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# Ben Franklin temperate reef and deep sea 'Agassiz Coral Hills' in the Blake Plateau off North Carolina



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## Abstract

This paper deals with two deep water coral ecosystems off the North Carolina coast, both under the depositional, erosional, and biological influence of the Gulf Stream and its eddies and episodic upwelling processes. The first coral community, Ben Franklin temperate reef, is located at 20 meters in Onslow Bay and is characterized by the ahermatypic coral *Oculina arbuscula* Verrill and unusually high abundance of the small predatory isopod *Eurydice bowmani* George and Longerbeam. The deep sea coral community, Agassiz Coral Hills, is located over the Blake Plateau at 650 meters, dominated by the fossilized, dead and living coral *Bathypsammia tintinnabulum*, with rare occurrence of the deep sea solitary coral *Flabellum goodei*. The deep sea coral sites were sampled with an otter trawl, outfitted with 'Benthos' flotation spheres. The results suggest that the fish and shrimp fauna exhibits high species richness in the Agassiz Coral Hills off North Carolina in comparison with a control site over the Blake Plateau off Florida. Species richness may be linked to episodic upwelling events along the Gulf Stream meanders. The fish fauna in the Agassiz Coral Hills includes the following two commercially important deep sea fish species: the wreck fish *Polyprion americanus* and the eel *Synaphobranchus koupi*. The Ben Franklin reef and the Agassiz Coral Hills are recommended as Marine Protected Areas.

## Introduction

In the temperate mid-latitudes of the Northwestern Atlantic Ocean off the coast of North Carolina, hard-bottom areas and rock out-crops occur sparsely in the foraminiferan sand floor of the continental shelf environment. The mid-shelf region off the North Carolina coast includes a luxuriant benthic community on these rock out-crops that support the growth of the ivory tree coral, *Oculina arbuscula*.

Schultz & McLoskey (1967) reported three species of isopod crustaceans associated with these ahermatypic corals in Onslow Bay off Cape Lookout, North Carolina. George & Longerbeam (1998) discovered a new species of flabelliferan predatory isopod, *Eurydice bowmani*, numbering in the hundreds on these mid-shelf temperate reefs from samples taken with light traps. Hernandez & Lindquist (1999) pointed out that light traps are suitable devices to document recruitment of fish larvae and juveniles over this reef ecosystem. Their observations indicated the great abundance of these small peracaridan crustacean predators, causing significant mortality of fish larvae.

In this paper, emphasis is placed on one selected temperate reef ecosystem: "Ben Franklin Temperate Reef", that is frequently under the influence of the Gulf Stream (originally charted by Benjamin Franklin). Ben Franklin reef is located in the "Lindquist *Oculina* Coral Masiffs (LOCOM)" in Onslow Bay, 23 miles from the North Carolina coast. Ben Franklin reef contains several sessile invertebrate species, including the coral *Oculina*, and is covered with a rich growth of several algal species. This paper discusses the data on the numerical abundance of the reef isopod, *Eurydice bowmani*, captured by the light traps in the spring and summer of 1995.

In a recent report, Kensley (1998) suggested that species richness of coral associated peracaridan crustaceans, as known from the literature today, is far less than the real diversity in nature. He estimated that there are approximately 54 500 species of peracaridan crustaceans (isopods, amphipods, cumaceans,

mysids and tanaids) associated with the world's coral reefs. Less than 5% of these species is now known to science and 95% of the species have yet to be described. It is important, therefore, to apply innovative techniques, such as the light trap and sound trap, to explore the biodiversity of these small cryptic peracaridan crustaceans in future studies on deep sea and tropical reefs.

The deep sea coral banks in the Blake Plateau, located at 700 to 850 m, 165 miles to the southeast off the South Carolina coast, originally discovered by Stetson et al. (1962), are similar to those first reported by Sars (1865). These deep sea coral reefs, despite their existence in the dark depths without any symbiotic zooxanthellae, are sources of appreciable deposits of calcium carbonate and constitute a variety of niches for small cryptic species and habitats for a variety of sessile benthos. The ahermatypic coral 'reefs' are also colonial forms with individual colonies reaching significant size. These aggregations of corals are essentially formed by asexually budded polyps that grow in irregular clusters. Le Danois (1948) described coral 'massifs' over the continental slope from the Porcupine Bank, off Ireland to Spain between 200 and 2000 m with the dominance of *Lophelia* and *Madrepora*. Stetson et al. (1962) recognized that the coral banks off South Carolina, between latitude 31° 44′ and 32° 03′ N and longitude 77° 32′ and 77° 34′ W, are dominated by *Lophelia prolifera* and *Dendrophyllia profunda*. Other coral species associated with these two species are *Bathypsammia* spp., *Balanophyllia* sp. and *Caryophyllia clavus*.

In this paper, a deeper coral bank northeast of Cape Fear, North Carolina, at the northern most boundary of the Blake Plateau between 650 and 750 m, is described. The coral bank is mostly dominated by a great abundance of *Bathypsammia tintinnabulum*, with rare occurrence of the solitary coral, *Flabellum goodei*. The growth of these scleractinian deep-sea corals in comparison with that of the shallow water coral *Montastrea annularis* from the Hen and Chicken reefs off the Florida Keys was the subject of a study done by this author in collaboration with Prof. C. Emiliani of the University of Miami (Emiliani et al., 1978). This reef community is rich in biodiversity of megafaunal shrimp and fish species, as evidenced from the samples of the otter trawls taken over the Agassiz Coral Hills on the Blake Plateau. Emphasis is placed on the relative abundance of the deep sea shrimp and fish species in the Agassiz Coral Hills off North Carolina in comparison with a control site in the Blake Plateau off Jacksonville, Florida.

This study examines the hypothesis that species diversity of coral associated decapods and demersal fish is significantly higher in the Agassiz Coral Hills than elsewhere in the Blake Plataeau.

## Materials and methods

The four chambered light traps, originally designed by Doherty (1987), were deployed over the Ben Franklin reefs (33° 59′ 63″ N, 77° 21 18′ W), located approximately 36.8 km offshore, northeast of Cape Fear in Onslow Bay at 20 m (see Hernandez & Lindquist, 1999 for trap design and see Potts and Hulbert, 1994 for site description). Light traps were deployed during two nights (April 18, 26) in the spring of 1995 and three nights (July 5, 6 and 20) in the summer of 1995. Light traps were connected at 1 m depth on a long-line at 50 m intervals and allowed to drift across the reef for 1 h before retrieval to the surface . The fish larvae were isolated from the trap samples in the laboratory of Dr David Lindquist at the University of North Carolina at Wilmington for assessment of fish recruitment processes over the reefs. The peracaridan crustaceans (isopods, amphipods, cumaceans, mysids and tanaids) from the trap samples were isolated in my laboratory under a Wild dissecting microscope. Each trap sample was aliquoted into 1/8 with a plankton splitting apparatus and two 1/8 aliquots were carefully sorted under a microscope to count each species. Two trap samples were used with 1/8 aliquots and this procedure provided four aliquots ($N$=4) for calculating mean and standard deviation. The sex ratio was determined for each aliquot for all species and the size frequency of each species was also assessed. The data were entered on a spread-sheet and bar diagram for density per hour in relation to season was generated using the Excel program.

The otter trawl, with two heavy metal doors as used in this study, was developed in collaboration with Dr John Staiger of the University of Miami for use over the Blake Plateau aboard R/V GILLISS. The 30 m long bridle with the two doors were deployed with a small hydrographic winch to allow the trawl to have a wide mouth of 10 m. However, trawling in the deep water was done with a large deep-sea winch with 1/2 inch cable after transferring the wire from the small winch to the large winch with a swivel-shift procedure. Benthos floats were attached to the upper lip of the

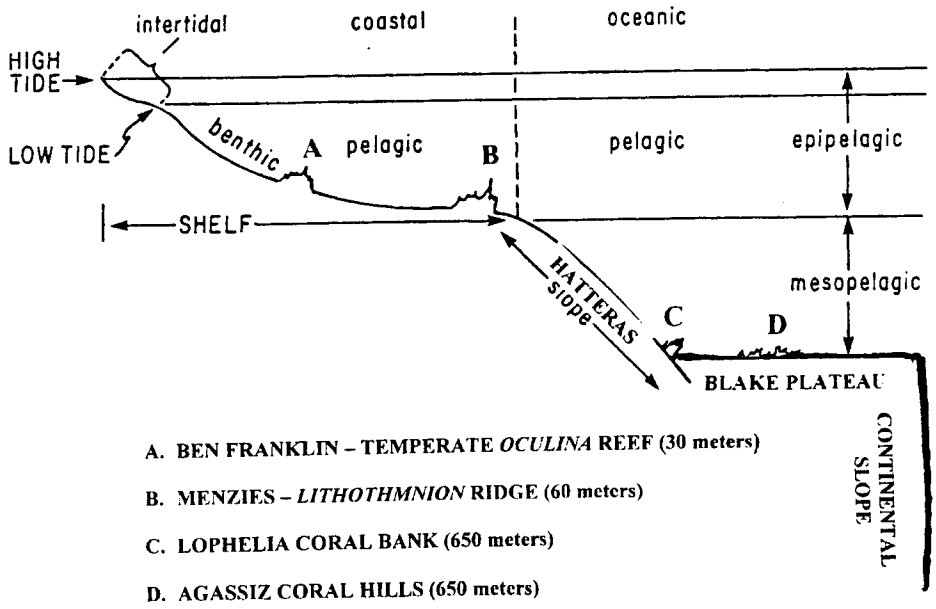


*Figure 1.* Topographic diagram showing the vertical profile of the continental shelf, Hatteras slope, the Blake Plateau off Cape Lookout, North Carolina. Note the study sites – Ben Franklin Reef (A) and the Agassiz Coral Hill (D).

trawl mouth to enable a wide vertical opening for entry of the benthopelagic fish and shrimps. These large fish were sorted into species and the relative abundance of each was determined on the deck. Selected samples of specimens of each species of fish were fixed with 95% ethanol. All shrimp specimens were transported to my laboratory for identification and sorting. At each station, the otter trawl was deployed three times in the Agassiz coral hills off North Carolina (32° 36.3′ N, 76° 57.7′ W, 650–750 m) and three times at the control site on the Blake Plateau off Florida (29° 30.8′ N. 77° 58.7′ W, 650–800 m).

## Results and discussion

*Abundance of predatory isopods on Ben Franklin Reef*

In 1995, the light trap samples above the Ben Franklin Reef (Fig. 1) contained 215–5980 *Eurydice bowmani* (isopods) per hour, with a clear indication of seasonal change in density. The isopod numerical abundance was significantly higher in the Spring (April 18) as shown in Figure 2. The average number of isopods captured nightly per hour on April 18 ranged from 1680 to 5980 individuals of three different size classes. The average number of the isopods captured nightly per hour on July 20, however, ranged from 215 to 680 individuals of two different size classes.

In the same light traps, larval and presettlement fish larvae, belonging to 34 fish families were captured (Hernandez & Lindquist, 1999). The herbivorous fish larvae and juvenile fish feed on diatoms. This study site over Ben Franklin reef is frequently, at least twice a month, subjected to episodic meandering of the Gulf Stream warm core rings and meanders (Fig. 3). On the basis of phytoplankton samples taken over the Ben Franklin reef, the following diatom species were identified: (1) *Rhizosolenia* – 18% (2) *Leptocylindricus* – 30% (3) *Thalassiothrix* – 6% (4) *Streptotheca* – 23% (5) *Chaetoceros* – 14% and (6) *Skeletonema* – (7%). Therefore, the fish larval abundance and diversity is probably a reflection of the increased diatom biomass associated with the spring bloom in temperate regions. The light trap samples frequently contained several mutilated fish larvae with devoured eyes, suggesting that these larvae were victims of carnivorous isopod predators. The precise role of this predation pressure on fish recruitment is unclear and calls for future studies.

It is of interest to note that the light traps did not capture any one of the three isopod species, the asellote *Joeropsis coralicola*, the idoteid *Erichsonella filiformis* or the flabelliferan *Paracerceis tomentosa*, previously known as cryptic species associated with the ahermatypic coral *Oculina arbuscula* (Schultz and McLoskey, 1967). The light traps evidently attracted the natatory isopods, adapted for swimming and a predatory life-style.

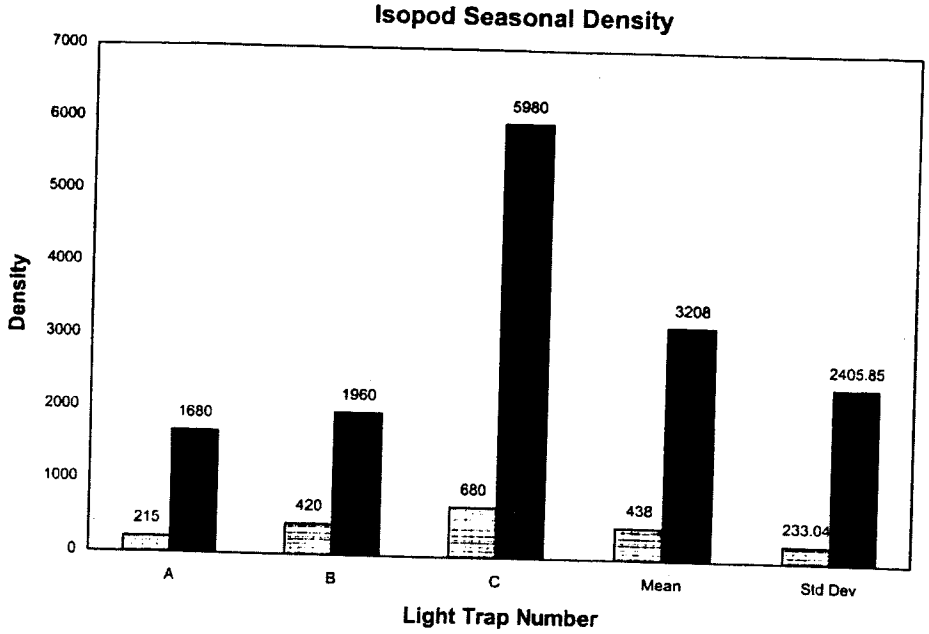


*Figure 2.* Number if Isopods attracted to the light traps in three night deployments over one hour at one meter above the Ben Franklin Reef (A. B & C shown on the left) and the mean number of isopods captured per hour, Spring (April 18, 1995) *versus* Summer (July 20, 1995), shown on the right. Dark indicates spring.

*Species richness of demersal shrimp and fish over the Agassiz Coral Hills*

The results of the otter trawl samples over the Agassiz Hills (Fig. 1) on the Blake Plateau revealed the presence of five penaeid shrimp species, with the occurrence of two sympatric species of the genus *Hymenopenaeus* (Table 1). In contrast, only two species of penaeid shrimp were captured in the otter trawls over the Blake Plateau control site off Florida. *Hymenopenaeus debilis* was found at both sites but it was significantly more abundant in the Agassiz Coral Hills. *Benthesicymus bartletti* was absent in the coral hills off North Carolina.

The high species richness of shrimp fauna in the Agassiz coral hills is evident from the presence of 13 caridean species, belonging to 11 genera and 7 families (Table 2). In the control site, only five caridean shrimp species were captured. The Agassiz coral hills contained two sympatric species of the genus *Systelaspis* (*S. braueri* and *S. debilis*). *S. debilis* was also found in the control site off Florida. However, the other four species from the control site, *Oplophorus grimaldi*, *Nematocarcinus* sp., *Parapasiphae sulcatifrons* and *Stylodactylus serratus* were absent from the Agassiz Coral Hills.

The higher species richness of the shrimp species in the Agassiz Coral Hills is possibly attributed to the following two reasons: (1) The Coral Hill area over the Blake Plateau (Fig. 4) covers hard substrata with diversified niches that developed in the course of evolution, thus accommodating a rich variety of shrimp species. (2) The Coral Hills offer favorable feeding conditions, possibly under the influence of episodic upwellings over the Agassiz Coral Hills, as opposed to the site off Florida, promoting the emergence of abyssal species from the upper Carolina continental slope (1000–3000 m). This trend is clear from the presence of four caridean shrimp species and two abyssal penaeid species in the Agassiz Coral Hills that are also captured by the otter trawls over the continental slope (Table 3). The deep sea panaeid red shrimp *Plesiopenaeus edwardsianus* has a wide bathymetric range from 600 to 5200 m off North Carolina coast. Nevertheless, this shrimp species is more abundant on the Agassiz Coral Hills between 700 and 850 m.

The demersal fish fauna over the Agassiz Coral Hills included 24 fish species, belonging to 20 genera and 16 families (Table 4). The ichthyofauna is much impoverished at the control site off Florida. Four deep sea fish species, that were captured at the control site, include *Etmopterus bullis*, *Breviraja plutonia*, *Nezumia aqualis* and *Nezumia bairdi*. All four species occurred at higher densities at the Agassiz Coral Hills. However, the commercially important rattail fish, *Coryphenoides armatus*, was twice as abundant at the Florida site (34 per trawl) than the North Caro-

*Table 1.* Deep Sea Penaeid Shrimp Species in the Blake Plateau in the Agassiz Coral Hills off North Carolina and the control site off Jacksonville, Florida. (In parenthesis the mean number of shrimps caught per trawl ($N$=3) is given)

| Family Penaeidae | Agassiz Coral Hills (Off North carolina) | Control Site (Off Florida) |
|---|---|---|
| 1. *Hymenopenaeus debilis* | XX (26) | X (4) |
| 2. *Hymenopenaeus aphoticus* | X (7) | 00 |
| 3. *Gennadas elegans* | X (9) | 00 |
| 4. *Funchalia villosa* | X (5) | 00 |
| 5. *Plesiopenaeus edwardsianus* | XX (14) | 00 |
| 6. *Benthesicymus bartletti* | 00 | X (4) |
| Total Number of genera: | 4 | 2 |
| Total Number of species: | 5 | 2 |

lina site (17 per trawl). Midwater trawls taken above the Agassiz coral hills revealed a variety of pelagic species including squids and mid-water fishes. *Coryphaenoides armatus* is known to prey upon pelagic species despite their residence over the benthic habitats of the Blake Plateau and over the northern slopes (Haedrich & Hendersen, 1974).

Two other commercially important deep sea fish species occur at the Agassiz Coral Hills. These species are: (1) the deep sea eel *Synaphobranchus kaupi* (16 per trawl) and (2) the deep sea wreck fish *Polyprion americanus*, which is previously known to inhabit the hard bottom areas, usually between 400 and 650 m, and occasionally penetrating to depths as great as 1800 m. The maximum catch of this deep sea fish attained as much as 6 million pounds per year in 1995. The wreckfish reaches a maximum length of 6 feet, weighing as much as 100 kg. Because of the fishing pressure, the maximum sustainable population for this deep sea fish was established as 1.2 million pounds per year by the South Atlantic Fishery Management Council (Vaughan & Manooch, 1993 and 1995).

The deep sea wreckfish is a K-strategist, similar to the orange roughy, *Hoplostethus atlanticus*, with a life span of approximately 40 years. Therefore, fishing pressure can bring about irreversible damage to the fish stock. There is definitely more research needed to document the distribution of the wreckfish in relation to Agassiz Coral Hills on the Blake Plateau.

Markle et al. (1988) discovered that the numerically dominant demersal fish species around 800 m on the upper continental slope off Nova Scotia (St. Pierre Banks) are *Phycis chesteri*, *Sebastes* spp. and *Glyphocephalus cynoglossus*. The first two species were not found over the Blake Plateau, but *G. cynoglossus* was captured in this study over the Agassiz coral hills. The rattail *Nezumia bairdi* was abundant off Nova Scotia but low in density at the Blake Plateau site off North Carolina. Off Nova Scotia, the rattail, *Coryphenoides rupestris*, is the most common deep sea fish but off North Carolina another congeneric species *C. armatus* was more common in the deep sea. Nevertheless, the ubiquitous deep sea eel, *Syphanobranchus kaupi*, tends to occur both off Nova Scotia and off North Carolina.

The comparison of decapod fauna between Nova Scotia and North Carolina deep sea sites at 800 m presents a similar picture to that of the deep sea ichthyofauna. The most dominant shrimp species off Nova Scotia, such as *Pandalus propingus* and *Pontophilus norvegicus*, are absent from the Agassiz coral hills. However, the ubiquitous deep sea red shrimp, *Plesiopenaeus edwardsianus*, occurs at 400 m off Nova Scotia and at much deeper depths off North Carolina, suggesting the phenomenon of midlatitude submergence. The only caridean shrimp species common to Nova Scotia slope and the Blake Plateau is *Sabinea hystrix*, even though this species is far more dense at St.Pierre Banks. The most abundant shrimp species in the Agassiz coral hills is the caridean *Nematocarcinus cursor* (238 per trawl). Agassiz (1888) first reported this species from the Blake Plateau during the three cruises of the Blake. The relative abundance of this species on the Blake Plateau off North Carolina suggests that this species plays an important role in the food chain as prey species for benthic fish species like the rattail, *Coryphaenoides armatus*.

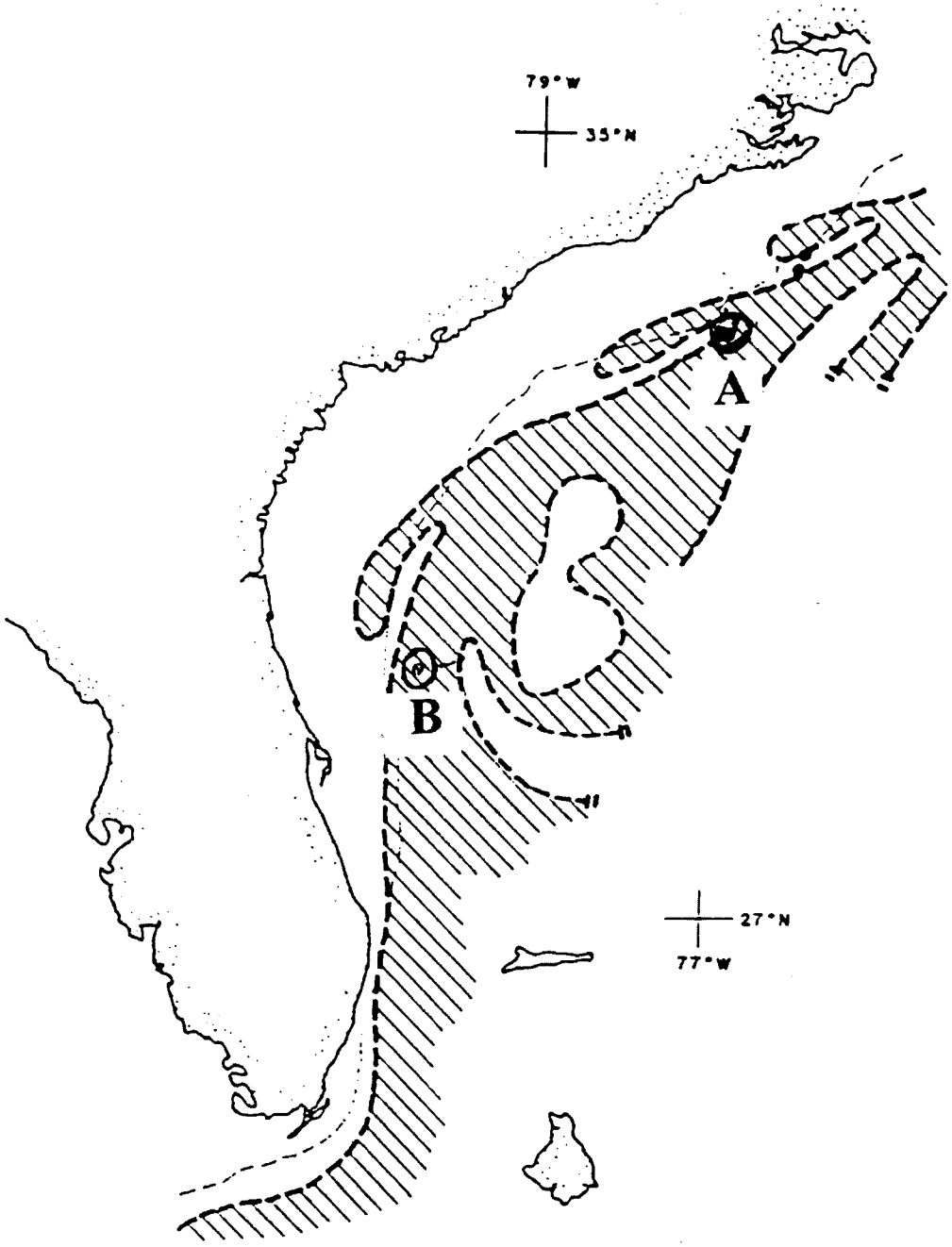


*Figure 3.* The Gulf Stream off Southeastern United States with finger-like eddies from the western wall of the Gulf Stream. Note the study sites over the Blake Plateau (A), off Cape Fear, North Carolina and (B), off Jacksonville, Florida.

Abele (1974, 78), while elucidating the species diversity of decapod crustaceans in marine habitats, including the coral *Pocillopora* community on the Pacific coast of Panama, concluded that species richness of decapods is significantly higher in constant (stable) environments than in fluctuating environments (Pearl Island reefs). He encountered 55 decapod species in the coral heads of *Pocillopora damicornis* in a stable locality and 37 decapod species at a fluctuating locality. The 55 decapod species include anomuran and brachyuran crabs, lobster species and shrimp fauna. Shrimp species diversity in the Agassiz coral hills with 18 coexisting species is possibly attributed to the rich niche diversification in this hard bottom zone of the Blake Plateau and the benthic pulse of organic carbon from the episodic upwellings between the western wall of the Gulf Stream (Fig. 5) and the shelf-ward protruding meander (George & Lindquist, 1999). This

*Table 2.* Deep Sea Caridean Shrimp species in the Blake Plateau in the Agassiz Coral Hills off North Carolina and the control site off Florida. (In parenthesis the mean number if shrimp caught per trawl ($N$=3) is given)

| | Agassiz Coral Hills (Off North Carolina) 650–750 m | Control Site (Off Florida) 700–800 m |
|---|---|---|
| A. Family: Pandaleidae | | |
| 1. *Plesionika martia* | XX (17) | 00 |
| 2. *Parapandalus richardi* | X (3) | 00 |
| B. Family: Oplophoridae | | |
| 3. *Systellaspis braueri* | X (9) | 00 |
| 4. *Systellaspis debilis* | X (6) | X (4) |
| 5. *Acanthephyra purpurea* | X (12) | 00 |
| 6. *Heterogenys microphthalma* | X (14) | 00 |
| 7. *Oplophorus grimaldi* | 00 | X (6) |
| 8. *Janicella spinicauda* | X (8) | 00 |
| 9. *Hymenodora gracilis* | X (14) | 00 |
| C. Family: Nematocarcinidae | | |
| 10 *Nematocarcinus cursor* | XXX (238) | 00 |
| 11. *Nematocarcinus* sp. ? | 00 | X (7) |
| D. Family: Pasiphaeidae | | |
| 12. *Pasiphae merriami* | 00 | X (9) |
| 13. *Parapasiphae sulcatifrons* | XX (24) | 00 |
| E. Family: Bresiliidae | | |
| 14. *Lucaya bigelowi* | XX (6) | 00 |
| F. Family: Stylodactylidae | | |
| 15. *Stylodactylus serratus* | 00 | X (2) |
| G. Eugonatonotidae | | |
| 16. *Eugonatonotus crassus* | X (6) | 00 |
| H. Family: Crangonidae | | |
| 17. *Sabinea hystrix* | X (7) | 00 |
| Total Number of species: | 13 | 5 |
| Total Number of genera: | 11 | 5 |
| Total Number of families: | 7 | 3 |



hypothesis on the influence of upwelling process on the species richness and abundance in the northern most part of the Blake Plateau needs testing.

In a project done in collaboration with Prof. C. Emiliani of the University of Miami, the K-strategy of the coral, *Bathypsammia tintinnabulum*, was earlier established with evidence of slow growth in comparison with rapid growth of shallow water coral, *Montastrea annularis*, from Hen and Chicken Reefs of the Florida Keys (Emiliani et al., 1978). Carbon and oxygen isotope analysis through a 30-year (1944–1974) growth of *Montastrea annularis* shows a strong yearly variation in the abundance of both carbon-13 and oxygen-18 and a broad inverse relationship between the two isotopes. The isotopic results on the deep sea coral, *Bathypsammia titinnabulum*, where Zooxanthellae are nonexistent, indicates that the abundance of the heavy isotopes cabon-13 and oxygen-18 is inversely related to growth rate, with both carbon and oxygen approaching equilibrium values with increasing skeletal age. It became apparent from this study that strong yearly isotopic variations

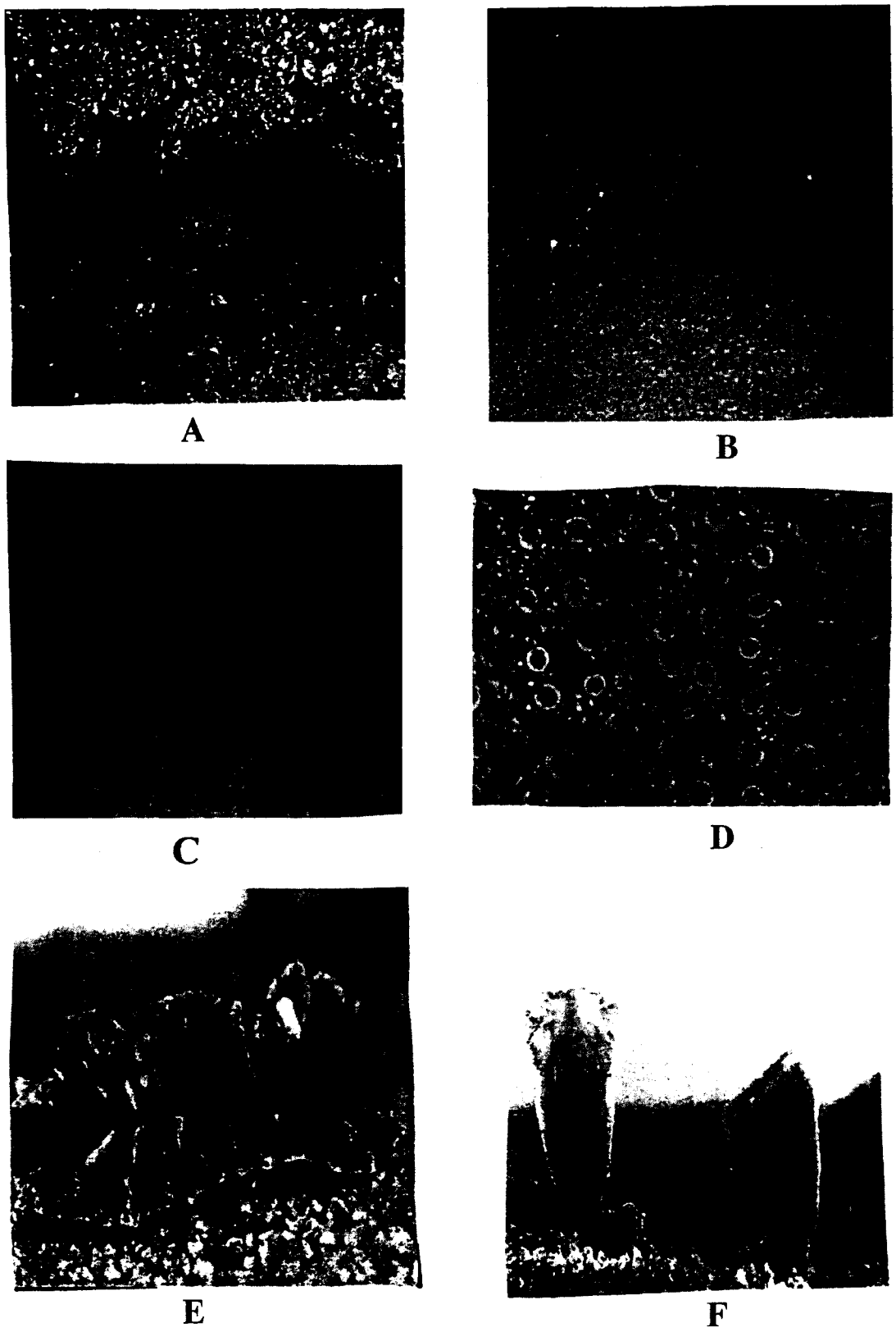


*Figure 4.* (A) *In situ* photograph of Ben Franklin reef. (B) *In situ* photograph of a square meter of the sea floor over the Agassiz Coral Hills. Note the presence of the coral *Bathypssamia tintinnabulum* and the deep sea hermit crab *Parapagurus pilosimanus*. (C) Ripple marks on the sea floor bathed by gulf stream in the vicinity of Ben Franklin reef. (D) Enlarged picture of a cluster of the deep sea coral from Agassiz Coral Hills. (E) Photo of a living deep sea coral *Flabellum goodei*. (F) Photo of living coral *Bathypssamia tininnabulum*.

*Table 3.* Deep Sea shrimp species emerging from Continental slope sites to Agassiz Coral Hills over the Blake Plateau off North Carolina (Mean number of three otter trawls)

| | Agassiz Coral Hills | Carolina Slope |
|---|---|---|
| A. Caridean Shrimp Species: | | |
| 1. *Systelaspis braueri* | 9 per trawl | 3 per trawl |
| 2. *Systelaspis debilis* | 6 per trawl | 2 per trawl |
| 3. *Acanthephyra microphthalma* | 14 per trawl | 2 per trawl |
| 4. *Parasiphae sulcatifrons* | 24 per trawl | 6 per trawl |
| B. Panaeid Shrimps | | |
| 5. *Hymenopenaeus debilis* | 26 per trawl | 4 per trawl |
| 6. *Plesiopenaeus edwardsianus* | 14 per trawl | 3 per trawl |

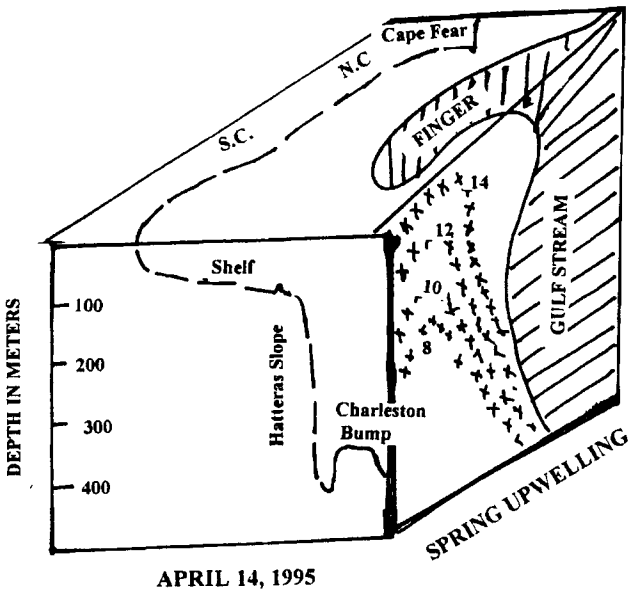


*Figure 5.* Upwelling event between the western wall of the Gulf Stream and the finger-like gulf stream protrusion above the Agassiz Coral Hills on April 14, 1995.

occur in the growth of the shallow reef coral, *Montastrea annularis*. The deep sea coral, whose skeleton seldom exceeds 2.5 cm in height, exhibits regular and irregular growth rings. These epithecal rings may represent a longer growth period and greater amplitude than those of *Montastrea annularis*.

## Conclusions

'Ben Franklin reef', located 36.8 kilometers offshore from Cape Fear, North Carolina, is characterized by high species richness of small peracaridan crustaceans

*Table 4.* Deep Sea Fish Species from the Agassiz Coral Hills from the Blake Plateau and from the control site off Florida in the Blake Plateau at a similar isobath (650 m) (*Commercially important deep sea fish species) (In parenthesis the mean number for 3 otter trawls is given)

| | Agassiz Coral Hill (Off North Carolina) 650–750 m | Control Site (Off Florida) 700–800 m |
|---|---|---|
| A. Family: Myxinidae | | |
| 1. *Myxine glutinosa* | XX (18) | 00 |
| B. Family: Squalidae | | |
| 2. *Etmopterus bullis* | XX (12) | X (3) |
| C. Family: Rajidae | | |
| 3. *Breviraja plutonia* | X (8) | X (2) |
| D. Family: Congidae | | |
| 4. *Pseudophichthys splendeus* | XX (14) | 00 |
| E. Family: Synaphobranchidae | | |
| 5. **Synophobranchus koupi* | XX (16) | 00 |
| F. Family: Haulosauridae | | |
| 6. *Aldrovandia phalacra* | X (9) | 00 |
| 7. *Haulosaropsis macrochir* | X (2) | 00 |
| G. Family: Chlorophthalamidae | | |
| 8. *Chlorophthalmus agassizi* | XX (52) | 00 |
| H. Family: Serranidae (grouper family, not bass family Percichthidae) | | |
| 9. **Polyprion americanus* (Wreck Fish) | XX (14) | 00 |
| I. Family: Ogcocephalidae | | |
| 10. *Dibranchus atlanticus* | X (9) | 00 |
| J. Family: Moridae | | |
| 11. *Antimora rostrata* | X (2) | 00 |
| 12. *Laemonema barbatulum* | X (3) | 00 |
| K. Family: Gadidae | | |
| 13. *Urophysis chesteri* | X (4) | 00 |
| 14. *Urophysis regius* | X (8) | 00 |
| L. Family: Merluciidae | | |
| 15. *Merlucius albidus* | XX (22) | 00 |
| M. Family: Zoarcidae | | |
| 16. *Lychenchelys verrili* | XX (24) | 00 |
| 17. *Lycodes Sp. ?* | X (1) | 00 |
| 18. *Lycodes brunneus* | X (6) | 00 |
| N. Family: Macruridae (rat-tail fish) | | |
| 19. *Coryphenoides armatus* | XX (17) | XX (34) |
| 20. *Bathygadus melanobranchus* | X(2) | 00 |
| 21. *Nezumia aqualis* | XX (18) | XX (12) |
| 22. *Nezumia bairdi* | X (6) | X (4) |
| O. Family: Bothidae | | |
| 23. *Cithachthys arctifrons* | X (2) | 00 |
| P. Family: Pleuronectidae | | |
| 24. *Glytocephalus cynoglossus* | X (3) | 00 |
| Number of deep sea fish species | 24 | 5 |
| Number of deep sea fish genera | 20 | 4 |
| Number of deep sea fish families | 16 | 3 |

(isopods) with a pronounced numerical abundance (in hundreds) of the predatory isopod, *Eurydice bowmani*. These crustaceans, associated with the *Oculina* coral community, previously unknown, now have come to light on the basis of innovative light trap studies over the Ben Franklin Reef.

Agassiz Coral Hills', dominated by the deep sea coral, *Bathypsammia tintinnabulum*, at the northern most extremity of the Blake Plateau at 650–750 m, exhibits high species richness of shrimp and fish fauna, with the incidence of three commercially important deep sea fish species: (a) Wreckfish *Polyprion americanus* (b) deep sea eel *Synaphobranchus kaupi* (3) grenadier (rattail fish) *Coryphenoides armatus* and two commercially important deep sea decapod species (a) deep sea red crab *Chaceon quinquedens* and (b) deep sea red shrimp *Plesiopenaeus edwardsianus*.

The results of this study on Ben Franklin Reef and Agassiz coral hills over the Blake Plateau provide impetus to create a "Marine Protected Area (MPA)" in a National Marine Sanctuary in Onslow Bay off the North Carolina coast for conservation that curtails over-fishing, prevents oil and gas drilling, and precludes phosphorite polymetalic nodule mining activities (Thiel, 1991), restricts large scale ecological research (Thiel et al., 1998) and limits otter-trawling with heavy metal doors for the benefit of future generations.

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The etymology of the two coral reef ecosystems. discussed in this paper, is as follows: "Ben Franklin Reef" is named in honor and memory of the renowned American scientist and political philosopher Benjamin Franklin for his original description of the Gulf Stream. "Agassiz Coral Hills" are named in honor and memory of the American founder of 'deep sea biology' Alexander Agassiz of Harvard University for his original studies aboard the US Coast and Geodetic Survey Steamer *Blake*.

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