

Do Low-Salinity, Rock Jetty Habitats Serve as Nursery Areas for Presettlement Larval and Juvenile Reef Fish?

FRANK J. HERNANDEZ, JR.¹, RICHARD F. SHAW¹, JOSEPH S. COPE², JAMES G. DITTY³ and TALAT FAROOQI¹

¹*Department of Oceanography and Coastal Sciences, Coastal Fisheries Institute, Louisiana State University
Baton Rouge, LA 70803 USA*

²*Pfleger Institute of Environmental Research
1400 N. Pacific St.,
Oceanside, CA 92054 USA*

³*NOAA/NMFS, Fish Ecology Section
4700 Ave. U
Galveston, TX 77551 USA*

ABSTRACT

Previous investigations of artificial reef habitat in the northcentral Gulf of Mexico have identified the importance of offshore oil and gas platforms to economically-important reef fish. This study investigated the potential importance of another structurally-complex, hard-substrate habitat, a coastal rock jetty system, as a low-salinity, landward endmember of artificial reefs along a transect of three oil and gas platforms extending from the inner continental shelf to the shelf break. Quatrefoil light-traps and a bow-mounted plankton pushnet were used to collect fish along a pair of stone rubble jetties at Belle Pass near Fourchon, Louisiana during new moon and full moon phases from April to August, 1997. Light-traps and the pushnet collected 17,949 and 111,854 fish, respectively. Clupeiformes (engraulids and clupeids) comprised approximately 95% and 70% of the total light-trap and pushnet catch, respectively. Reef (or structure-dependent) fish, though not as abundant, included blennies, gobies, eleotrids, sparids, and lutjanids. The pushnet collected more individuals and taxa than did the light-trap. There were significantly higher pushnet densities and light-trap catch-per-unit-efforts (CPUEs) during new moon periods than full moon periods. This result may reflect a gear avoidance phenomenon where light-traps are more effective when not competing with the ambient light of a full moon and the pushnet is more effective under the darkness of new moon. An alternative hypothesis could also be related to lunar spawning and/or settlement periodicities. Significantly lower densities and CPUEs were observed at sampling stations located within the jetty walls versus stations located externally. This result may be related to possible differences in environmental parameters (turbidity, temperature, salinity, and dissolved oxygen) between inner (estuarine) and outer (coastal) sampling stations. Preliminary results indicate

that the jetty may serve as a refuge area for presettlement reef fish in the absence of other structurally-complex habitat.

KEY WORDS: Rock jetty, nursery area, presettlement reef fish

INTRODUCTION

There are approximately 4,500 oil and gas platforms in the Gulf of Mexico, many of which serve as artificial reef habitat for economically-important reef fish (CDOP 1985, Gallaway 1981, Rooker et al. 1997). A debate persists, however, as to whether or not the fish associated with these structures and other artificial reefs are the result of increased fish production or simply aggregation (Bohnsack 1989, Pickering and Whitmarsh 1997, Seaman and Sprague 1992). Bohnsack et al. (1994) state that a major problem for managing reef resources is the incomplete understanding of the interactions between recruitment and habitat structure. In an effort to address questions concerning reef fish seasonality and across-shelf distribution, we have sampled extensively the early life history stages at several artificial reef habitats, including platforms located on the shelf slope (220 m depth), mid-shelf (61 m depth), inner shelf (22 m depth). This paper addresses preliminary results from the coastal endmember of this cross-shelf transect and another potentially important artificial habitat, a low-salinity, rock jetty system.

Many species of reef fish do not settle directly onto reefs but utilize other coastal habitats as nursery grounds prior to moving to offshore reefs. While habitats such as high-salinity seagrass beds are important to many reef related species (Connolly 1994), other structurally-complex habitats have been identified as nurseries (Ferrell and Bell 1991, Bennett 1989, Ross and Moser 1995). Seagrass beds are often the most common form of shelter available in certain settlement areas, but experimental evidence suggests that presettlement larvae of a number of different species select any complex structure at the time of settlement (Bell et al. 1987). Due to the overwhelming influence of the Mississippi River and its tributaries, Louisiana estuarine and coastal areas are generally low salinity, turbid, and lacking in seagrass beds and naturally-occurring hard substrate habitats (except for oyster reefs).

The objective of this study was to determine the composition and abundance of postlarval and juvenile fish inhabiting a coastal Louisiana jetty environment with particular emphasis on reef fish taxa. In addition, we were interested in comparing the light-trap and plankton pushnet methodologies in a low-salinity, turbid environment.

MATERIALS AND METHODS

The study was conducted along a pair of stone rubble jetties located at the terminus of Belle Pass, a major shipping channel near Fourchon, Louisiana, USA (29° 03.90' N, 90° 13.80' W). The jetties are approximately 91 m apart and run in a general north-south direction (Figure 1). The east jetty is approximately 335 m long and the west jetty is approximately 305 m long. Depths along the jetties ranged from 3 - 5 m. For sampling purposes, the sides of the jetties were labeled as East Exterior (EE), East Interior (EI), West Interior (WI), and West Exterior (WE). Four sampling stations, one on each side of each jetty, were located approximately at the jetty midpoints and were identified during sampling by distinct rock outcroppings.

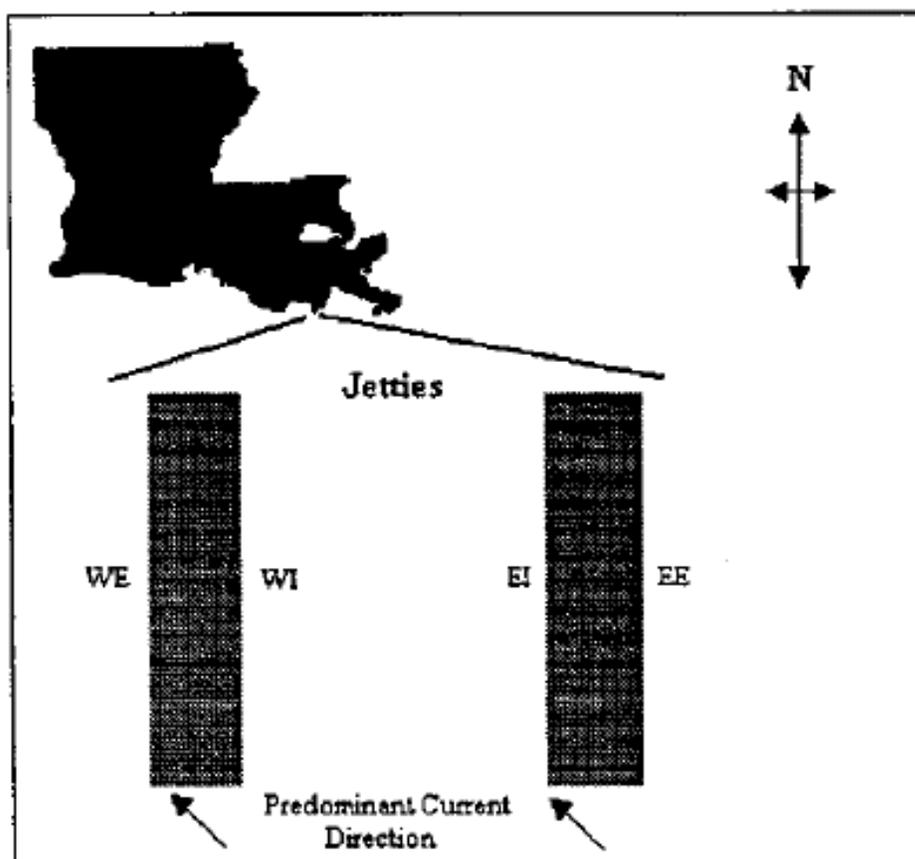


Figure 1. Schematic diagram of the study site with the sampling stations: west exterior (WE), west interior (WI), east interior (EI), and east exterior (EE).

A quatrefoil light-trap and a bow-mounted push plankton net were used to collect fish during two consecutive nights around new and full moon periods in 1997 from April through August, the estuarine recruitment period for a large

number of our reef fish. New and full moon lunar phases were chosen because previous studies have indicated that reef fish exhibit lunar patterns in both spawning and recruitment (Robertson 1992, Kingsford and Finn 1997). Two sets of samples were taken each night. A set included a light-trap and a bow-mounted pushnet sample at each of the four stations. The order of stations sampled within each set was chosen using a random number table. Light-traps were equipped with a Brinkman Q Beam Starfire II halogen fishing light (12-v, 250 000 candlepower) and a submersible battery that was secured to the top of the light-trap with bungee cords. A 1000 μm mesh size was used for the bottom draining cod end. At each station, a buoyed mooring was used to suspend the light-trap approximately 1 m below the surface as close to the jetty as possible, which was usually between 0.5 - 2 m of the surface- exposed rock. The light-trap was allowed to fish for 10 minutes. Then, a bow-mounted pushnet with a 1000 μm mesh net mounted on a 1 m x 1 m frame was fished subsurface along the edge of the jetty for 3 - 5 minutes. A General Oceanics flowmeter (large rotor) was used to determine the volume of water filtered. All samples were fixed in 2 - 4% buffered formaldehyde. Subsurface and nearbottom salinity, temperature, dissolved oxygen, and turbidity were measured at each station using a DataSonde 3 Hydrolab and a DataSonde 3 Multiprobe Logger. Within 12 hours of collection all samples were rinsed and switched to an 80-90% ethanol solution. A projected 352 samples were to be collected [(5.5 months x 2 trips/month x 2 nights/trip x 2 sets/night x 4 jetty stations x (1 light-trap + 1 push trawl))] over the course of the study. However, not all stations were sampled equally due to adverse weather conditions and/or equipment failure. A total of 297 samples (148 light-trap samples and 149 push trawl samples) were collected and analyzed.

Samples were picked for all fish larvae, juveniles, and adults. Fish were measured to the nearest mm with an ocular micrometer (<10 mm) or a small ruler (>10 mm) and identified to the lowest possible taxonomic level. Preflexion larvae were measured to the end of the notochord (NL) and all postflexion larvae, juveniles, and adults were measured to the posterior end of the vertebral column (SL). Due to the very large numbers of clupeiform fishes (clupeids and engraulids), statistical analyses were performed on the data without all clupeiform fish, since these fish are seldom the taxa of interest in reef studies and their abundance tends to overwhelm the trends of other taxa (Choat et al. 1993). Light-trap samples were standardized to a catch-per-unit-effort (CPUE) of fish per minute. An ANOVA was run on the rank-transformed CPUEs for the effects of lunar phase and station location. Also customized comparisons were made using contrast statements in the SAS statistical package to test for differences between different combinations of the jetty stations, such as east stations vs. west and internal stations vs. external. Pushnet samples were

standardized to the number of fish per 100 m³ (density) and the same ANOVA design was run on the log-transformed mean densities for the pushnet data.

RESULTS

The light-trap and pushnet collected 17,949 fish and 111,854 fish, respectively. Catches by both gear types were dominated by clupeiform fishes (engraulids and clupeids) which comprised 95.26% of the light-trap total catch and 68.32% of the total pushnet catch. Only one non-clupeiform species, *Membras martinica* (Atherinidae), comprised over 1% of the total light-trap catch. Non-clupeiform taxa collected by the pushnet that comprised over 1% of the total catch include an unidentified gobiid (referred to as Goby Type I), *Cynoscion arenarius* (Sciaenidae), *Gobionellus oceanicus* (Gobiidae), *Citharichthys* sp. (Bothidae), *Symphurus* sp. (Soleidae), and *Microgobius* sp. (Gobiidae). Though not as common as other taxa, reef fish taxa were collected by both gear types (Table 1). The light-trap collected individuals from four reef fish families, while the pushnet collected fish from 12 reef fish families. Overall, the light-trap collected fish from 21 families with 38 taxa identifiable to at least the genus level. The pushnet collected fish from 41 families with 80 taxa identifiable to at least genus. The most dominant taxa were presettlement blenniids and gobiids. All taxa sampled with the light-trap were also collected by the pushnet but in greater numbers.

Mean light-trap CPUEs for each trip ranged from 0 – 1.48 fish per minute (Figure 2). The ANOVA on the ranks of mean CPUE values (minus clupeiforms) indicate significantly higher CPUEs occurred during new moon phases than full. There was also a significant difference between the different sampling stations, with significantly higher CPUEs occurring at the external (WE and EE) stations than the internal (WI and EI) stations (Figure 3).

Mean pushnet densities for each trip ranged from 18 – 288 fish/100 m³ (Figure 4). ANOVA results on the log-transformed, pushnet mean densities also indicated that significantly more fish were collected during new moon phases than full. Significantly higher densities also occurred at the external stations vs. the internal stations (Figure 5).

Table 1. List of reef fish taxa and the total number of each collected with light-traps (LT) and pushnet (PN) during the course of the study.

Taxon	Total Number	
	LT	PN
Blenniidae		
<i>Chasmodes</i> sp.		1
<i>Hypleurochilus bermudensis</i>		1
<i>Hypsoblennius hentz/onthas</i>	154	551
<i>Scartella</i> sp.	4	87
Unidentified	3	7
Eleotridae		
<i>Bathygobius soporator</i>		3
<i>Dormitator maculatus</i>	18	252
Unidentified	3	53
Ephippidae		
<i>Chaetodipterus faber</i>		13
Gobiidae		
<i>Gobionellus oceanicus</i>	16	2201
<i>Gobiosoma bosc</i>		11
<i>Gobiosoma</i> sp.	40	402
<i>Microgobius</i> sp.	7	1175
Type I	88	11890
Unidentified	4	231
Haemulidae		
Unidentified		1
Labridae		
Unidentified		3
Lutjanidae		
<i>Lutjanus griseus</i>	2	18
<i>Lutjanus synagris</i>		8
Unidentified	1	
Mullidae		
Unidentified		1
Rachycentridae		
<i>Rachycentron canadum</i>		2
Serranidae		
<i>Mycteroperca</i> sp.		1
Scaridae		
<i>Sparisoma</i> sp.		4
Sparidae		
Unidentified		9

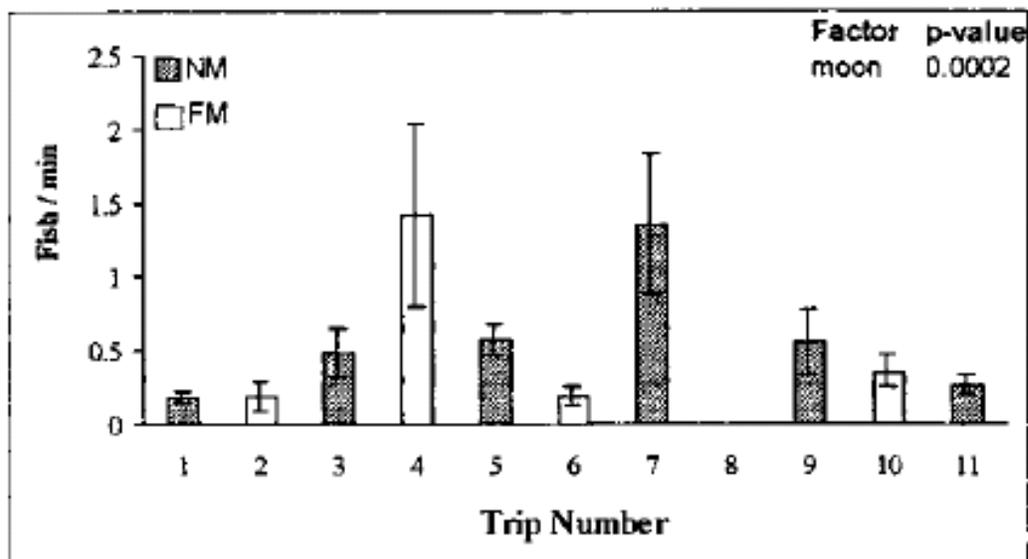


Figure 2. Mean light-trap CPUEs (minus clupeiforms) for each sampling trip. Open columns indicate trips during full moon phases and dark columns indicate trips during new moon phases. Error bars are standard errors of the mean.

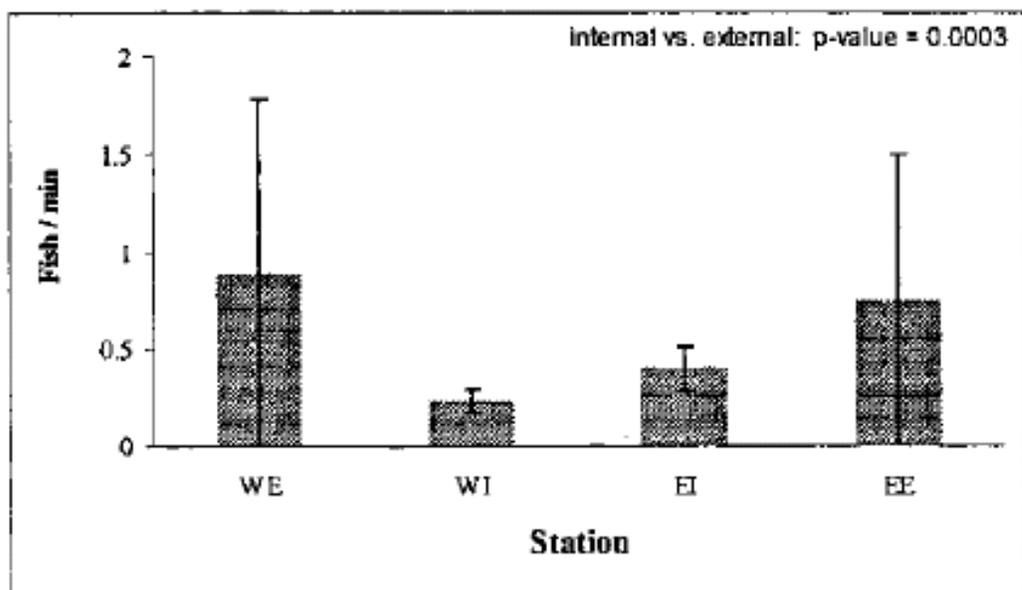


Figure 3. Mean light-trap CPUEs (minus clupeiforms) for each sampling station. Error bars are standard errors of the mean.

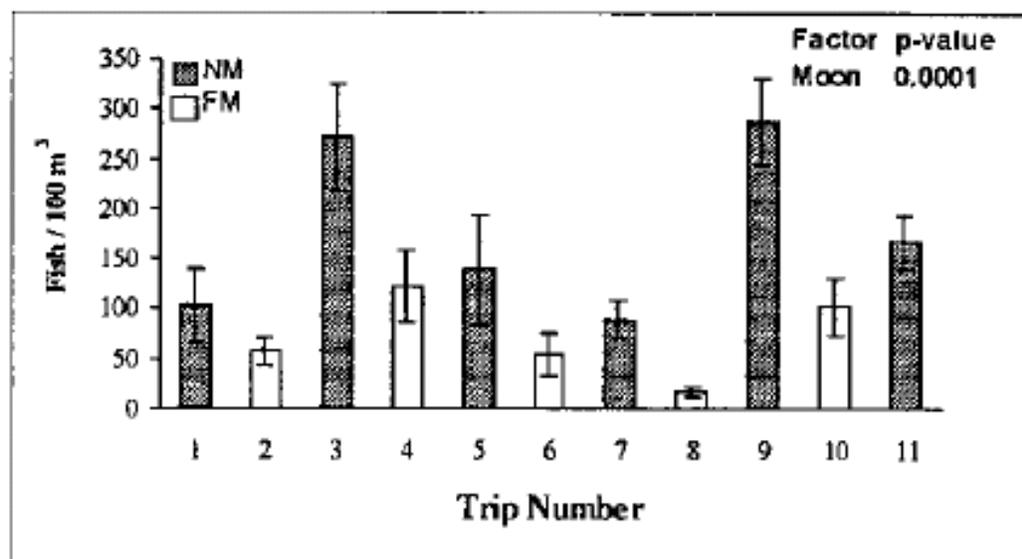


Figure 4. Mean pushnet densities (minus clupeiforms) for each sampling trip. Open columns indicate trips during full moon phases and dark columns indicate trips during new moon phases. Error bars are standard errors of the mean.

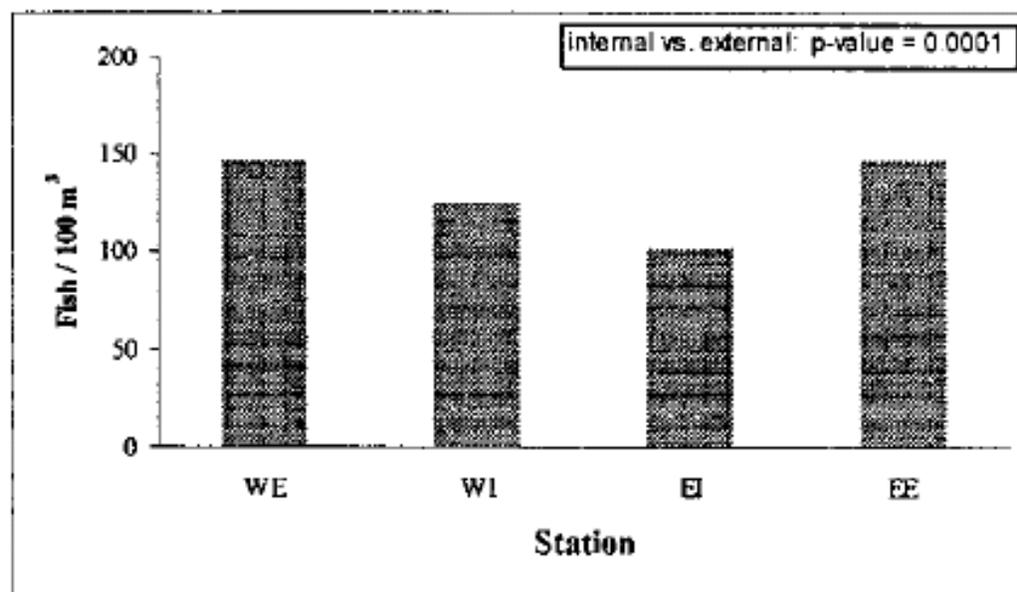


Figure 5. Mean pushnet densities (minus clupeiforms) for each sampling station. Error bars are standard errors of the mean.

DISCUSSION

An advantage to using light-traps and pushnets is that both gears have demonstrated the ability to sample larger larvae and juvenile fishes (Herke 1969, Kriete and Loesch 1980 Choat et al. 1993, Hernandez and Lindquist 1999). In this study, both gears sampled primarily postsettlement and juvenile individuals. Future analyses will look at the length-frequency distributions to statistically compare the sizes of the fish collected by each gear type. Also, both gears were easily deployed in this relatively structurally-complex environment. A potential disadvantage of the light-trap is that it tends to be taxon-specific, attracting only photopositive taxa (Doherty 1987, Choat et al. 1993). This can result in samples dominated by relatively few taxa (Doherty 1987, Brogan 1994 Choat et al. 1993). Our results are typical in this respect as clupeiform fishes comprised over 95% of total light-trap catch. The dominance of clupeiform fishes in the pushnet samples (near 70%) attests to the abundance of these species in the nearshore environment. The pushnet catches were larger and more diverse than the light-trap catches. Again, this is probably related to the taxon selectivity of the light-trap, and the volume of water sampled, although to date there is no accurate way to calculate the volume of water sampled by a light-trap.

The most common reef or structure-dependent fishes were gobiids, blenniids, and cleotrids (Table 1). These species, while present on offshore artificial reef sites such as oil and gas platforms, are also common in the nearshore and estuarine environment which probably explains their high abundance. While these taxa are small cryptic inhabitants in artificial reef environments and are not economically important, they may serve as model species in looking at cross-shelf distribution patterns of reef fish recruitment. For example, presettlement juveniles of *Hypsoblennius hentz/ionthas* were common not only at the jetty site but at our innershelf platform site, which was sampled during the same year. Once the identification of this species can be confirmed, it will be used in otolith analyses to determine pelagic larval durations for individuals collected at the jetty versus the innershelf platform. This, combined with information on local current patterns, can give us an idea of the effective transport radius for this species. Also, otolith-based growth estimates for these fish will be compared between the two locations to compare pelagic larval durations, settlement times, and any other advantages (with respect to accumulative mortality) that early settlement times at one habitat versus another may confer.

While other species of reef fish were less common, their presence indicates the jetty environment can serve as a nursery area. During their pelagic phase, mortality rates of reef fish larvae approach 100% (Leis 1991), and juveniles always appear to be rare. Louisiana coastal waters are dominated by mud and silt bottoms with little bathymetric relief and are devoid of typical reef fish nursery habitats such as natural reefs and seagrass beds. Therefore, the role of the

artificial habitats such as jetties and breakwaters may become more important as islands of refuge for individuals that would otherwise be lost to unsuitable habitat and, therefore, mortality.

The larger mean light-trap CPUEs and pushnet densities during new moon phases may be a result of gear efficiency. Light-traps rely on illumination in the surrounding water mass to attract fish. Theoretically, the contrast in trap-generated illumination should be greater when there is less ambient light such as during a new moon phase as opposed to a full moon. Few studies utilizing light-aggregating devices have addressed this efficiency issue within the framework of lunar periodicities in fish spawning, larval supply (transport) and settlement advantages. Gregory and Powles (1985) observed higher catches during new moon phases in a freshwater system but didn't report a statistical difference. Rooker et al. (1996) used a nightlight lift-net in nearshore habitats in Puerto Rico and looked at sampling abundances for all four lunar phases. They found that new moon abundances of larval fish were four times higher than the next most abundant phase (last quarter) during the summer months and suggested the ambient light intensities might have played a factor in gear efficiency.

Another possible reason for larger catches during new moon periods may be related to the lunar periodicities of some taxa with respect to spawning, recruitment, and settlement. Robertson (1991) noted that many larval biology hypotheses concerning lunar reproductive patterns pertain to propagule dispersal and predation rates and occur both at the beginning and end of the planktonic phase. Many reef fish, for example, time their spawning events with different lunar cycles (Thresher 1984). Previous studies have also documented higher rates of fish settlement during darker, new moon periods than full moon periods (Victor 1986, Rooker et al. 1996), presumably a response to decrease mortality from visual predators. These patterns of spawning and recruitment, in association with the local physical regime, result in variable larval supply and settlement patterns often with distinct lunar signals.

A similar gear efficiency effect may be occurring with the pushnet. Net avoidance is a well documented phenomenon and several studies have demonstrated increased net avoidance during the day as opposed to night (Brander and Thompson 1989, Suthers and Frank 1989, Leis 1991). While all of our pushnets were taken at night, there may have been higher incidences of net avoidance during brighter, full moon periods than darker, new moon periods.

Another factor that may affect the efficiency of both gear types is the turbidity of the water masses sampled. Higher turbidity should decrease the effectiveness of the light-trap and increase the effectiveness of the pushnet. Turbidity data was collected but has not been analyzed yet. Differences in turbidity may explain the observed differences between the internal stations versus the external stations (Figures 3 and 5). Though the tidal currents are not

particularly strong in this location, there may be significantly higher mixing in the channel between the jetty walls resulting in higher turbidities than outside the jetty walls. Turbidity and other environmental parameters (salinity, temperature, dissolved oxygen) will be analyzed in the future to explain the differences in catches between the internal and external stations.

In addition to the environmental factors, the hydrology around the mouth of the inlet may aid in concentrating fish at the outer stations. Hydrodynamic models describing tidal inlet flow patterns often predict the formation of eddies upstream and downstream of inlet mouths (Carter 1988). There is a west-northwest net residual coastal flow along the Louisiana coast that is favorable for this type of eddy formation/setup. While many of these models predict the movement of passive particles, the mechanism may still be a valid explanation for the concentration of postlarval and juvenile fish at the outer stations of our sampling site.

LITERATURE CITED

- Bell, J.D., M. Westoby, and A.S. Steffe. 1987. Fish larvae settling in seagrass: do they discriminate between beds of different leaf density? *J. Exp. Mar. Biol. Ecol.* 111:133-144.
- Bennett, B.A. 1989. The fish community of a moderately exposed beach on the Southwestern Cape coast of South Africa and an assessment of this habitat as a nursery for juvenile fish. *Estu., Coast., & Shelf Sci.* 28:293-305.
- Bohnsack, J.A. 1989. Are high densities of fishes at artificial reefs the result of habitat limitations or behavioral preference? *Bull. Mar. Sci.* 44:631-645.
- Bohnsack, J.A., D.E. Harper, D.B. McClellan, and M. Hulsbeck. 1994. Effects of reef size on colonization and assemblage structure of fishes at artificial reefs off southeastern Florida, U.S.A. *Bull. Mar. Sci.* 55:796-823.
- Brander, K. and A.B. Thompson. 1989. Diel differences in avoidance of three vertical profile sampling gears by herring larvae. *J. Plankton Res.* 11:775-784.
- Brogan, M.W. 1994. Two methods of sampling fish larvae over reefs: a comparison from the Gulf of California. *Mar. Biol.* 118:33-44.
- Carter, R.W.G. 1988. *Coastal Environments: An Introduction to the Physical, Ecological, and Cultural Systems of Coastlines*. Academic Press, London.
- CDOP (Committee on Disposition of Offshore Platforms). 1985. *Disposal of offshore platforms*. Marine Board, Commission on Engineering and

- Technical Systems, National Research Council, National Academy Press, Washington, D.C. 76 pp.
- Choat, J.H., P.J. Doherty, B.A. Kerrigan, and J.M. Leis. 1993. A comparison of towed nets, purse seine, and light-aggregation devices for sampling larvae and pelagic juveniles of coral reef fishes. *Fish. Bull., U.S.* 91(2):195-209.
- Connolly, R.M. 1994. A comparison of fish assemblages from seagrass and unvegetated areas of a southern Australian estuary. *Australian J. Mar. Freshwater Res.* 45:1033-1044.
- Doherty, P.J. 1987. Light-traps: selective but useful devices for quantifying the distributions and abundances of larval fishes. *Bull. Mar. Sci.* 41(2):423-431.
- Ferrell, D.J. and J.D. Bell. 1991. Differences among assemblages of fish associated with *Zostera capricorni* and bare sand over a large spatial scale. *Mar. Ecol. Prog. Ser.* 72:15-24.
- Gallaway, B.J. 1981. *An ecosystem analysis of oil and gas development on the Texas-Louisiana continental shelf*. U.S. Fish & Wildl. Serv., Office of Biological Services, Washington, D.C., FWS/OBS-81/27. 89 pp.
- Gregory, R.S. and P.M. Powles. 1985. Chronology, distribution, and sizes of larval fish sampled by light traps in macrophytic Chemung lake. *Can. J. Zool.* 63:2569-2577.
- Herke, W.H. 1969. A boat-mounted surface push-trawl for sampling juveniles in tidal marshes. *Prog. Fish-Cult.* 31:177-179.
- Hernandez, F.H., Jr. and D.G. Lindquist. 1999. A comparison of two light-trap designs for sampling larval and presettlement juvenile fish above a reef in Onslow Bay, North Carolina. *Bull. Mar. Sci.* 64(1):173-184.
- Kingsford, M. and M. Finn. 1997. The influence of phase of the moon and physical processes on the input of presettlement fishes to coral reefs. *J. Fish. Biol.* 51(Supp. A):176-205.
- Kriete, W.H., Jr., and J.G. Loesch. 1980. Design and relative efficiency of a bow-mounted pushnet for sampling juvenile pelagic fishes. *Trans. Am. Fish. Soc.* 109:649-652.
- Leis, J.M. 1991. The pelagic stage of reef fishes: the larval biology of coral reef fishes. Pages 183-230 in: P.F. Sale (ed.) *The Ecology of Fishes on Coral Reefs*. Academic Press, San Diego.
- Pickering, H. and D. Whitmarsh. 1997. Artificial reefs and fisheries exploitation: a review of the 'attraction versus production' debate, the influence of design and its significance for policy. *Fish. Res.* 31:39-59.
- Robertson, D.R. 1991. The Role of Adult Biology in the Timing of Spawning of Tropical Reef Fishes. Pages 356-386 in: P.F. Sale (ed.) *The Ecology of Fishes on Coral Reefs*. Academic Press, San Diego.

Proceedings of the 52nd Gulf and Caribbean Fisheries Institute

- Robertson, D.R. 1992. Patterns of lunar settlement and early recruitment in Caribbean reef fishes at Panama. *Mar. Biol.* **114**:527-537.
- Rooker, J.R., G.D. Dennis, and D. Goulet. 1996. Sampling larval fishes with a nightlight lift-net in tropical inshore waters. *Fish. Res.* **26**:1-15.
- Rooker, J.R., Q.R. Dokken, C.V. Pattengill, and G.J. Holt. 1997. Fish assemblages on artificial and natural reefs in The Flower Garden Banks National Marine Sanctuary, USA. *Coral Reefs.* **16**:83-92.
- Ross, S.W. and M.L. Moser. 1995. Life history of juvenile gag, *Mycteroperca microlepis*, in North Carolina estuaries. *Bull. Mar. Sci.* **56**:222-237.
- Seaman, W., Jr. and L.M. Sprague (Eds.). 1992. *Artificial Habitats for Marine and Freshwater Fisheries*. Academic Press Inc., New York. 285 pp.
- Suthers, I.M. and K.T. Frank. 1989. Inter-annual distributions of larval and pelagic juvenile cod (*Gadus morhua*) in southwestern Nova Scotia determined with two different gear types. *Can. J. Fish. Aquat. Sci.* **41**:1428-1435.
- Thresher, R.E. 1984. *Reproduction in Reef Fishes*. T.F.H. Publications, Inc. 399 pp.
- Victor, B.C. 1986. Larval settlement and juvenile mortality in a recruitment-limited coral reef fish population. *Ecol. Monogr.* **56**:145-160.

Hernandez, F. J., Jr., R. F. Shaw, J. S. Cope, J. G. Ditty and T. Farooqi. 2001. Do low-salinity, rock jetty habitats serve as nursery areas for presettlement larval and juvenile reef fish?, p. 442-454. *In*: R. L. Creswell (Ed.), Proceedings of the Annual Gulf and Caribbean Fisheries Institute, Vol. 52, 766 total p.