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Research Note: The Summers of 1986 and 1987 (or "What Happened to the Whales?)

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THE SUMMERS OF 1986 AND 1987

(or "What happened to the Whales?")

by John C. Jahoda and Michael C. Ryer

The summer of 1986 saw a marked change in the ecosystem of Stellwagen Bank off the coast of Massachusetts. The most noticeable effect of this was the disappearance from the Bank of the Humpback whale, *Megaptera novaeangliae*. From a biological research viewpoint the events of the past two summers were very dramatic and valuable since they verified some parts and clarified others of a model of the Stellwagen Bank ecosystem that we have been working on for several years. These events also provided a clearer understanding of the development and dynamics of the Stellwagen Bank ecosystem from the early 1970's until the present. It is an understanding of this dynamic that is one of our major research interests.

Figure 1 shows the Stellwagen Bank ecosystem as it existed during the peak period for whale watching from 1977-1986. Figure 2 shows the ecosystem after the humpbacks left in 1986. The major difference in these models is the change in the role of the sand lance population. (The sand lance is a small, elongated sea fish). Figure 3 shows the internal dynamics of the humpback whale population.

Routine surveys of fish stocks by National Marine Fisheries Service personnel confirmed that the sand lance population on Stellwagen Bank had experienced a gradual decline. Michael Payne of the Manomet Bird Observatory has data that suggests the decrease started about 4 years ago. The data from the spring of 1986 indicated that the population had crashed, and data gathered since that time has shown little significant recovery in sand lance stocks. The reasons for the crash have been a subject of speculation; minute changes in water temperature, interspecific competition, and ocean dump sites have been suggested as possible causes.

Analysis of dogfish stomachs by the National Marine Fisheries Service indicates that up until 1985 the dogfish were feeding almost exclusively on sand lance. In 1986 there were no sand lance in dogfish stomachs. Research also shows an increase in the mackerel population which feeds on immature stages of sand lance. This may be one of the factors causing the decline in the sand lance population. In December of 1986 I observed humpback whales feeding heavily on mackerel off Provincetown. Observations from the summer of 1987 suggest that the few humpbacks found on the bank during 1987 were also feeding on mackerel. Most marine biologists believe that the decline in the sand lance is cyclic and a completely natural event.

It is a truism in ecology that vertebrate predators can never extinguish their prey. The reasons for this are complex, but simply stated are related to the low reproductive rate of most vertebrate predators, which means that under normal circumstances the prey can simply outbreed them. However, vertebrate predators tend also to be large and long-lived. This means that should a decline in the prey population be initiated by other factors, the predators do not decline immediately with the prey, as is the case for short-lived predators, such as insects. Instead they stay around, and although they may ultimately starve or move elsewhere, they can become a very significant factor pushing a declining prey population to virtual extinction. Perhaps the classic example of this is the snowshoe hare and Canada lynx of the arctic. When the hare population is doing well, the lynx population is slowly building. Once the decline in the hare population begins, the lynx then becomes a major factor causing a near extinction of the hare.

Similar events seem to occur in marine ecosystems. NMFS data suggest that the reason herring populations on Georges Bank almost disappeared and failed to recover from the effects of overfishing may be the continued presence of large, long-lived vertebrate predators, specifically the finback whales. Overfishing caused the initial decline, and once on the decline the whales then exerted an increasing predator pressure on a continually declining resource. As the prey continues to decline the predator pressure continues to build, at least until the predator pressure is finally released due to either starvation or elimination of the predator.

Whales differ in a significant way from most terrestrial predators such as the lynx in that they are able to move over considerable distances. In this they are more similar to avian predators. This ability to move over long distances relatively fast allows whales to move in and decimate a building population and then move off to more favorable hunting waters, to return again if the

population begins to make a comeback. This behavior will tend to keep the prey population depressed until the whales stop returning to the area. Thus, the declining sand lance population was being subjected to increasing predator pressure by the humpback whale.

This pressure was intense during the summer of 1985. Some of our most extended and interesting records of humpback feeding behavior occurred during 1985, including large groups of humpbacks feeding in close proximity. 1985 was an excellent year for research on humpback whale feeding behavior and observations made during that summer formed the basis for our ethogram on the humpback whale. The humpbacks arrived as usual in the early spring of 1986, and by the Friday before Labor day they had taken what few sand lance remained on the bank and left. By May 15 sightings of humpbacks on Stellwagen fell off dramatically and reports began to filter in of a large group of humpbacks feeding in the great south channel some 60 miles east of Chatham. This new location was simply too far for most whale-watching boats, with only a few trips being made from Provincetown. Several research cruises were made to the area by researchers from the Provincetown Center for Coastal Studies.

The humpback whale was the species the general public most wanted to view. This species is the one which most commonly approaches boats and puts on a display of flipper flapping, lob-tailing, breaching and other interesting behaviors. Because the humpback tended to put on a good show, it was the species the commercial whale-watching boats sought out. Since most of our research effort depends on the commercial boats as observation platforms, we were often compelled to focus our research efforts on the humpback whale.

From the mid 1970's until the summer of 1986, 300 to 350 humpback whales summered on Stellwagen. During late summer of 1986 a lone humpback would from time to time show up on the bank, perhaps searching for sand lance, and would shortly be seen heading straight back toward the great south channel, as no sand lance were to be found. The summer of 1987 found a few humpbacks scattered thinly over the bank, perhaps feeding on alternate prey which could not support a heavy density of whales.

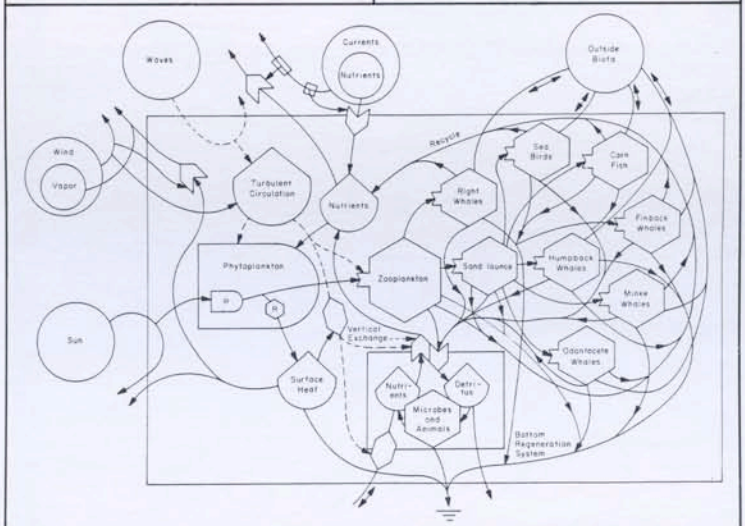

FIGURE 1
Model of Stellwagen Bank Ecosystem

These occasional visits and scattered residents suggest something about the situation at the great south channel. This suggestion is confirmed by observations on the behavior of the whales on the great south channel feeding grounds. The humpbacks observed at great south channel were feeding intensely. The large amount of feeding activity observed suggests that the forage conditions were not ideal and the whales had to spend a large portion of the day feeding in order to meet their energy demands. That whales left every so often to scout for better forage conditions on Stellwagen confirms the supposition that the feeding situation in the great south channel was less than ideal.

The events on Stellwagen were also of great interest, and from a biological standpoint the summer of 1986 was extremely exciting. As Aaron Avellar of the Dolphin fleet of Provincetown noted, "the public's perception is that there are no whales, but this is not true." Avellar was right because the changes that caused the humpback to leave also caused the arrival of other species of whales (specifically plankton eaters) to Stellwagen, some of which were more exciting to biologists than the humpback.

However, the circus atmosphere of humpbacks performing tricks for boatloads of people was gone.

To biologists what happened next was both enlightening and exciting. After the humpbacks left, whale-watching hit its lowest point. A good trip reported 2-3 fin whale sightings; many trips saw no whales at all. An industry that had prided itself on a high success rate (90 percent or better) and in some cases even guaranteed sightings, came abruptly upon hard times. However, by late June and early July of 1986 things began to change. We do not know the mechanism that attracts planktonivorous animals, but they were showing up on Stellwagen by midsummer of 1986 in large numbers. By late June right whale, *Eubalaena glacialis*, sightings became common and continued throughout the season. A small resident population became established with at least one cow nurturing her calf all season in the area. In July, South Shore beaches were closed due to sightings of planktonivorous Basking sharks. These are totally harmless sharks, but the public reaction to a shark in any form was predictable. Higher than usual numbers were sighted within Cape Cod Bay and on Stellwagen Bank. Blue fin tuna were especially abundant and 1986 was a record year for blue fin fishermen. The abundance of tuna perhaps explains the brief appearance of a pod of killer whales, *Orcinus orca*, during the third week of July. Sei whales, *Balaenoptera borealis*, were sighted on eight trips during the second and third weeks of August, feeding on the surface on zooplankton. Fin whales, *Balaenoptera physalus*, unlike the humpbacks, did not leave the bank but shifted from feeding on sand lance to feeding on zooplankton. Finally on October 10th the event of the season occurred. A lone 60' blue whale, *Balaenoptera musculus*, was positively identified by biologists aboard the Captain John II out of Plymouth. This was the first blue whale seen on Stellwagen in more than 50 years. Observations on this whale's behavior suggested it was feeding on zooplankton below the surface.

The summer of 1987 started out similarly to 1986, with the humpbacks arriving early and then departing. However, the rest of the summer showed a different pattern. A few humpbacks returned to the bank and remained as scattered residents throughout the summer. These scattered humpbacks and the resident finbacks

served to support whale watching activities on the bank in 1987. These few individuals were probably feeding on alternate prey, perhaps mackerel. Phil Clapham (1987) reported that after a few days of intense feeding activity the humpbacks had thinned out along the southern edge of the bank by mid-May. The few humpbacks that remained in the area during late May and June showed no definitive distribution pattern and were often a long way off shore. In July a small number of sei and right whales joined the remaining humpbacks, but they did not stay long, with most individuals remaining on the bank for only a few days. Two blue whales also briefly visited the bank on August 11 and August 30, but also left the area quickly. The summer residency of sei and right whales that occurred in 1986 did not reoccur in 1987. Prey abundance was reported as low with few sand lance reported. Those whales that did occur appeared to be feeding on euphausiids, large shrimp-like zooplankton which seem on the increase on Stellwagen. Clapham also reports that large concentrations of humpbacks were seen feeding on sand lance and euphausiids in the great south channel during spring and early summer. By July the numbers of whales had declined and little feeding was observed. By mid-August very few whales had remained. 1987 was also a poor year on the northern section of Stellwagen and Jeffreys ledge. The pattern was similar to that in the lower section with a few humpbacks spread out and a modest number of finbacks sighted.

These are the events of the summers of 1986 and 1987 on Stellwagen. From an analysis of these events we can now reconstruct the dynamics of Stellwagen during the 1970's and the first half of the 1980's, and answer some important questions about the nature of such marine ecosystems. The central principle to be learned is that Stellwagen is, like most ecosystems, dynamic. Change is inevitable and there is probably no such thing as a norm. In recent years in ecology we have come to recognize that ecosystems are in constant flux, and that stability is often only an illusion. Even the tropical rainforest, long the classic example of a stable diversified ecosystem, is now thought to be diversified because it is in constant flux and anything but stable. The history of events on Stellwagen Bank from the 1970's when we began our involvement with the whales of the area until the present reveals this dynamic and can now be interpreted in light of the past two summers.

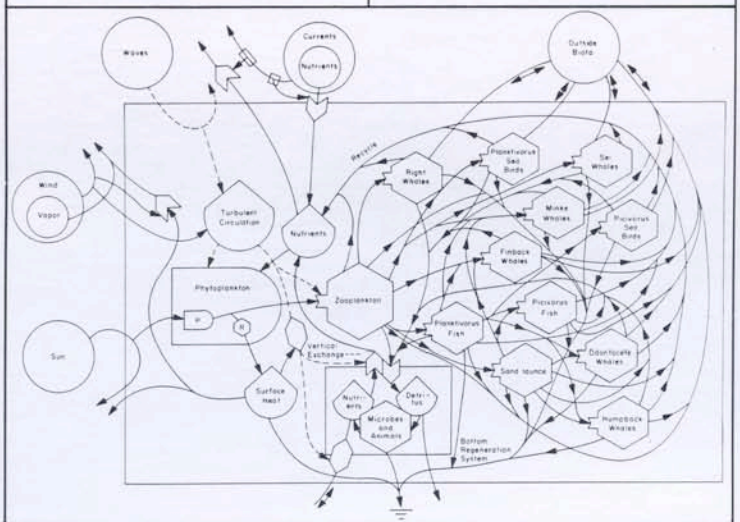

FIGURE 2
Model of Stellwagen Bank Ecosystem after the 1986 sand lance crash

On our first trips out of Provincetown in the mid 1970's we saw many finback whales. A humpback whale was seldom seen, and when they were spotted they tended to avoid boats. As the 1970's progressed the humpback whales became more frequent and the whale watching industry began to seek them out, presenting the illusion that they were more common than they really were. The behavior of the humpbacks began to change during the early years; when humpbacks were sighted they were usually feeding and showed little interest in boats, but as the 70's progressed we began to see more and more "friendly whale" behavior. Whales would approach boats, spy hop, swim under the boat, flipper slap, and breach near boats. Biologists speculated endlessly about the meaning of such behavior. As the 1980's began, we saw the peak of this behavior with many active whales on the bank, many of which had been returning for several years, and were well known as individuals to researchers, boat captains, and the public. This was the peak of whale-watching activity. However, in 1984 and 1985 a change occurred in the behavior of the humpbacks. Toward the end of the summer, in late July and August, the whales were observed feeding a great deal of the time. Spectacular displays of feeding activity occurred with interesting and varied strategies applied, including bubble clouding and bubble netting and the highly individualistic style of a whale called catspaw. Then came the events of 1986 and 1987.

What we now believe happened was that with the abundance of sand lance in the mid 1970's the humpback whale population on the bank was building. Thus, the observed increase in humpbacks was real. As the sand lance continued to build, or experienced only a slow decline, the humpbacks found feeding easy, and were able to spend less time feeding and more time in other activities and still achieve maximum energy assimilation. Display behaviors like flipper slapping and breaching became more common and logging, the whale equivalent of sleep, was more frequently observed. Close approaches increased and feeding activity became less commonly observed. These were fat, well-fed whales. Life was easy on Stellwagen. These were exciting times for whale researchers. From an interesting and unique novelty whale watching had become almost commonplace. However the support for this exuberance was changing.

As mentioned earlier, NMFS data indicated that from 1972 to 1985 the sand lance population had actually been slowly declining. The slow increase in the numbers of humpback whales during the early portion of this period was due to the very slow reproductive rate of humpbacks, again typical for a large vertebrate predator. By 1984 the humpback population on the bank had reached a number sufficient to begin to maximally exploit the slowly diminishing population of sand lance. This was reflected in the increased feeding activity observed during the later part of the summers of 1984 and 1985. These events set the stage for the crash in late 1985 or early 1986. When the humpbacks arrived in 1986 the sand lance population had already crashed and the ecosystem had changed dramatically.

Sand lance had served as the major secondary consumer on the bank. The primary consumers, the zooplankton, were heavily harvested by these fishes. A few competing secondary consumers such as

right whales were seen on Stellwagen during the early months of these years, but zooplankton resources were soon co-opted by the sand lance and the right whales, and other competing plankton feeders either left for better feeding conditions further north or remained in very small numbers. During this period the great numbers of sand lance tended to keep the zooplankton population in check. A fragile equilibrium existed during this period, as represented by figure 1, consisting of producers (primarily phytoplankton), zooplankton (primary consumers), sand lance (secondary consumers) and humpback and finback whales (tertiary consumers). There were several alternate energy flows such as additional tertiary consumers, including minke, *Balaenoptera acutorostrata*, whales, dolphins and piscivorous fishes (i.e. tuna and blue fish) but the major energy flow was through sand lance, humpback whales and finback whales. When the sand lance population crashed (and the humpback left), the zooplankton feeding the niche opened dramatically. Sand lance were replaced by a variety of planktonivorous animals including the right whales, sei whales, mackerel and other planktonivorus fishes, and the blue whale. The finbacks switched their diet. Thus, the bank's ecosystem came to resemble the system diagrammed in figure 2. Late December 1986 cruises on the R.V. Halos found humpbacks on the bank feeding primarily on mackerel.

One thing which seems clear is that the commercial whale-watching boats did not drive the whales away, as had been suggested by some amateur conservationists. When the sand lance were abundant and feeding was easy, the whales could probably achieve maximum energy assimilation levels, feeding only a few hours a day and giving them the free time to approach the boats and act in all those ways which made them so popular with the tourists. When the food supply began to decline, the whales returned to the important business of maximizing their energy intake. When they could no longer support their monstrous appetites on the bank (a ton of sand lance a day for each whale) they left. In all of this man appears to have been only an observer and did not influence the outcome.

What will the future of the bank be like? We, of course, cannot be sure, and ecological projection is inexact at best. However, it is not unreasonable to believe that the humpbacks will return again next spring and crop the surviving sand lance, thus keeping the sand lance population depressed. This pattern may be repeated for several years, with the early-arriving humpbacks keeping the sand lance down before departing for more productive feeding grounds elsewhere. Perhaps the pattern shown this past summer will be retained for several years. Many species which have depended upon the sand lance population, such as terns and carnivorous fish, may find feeding difficult. Other species which feed on plankton, like menhaden, storm petrels and herring, may increase. Eventually the humpbacks may stop returning to Stellwagen, having found better forage elsewhere. Perhaps then the sand lance population will begin to build again, leading to another cycle of sand lance abundance with eventual rediscovery and exploitation by humpback whales. Perhaps sand lance will not support the next cycle of humpback abundance, perhaps another planktonivorous fish like herring or caplin will build on the bank instead. It is these unknowns that make ecology an exciting and challenging science. We have had the opportunity of witnessing the dynamic flux of nature these past few summers on Stellwagen Bank, and the future cannot be predicted with any certainty. ■

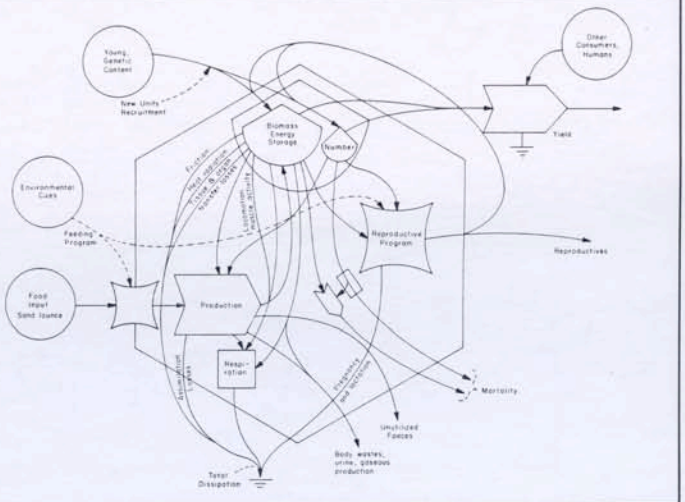

FIGURE 3
Energy diagram of the main sources and outflows of the Humpback whale population

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