key role in hiding surface oil that might otherwise have washed up on beaches today.

Dispersants are chemicals that break oil into small droplets, which are then distributed throughout

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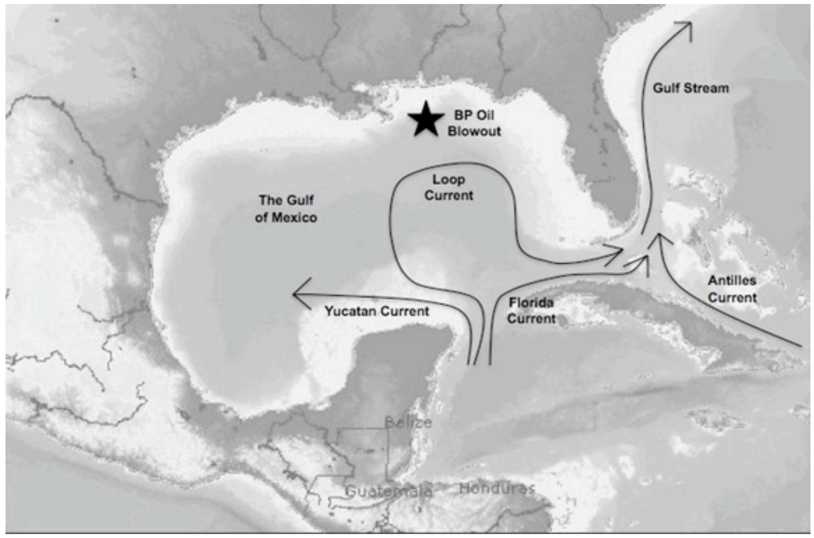
the water column by wave action and currents. Dispersants do not clean up or get rid of the oil – they simply spread it out. In July alone, the US dropped one third of the world's supply of dispersants into the Gulf of Mexico, effectively making the oil difficult to find.



Major currents in the Gulf of Mexico. Near SW Florida, the Loop Current flows far enough offshore that it has not carried oil to beaches.

You can compare the use of dispersants to a common scenario that most everyone experienced as a child – hiding a mess from your parents. Your mom is angry about the messy state of your room, so she tells you to clean it up. Instead of cleaning up the right way – putting each item where it belongs – you shove everything under the bed, hiding the problem. By using dispersants, the responsible parties were hiding the oil spill instead of cleaning it up.

Hiding the mess is an attractive temporary solution, but the problem becomes apparent when your mom looks under the bed. Now you are in big trouble. The consequences are much worse than if you had just initially taken the responsibility and time to clean up correctly.

A recent study of core samples taken from multiple locations in the Gulf revealed as much as 5 cm layers of oil on top of normal bottom sediments. Samantha Joye, a professor from the University of Georgia who collected the core samples, said in an interview with NPR, "The sheer coverage here is leading us all to come to the conclusion that it has to be sedimented oil from the oil spill, because it's all over the place." (http://www.npr.org/templates/story/story.php?storyId=129782098&ps=cprs)

Using dispersants to hide the oil was a fast and easy way to maximize the number of clean beaches and keep the general public happy by making the unpleasant effects of the oil spill appear to go away. However, the long-term environmental and ecological effects of spreading oil throughout the water column are unknown. The Obama administration's leader of the scientific response to the oil spill, Marcia McNutt, admitted last week that the government decided to use dispersants without prior knowledge of the potential environmental effects, saying "there was no science when you apply [chemical dispersants] in the deep sea — we didn't know the impacts on sea life." She also acknowledged that it may be years before we know the full impact of the decision (http://www.poptech.org/blog/marcia_mcnutt_on_uncertainty_in_the_flow). There is a strong chance that the combination of oil and chemical ingredients in the dispersants will have harmful effects on marine life and potentially the humans who choose to consume that seafood in the near future.

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Naturally, oil floats on the surface. This makes it possible (although difficult) to clean up. Sending oil to the bottom of the ocean makes it virtually impossible to remove. It also damages sea grass beds and coral reefs, and the oil is inadvertently consumed by mussels and other filter feeders – many of which make up the base of the Gulf food web. The chemicals in the oil (mixed with the mysterious chemicals in the dispersants) could accumulate up the food chain over time until high levels are found in commonly-consumed species. The U.S. Food and Drug Administration is monitoring seafood from the Gulf of Mexico carefully, and a number of independent studies are in progress.

The long-term effects of dispersants in the Gulf of Mexico are unclear at this point. The Gulf is one of the world's top food-producing regions, so dispersants could have huge implications for fisheries. Thanks to dispersants, people in southwest Florida can enjoy the beaches now, but they may not be able to enjoy local seafood safely in the years to come.

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The SeafoodPrint and the revival of the primary production required

by Wilf Swartz and Daniel Pauly

The October issue of the National Geographic magazine featured a story titled 'Time for a Sea Change' [1] with contributions from the *Sea Around Us* Project. The focus of the story was the ecological footprint of our seafood consumption, or SeafoodPrint. Much like the Ecological Footprints of Rees and Wackernagel [2], the SeafoodPrint is an attempt to express the impact of seafood consumption in terms of the productivity of the ecosystems from which they are derived. For this purpose, we revived the concept of the Primary Production Required (PPR) to sustain global fisheries, originally proposed by Pauly and Christensen in 1995 [3].

the current level of seafood consumption. We used the PPR conversion (based on the mean trophic transfer efficiency of marine systems, estimated as 10% by Pauly and Christensen 1995) to compute the ecological footprints (i.e., SeafoodPrints) of fish-consuming countries. The higher on the food web a fish is, the larger the footprint resulting from consuming such fish (Figure 1). Consuming 1 kg of northern bluefin tuna, at a trophic level 4.43, would be equivalent to 2,700kg of SeafoodPrint. Compare that with the SeafoodPrint for consuming 1 kg of Peruvian anchovies, at a trophic level 2.7, calculated as the equivalent of 500kg.

It has been widely recognized that seafood is one of the most traded food commodities in international markets...

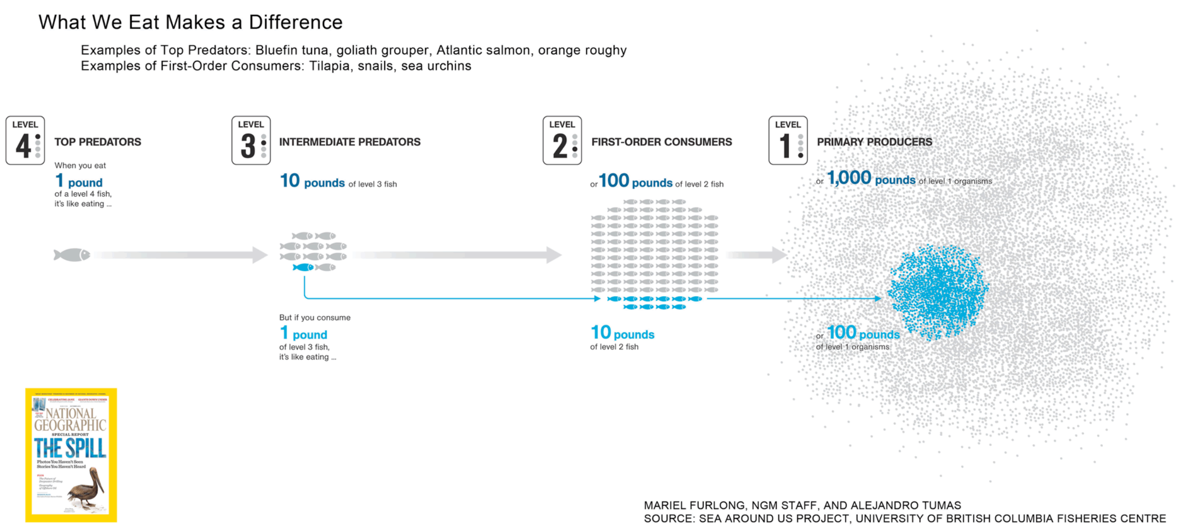

Figure 1. Schematics for computation of Seafood Print, estimated using 10% transfer efficiency between trophic levels, i.e., SeafoodPrint = (consumption)$10^{(TL-1)}$.*

PPR was designed to overcome the fact that every fish is different. Or more anthropocentrically, every kind of seafood is different. Since seafood covers a wide spectrum of species across marine food webs, the ecological impacts of seafood consumption also vary. While recognizing that assessments of the true ecological impacts of seafood consumption would require tremendous amounts of information about the status of each stock, fishing practices *etc.*, we defined, for our purpose, the ecological impacts (i.e., footprints) as the amount of marine primary productivity required to sustain

For the National Geographic piece, we computed the SeafoodPrint for all seafood consuming countries using the information on their fisheries landings, imports and exports. It has been widely recognized that seafood is one of the most traded food commodities in international markets, with the markets of the industrialized countries increasingly dependent on imports from foreign waters to meet their domestic demands [4]. Hence, rather than simply examining the fisheries of each country, it was important that the

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SeafoodPrints were applied to consumption. The result was not surprising with China as the largest consumer of seafood, followed by Japan and the United States. With benchmarks now established, we hope that the concept of SeafoodPrints will resonate with consumers and encourage a shift in demand from high trophic species to species that are sustainable and have lower ecological footprints.

... a third of the world's oceans and two-thirds of continental shelves are currently exploited at a level where PPR of fisheries exceeds 10% of local primary production

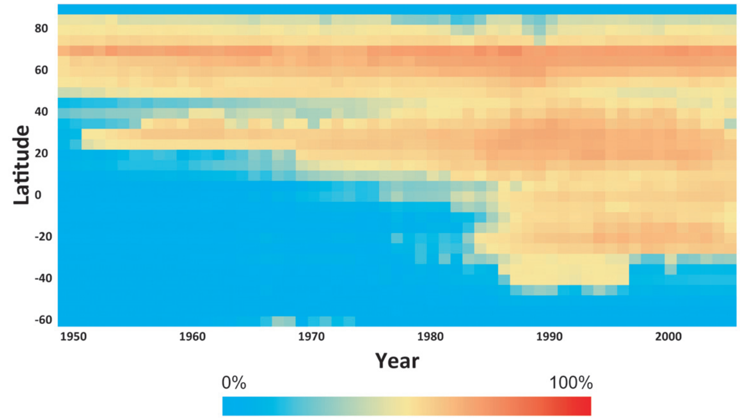

Figure 3. Time series of areas exploited by marine fisheries (PPR>10% PP) by latitude class, expressed as a percentage of the total ocean area.

Another outcome from the revival of the PPR is our new article in PLoS ONE [5] which applied the PPR of global fisheries for assessing the rates of their spatial expansion. For this study, we used three different threshold levels of PPR as percentage of local primary production to define 'fisheries exploitation,' and applied them to the *Sea Around Us* catch database (Figure 2). This approach allowed us to assign an exploitation status to each square of our ocean grid (exploited vs. unexploited) and trace the changes in their status over the years (Figure 3). Our analysis shows that fisheries expanded at the rate of about one million km^2 per year from 1950 to 1980, but this increased by 3-fold, following the series of EEZ declarations in the 1980s, with a large proportion of new fishing grounds coming from southern oceans.

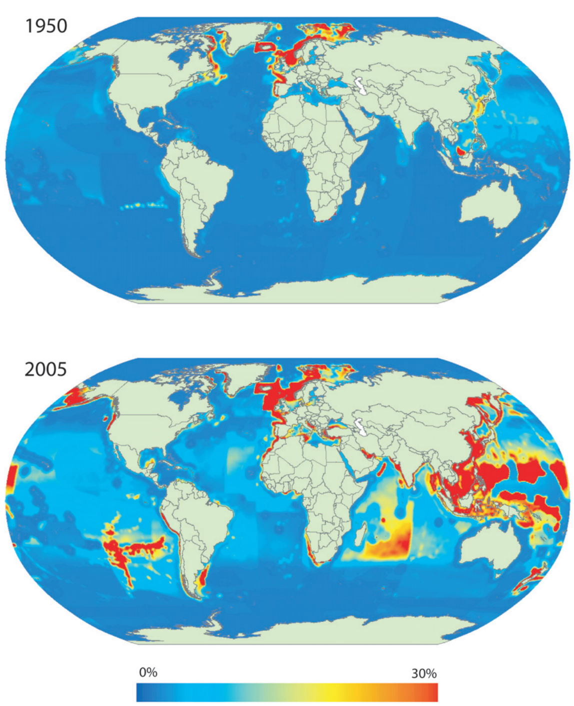

Figure 2. Primary production required to sustain global fisheries landings expressed as percentage of local primary production.

We also found that a third of the world's oceans and two-thirds of continental shelves are currently exploited at a level where PPR of fisheries exceeds 10% of local primary production, leaving relatively inaccessible waters in the Arctic and Antarctic as the last remaining 'frontiers.'

All of this should come as no surprise. The decline of newly exploited areas since the 1990s, which corresponds with the decline in the global landings, implies that the era of great expansion has come to an end. With limited room for expansion, the path toward sustainability of global fisheries must come through reduction of our SeafoodPrint. So let us hope that the article in National Geographic will raise a trickle then a flood of concerned citizen voices insisting that it is indeed "Time for a Sea Change".

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