The Use of Light Traps for the Catch of Prerecruited Young of Reef Fishes at the Florida Keys

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ABSTRACT

Recruitment and settlement of early juvenile reef fishes are multifactor-processes and the causes for their high variability are mostly unknown. The Southeast Florida and Caribbean Recruitment project (SEFCAR) aims to determine the role of major factors responsible for the variability of abundance and distrbución of prerecruitment stages of fish. The hydrographic regime, *e.g.*, the Florida Current, seems to be the major source of variability in the Florida Keys. However, influences of small scale physical and biological events on recruitment are also likely.

The present paper gives the details on the implementation plan of a light trap sampling program within SEFCAR. Light traps, which use submerged lights to attract and retain larval as well as early juvenile fish stages, are used since they are more effective than plankton nets in the shallow areas of the Florida Keys. This paper describes scientific hypotheses, relating the prerecruitment process of reef fish to different hypographic structures, construction and function of the light traps (Miami Version), as well as sampling strategies and analyses. Problems in light trap sampling are discussed.

KEY WORDS: fish larvae, Florida Keys, hydrography, light trap, recruitment, reef fish.

INTRODUCTION

Stocks of commercially important reef fish species along the southeast coast of the U.S.A. and in the Caribbean have declined significantly during the last decade (Anon., 1991). Most snapper and grouper populations seem to be overfished. As a consequence the US Government is considering implementing a network of marine reserves along the continental shelf. Reserves have already been proclaimed in the Florida keys for the protection of spawning populations and the enhance ment of recruitment of reef fishes. However, the recruitment of young stages of marine fish into the adult stock is a multidimensional process and does not depend on adult population and egg production sizes exclusively. The role of other factors is presently unknown. Consequently, it is impossible to understand the causes for variable recruitment in reef fish stocks at the Florida

Keys so far; but successful management of future fisheries depends on improved understanding of the recruitment process.

The Southeast Florida and Caribbean recruitment study (SEFCAR) aims to determine the relative importance of some major factors contributing to the variability in abundance and distribution of planktonic prerecruitment (presettlement) stages of reef fishes, *e.g.*, of snappers and groupers, in reef areas at the Florida Keys (Figure 1). The current regime, *e.g.*, the Florida Current and its related structures (Pourtales Gyre) south of the Keys, seems to be the major large-scale source for physical and biological variability at the Florida Keys (Lee *et al.*, 1992). Nevertheless, the possible relations of settlement pulses of reef fishes to perhaps even more important small-scale hydrographical and biological events are still unknown. This project will test specific hypothesis which are key to the understanding of recruitment processes in the northern Florida Keys. The formulation of hypotheses requires the knowledge of the current system in this area. Figure 2 gives a schematic overview, obtained from the hydrographical study within SEFCAR (for explanation see Lee *et al.*, 1992).

Main Hypotheses

1) There are seasonal recruitment and settlement periods in reef fish species, when late larvae and early juveniles are most abundant. Structure and diversity of the young fish community change between seasons and are linked to the hydrographical regime.

2) There are species of reef fish and non-reef fish which recruit locally inshore of the reef (retention model). Larvae and juveniles of these species are retained in coastal water and approach the reef from the coastal side during ebb tide prior to settlement (in the case of reef fish). The highest diversity of this young fish community occurs during the plankton bloom period in spring and early summer, which is related to the supply of nutrients, partly due to local upwelling produced by the Pourtales Gyre all seasons and the overall annual recruitment cycle of this group is relatively uniform.

3) Other species of reef fish recruit locally offshore from the reef (retention model), but their larvae and early juveniles are retained in the Pourtales Gyre during winter and spring and approach the reef from offshore during flood tides prior to settlement. The annual recruitment cycle of this group of species has a discrete pulse in spring, when their planktonic development of at least one month (e.g. snapper and grouper; Leis, 1987) is completed and the gyre is still strong.

4) The same species as in 3) and some additional species have remote upstream sources and are transported to the recruitment (settlement) grounds by the Florida Current (transportation model). Larvae and early juveniles of these species need the Pourtales Gyre or strong east winds (storms) in winter and

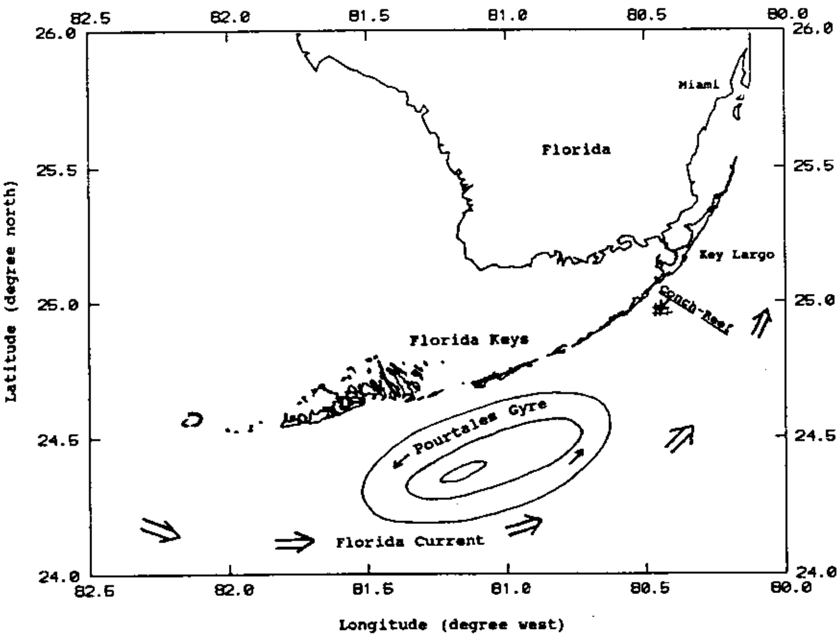

Figure 1. Area map of the Florida Keys. The area around Conch-Reef/Key Largo, where this study takes place, is marked.

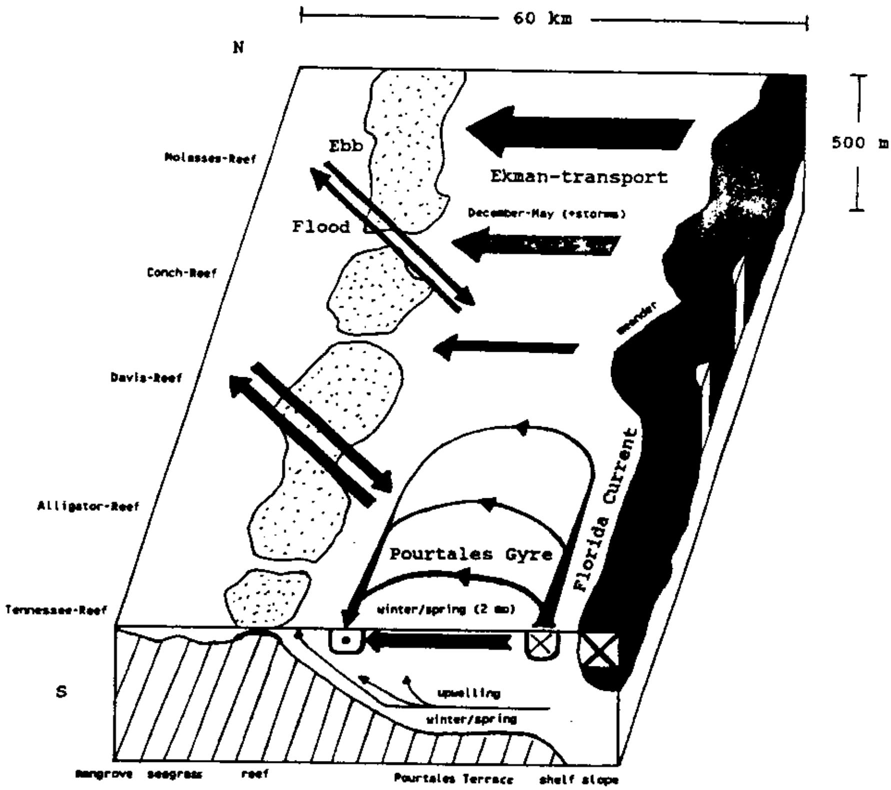

Figure 2. Schematic drawing of major hydrographic transport mechanisms at the southwestern side of the northern FLorida Keys.

spring for reaching the pulses of this group of fishes are seasonal and rather episodic due to high environmental variability.

5) Short-term recruitment pulses are related to short-term on-reef transport mechanisms (ebb current from inshore or flood current from offshore), especially when exceptionally strong currents due to lunar periodicity (New/Full Moon) appear.

6) Presettlement stages of fishes prefer dark nights (New Moon) and dark phases of the night (before moonrise or after moonset) for approaching the reef for predation avoidance.

7)Microstructures in the larval and early juvenile reef fish otolith reflect their age and the environment the early life stage was produced in. the growth varies between seasons and different kinds of environment. The growth history provides us with useful information on the larva's origin and drifting route.

For the first time late planktonic stages of Florida reef fishes will be caught in a relatively quantitative was. They represent the prerecruitment phase of their species' life cycle and their abundance is thought to be linked more closely to the subsequent recruitment strength than that of early fish larvae, which have a very high and variable mortality in any case. In addition, late larvae and early juveniles will provide useful specimens in ongoing taxonomic studies, *e.g.*, for snappers and groupers.

A relatively new sampling technique for the marine habitat will be applied to catch these transitional stages of reef fishes, because they cannot be caught efficiently with normal plankton nets (avoidance behavior). Light traps were shown to work as a better tool for testing hypotheses related to reef fish recruitment (Doherty, 1987; Milicich, 1988; Doherty and Thorrold, 1991). These traps collect the old larval and early juvenile stages of positively phototactic reef fish species during the night, when the great majority of settlement occurs (Robertson *et al.*, 1988). They are either competent or near-competent to settle (Doherty, 1987; Thorrold and Milicich, 1990) and have been shown to correlate with recruitment patterns at whole reef scales (Milicich *et al.*, in press). Thus, light traps can provide an estimate of larval supply to benthic habitats, reflecting spawning of different taxa and environmental variables which affect the arrival.

The present paper gives the details on the implementation plan of the light trap sampling program within SEFCAR and describes construction and function of the light traps as well as sampling strategies and analyses, and discusses problems in light trap sampling.

MATERIALS AND METHODS

Construction andFunction of the Light Traps

The construction of the new SEFCAR lights traps is very similar to the Australian prototype described by Doherty (1987), with a few modifications

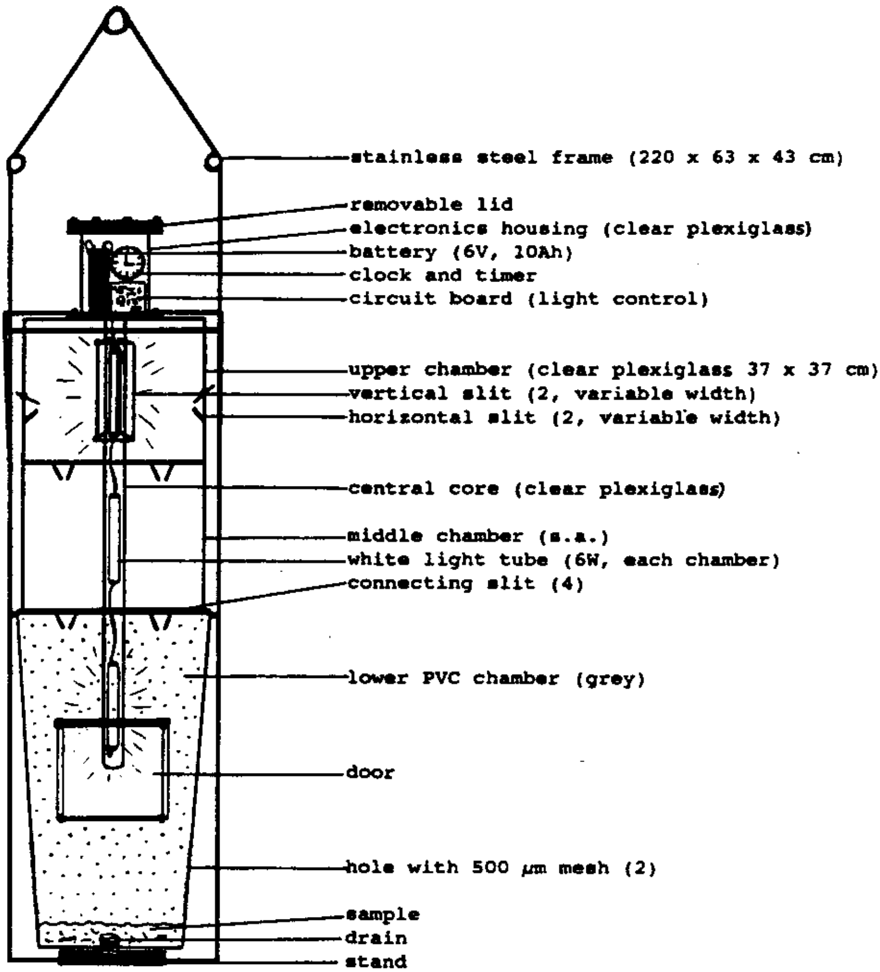

Figure 3. Construction plan of a light trap (Miami-Version).

(Figure 3). The light traps is mounted into a stainless steel frame (220 x 63 x 43 cm), which can be connected to floating and anchoring devices. It differs from the Australian type by a stronger encasement of the trap, keeping it safer in regard to possible hits. The trap consists of three chambers, two plexiglass chambers (37 x 37 cm), and one lower PVC drum, which acts as the final resevoir for the sample. It is supplied with a drain at the bottom for letting the sample out into a bucket. A new feature is that the lower chamber is supplied with a door (20 x 20 cm) for cleaning purposes (It was noted that many organisms stayed attached to the walls and the bottom of the PVC drum after draining). The three chambers are connected vertically by 2 non-variable slits of 2 cm width each. The top chamber has four slits of variable width (0-5 cm) to the outside (two are horizontal and two are vertical), through which photopositive organisms can enter the trap. A string of three flourescent light tubes (6 W, one for each chamber) is encased in a central vertical core (plexiglass), which is removeable from the top of the trap together with the electronics housing. The latter contains the rechargeable battery (6 V, 10 Ah), an electronic clock/timer (two 1.5 V batteries), and a circuit board, which controls the operation of individual lights. The lights in the two upper chambers are set on/off and off/on alternately during fishing, whereas the light tube in the bottom chamber is on all the time. The on/off intervals can be adjusted on the circuit board by dip-switch steeings to 3, 6 or 9 minutes. The timer allows a choice of four fishing periods per night.

At the start of a fishing period, the top and bottom lights are lit. The top light casts a pool of light of at least 5 m radius around the trap (Doherty, 1987). Attracted organisms enter the upper chamber through the slits. After a chosen period of 3, 6 or 9 minutes, the circuit board switches power from the top chamber to the middle one. Organisms in the upper chamber can follow by passing throught he connecting slits. At the same time the middle light still attracts organisms to the trap. When the top light is on again, new animals can enter the upper chamber and those in the middle chamber migrate to the lower resevoir through another set of slits attracted by the continuous light in that chamber. In this way organisms gradually accumulate in the lower chamber until the timer switches off all lights at the end of the first fishing period. It is likely that caught animals stay in the lower chamber since its volume is high compared to the small width of the slits. Additionally, it is unlikely that captured animals can find their way back through all the chambers and slits to the outside during darkness. Two sides of the lower resevoir have holes (each 400 cm^2) covered with 500 μm mesh, which allows water exchange. During the recovery process into the boat, these holes act as drains for the water in the trap.

Sampling Strategies and Analyses

The light traps can be used in two different ways in relation to the surrounding water. If used free drifting (Lagrangian point of view) the results will more or less reflect developments within a certain water mass or current. This strategy is not applicable forthis study, since the occurrence of different water masses containing the organisms of interest have to be observed at a geographic fix (reef). The so-called Eulerian point of view requires a mooring of the trap on the bottom using an anchor (Figure 4). The anchor cannot directly be fixed at the trap, since the trap would not stand vertically in the water column then because of the currents. A float has to be positioned at the anchor line near to the trap. It is also very important that the anchor line is shackled to the trap at the height of its center of gravity. The floats lined at the top of the frame keep the light trap buoyant in thw water column. The entering slits are about 1 m below the surface, where most larvae and juveniles of reef fish stay overnight, probable utilizing the wind-driven highest velocity surface layer for maximum horizontal transport.

The availability of fish survivors able to recruit will be monitored at Conch-Reef/Key Largo, Florida (Figure 1) bimonthly during 10 days around New Moon for the next 2 years. The program was started in September 1992 using 5 traps. An initial light on/off period of 6 minutes and a slit width of 1 cm were chosen. The use of larger slits on the first day resulted in the capture of 0-group juveniles of clupeids, which are not desired, since they might predate on larvae in the trap.

Testing different scientific hypotheses as well as answering methodological questions will require different sampling strategies regarding the positioning of the traps in relation to the reef and the time settings for fishing. However, the project was started with the sampling schedule drawn in Figure 5. The light traps were deployed relatively close (within 1.5 km) to the fixed NOAA Underwater System (model s4) which is measuring and recording data on temperature, conductivity, current direction and speed, as well as water depth (wave height) continuously offshore from Conch-Reef (water depth: 40 m) in two different depth horizons. This system will provide the needed data on current variability and water mass characteristics. The water depth range, where the 5 traps were moored, was about 4-10 m. The offshore trap was anchored in the greatest depth (ca. 10 m), where the bottom is slightly muddy and sandy, without any reef structure. This trap was set to a 4 hour sampling interval during the night's flood tide(s) and was adjusted to the tide's temporal shift. The trap monitored the reef's rate of supply with new fish arrivals ready to recruit from offshore during flood. The second trap was about 200 m further inshore, moored directly on Conch-Reef between patches of sand and rocks at a depth of about 4-5 m. This trap had the same settings as the offshore one, but had the task of monitoring not only the rate of fish arrivals during flood, but in addition a possible

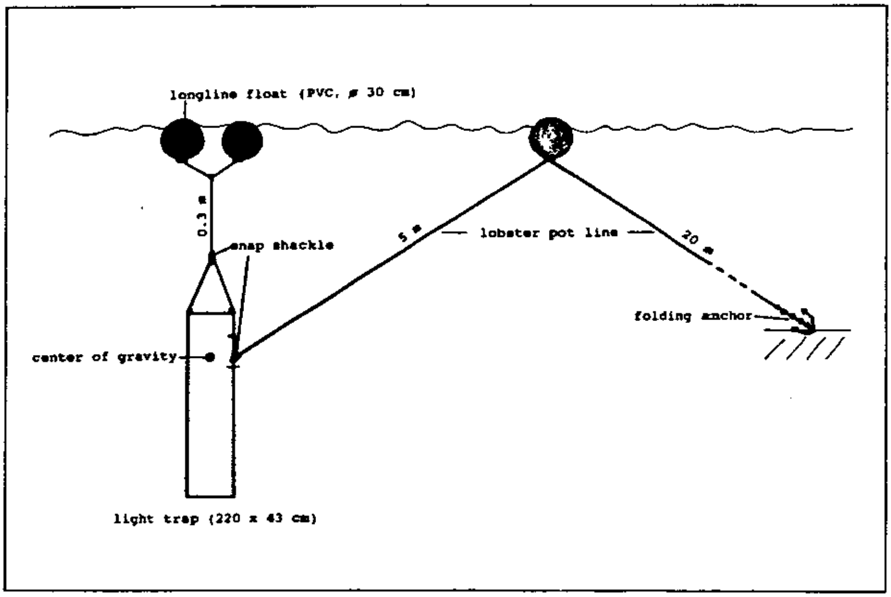

Figure 4. Mooring of a light trap at Conch-Reef during the first sampling period (September 1992).

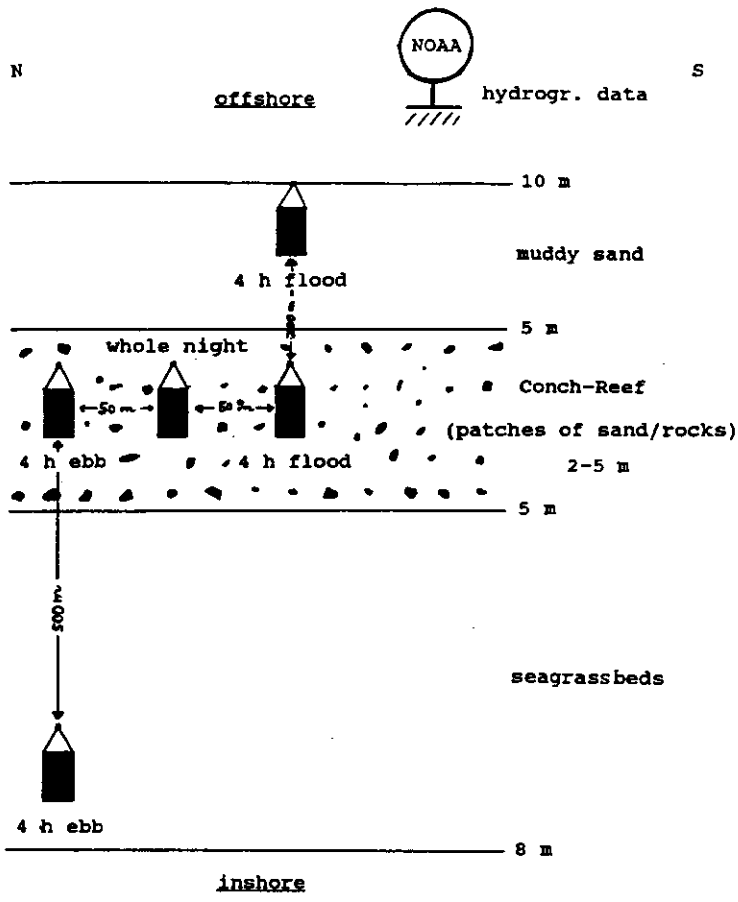

Figure 5. Diagramatic aerial view to show the relative position of the 5 light traps at Conch-Reef during the first sampling experiment (September 1992).

concentration or decrease of young fishes in the water column over the reef. The setup for the ebb tide traps was very similar, but because of the small spatial gradient between reef and seagrass bottom structure we decided to use a larger distance between both traps. The inshore trap was about 500 m from the reef trap over seagrass beds (water depth ca. 8 m). Both were set to a 4 hour sampling interval during the night's ebb tide(s), clearly separated from the main flood sampling period. The inshore trap was supposed to monitor the inshore abundance of young of both coastal and reef species, during ebb tide. This might also be a measure for the supply of the reef with those fishes. The ebb trap, which was moored on Conch-Reef about 100 m from the flood trap, worked as a sampler for arrivals from inshore and for the abundance over the reef. The fifth trap was fixed on the reef in the middle between the flood and ebbtraps, 50 m between each of them. This trap fished during the whole period of darkness (20-07 h, 11 hours). It monitored the total arrival and abundance of prerecruitment stages of fishes per night and should have captured more fishes than the ebb and flood traps together. This trap is especially important in the context of the comparison of days, months, and seasons, giving an index of prerecruitment.

Sorting and identification time will be negligible, because there are small volumes of plankton in the samples and the stages of fishes caught in light traps are readily identifiable. Some invertebrate groups will be counted. All fishes will be measured. The otoliths of important (groupers and snappers, etc.) and frequently captured species will be analyzed by light microscopy and automatic image analysis at the PC to count daily rings and observe microstructures for determination of age, growth, and origen. The final data evaluation will include community analyses, using cluster and principal component analysis with variables like species, size group, ebb/flood trap and day/month season of capture. Finally, those results have to be analyzed for possible relations to the hydrographical data, including satellite images of sea surface temperature.

DISCUSSION

The light trap sampling program within SEFCAR is in a starting phase now. Although the first sampling experiment was very successful in terms of realizing the proposed strategy and catching different species and size classes of invertebrates and fishes, there might be problems, which always have to be remembered during future analysis.

The main problem is that light traps, like plankton nets, are selective sampling devices. Their catchability is species and size specific as a function of behavioral differences in relation to the light and also to the prey or non-prey organisms attracted at the same time. However, many taxa were already shown to be attracted to light, *e.g.* pomacentrids, lethrinids, scorpaenids, carangids, and scombrids (Doherty, 1987; Doherty and Thorrold, 1991). Nevertheless, light trap samples cannot give values for concentration and abundance in the water, since the animals are concentrated by the light in the trap. The status of water clarity might also affect the degree of predation in the trap if the slit width is larger than 1 cm. However, comparative approaches, focusing relative abundances of species and size classes should be possible, if the catching conditions are constant.

Another problem in light trap sampling could be that due to a high degree of patchiness and small spatial integration only few larvae and juveniles of reef fishes might find their way into the traps, giving insufficient numbers for statistical analysis. On the other hand, light trap sampling allows us to make simultaneous samples under high temporal and spatial resolution, giving us synoptic pictures of abundance and distribution. Most of the captured fishes are still alive when they are removed from the sea and can be used for futher studies in the laboratory (*e.g.* for growth and identification studies). Light trap studies are low cost projects compared to other marine programs, which need large ships and much manpower for sampling and sorting the plankton. However, the sea has to be relatively calm. On a small boat (7 m) light traps can be handled only up to wave heights of about 1.5-2.0 m. Picking up and preparing the traps can be very difficult, especially if the wind and the current are strong. Those conditions might also be responsible for a decreasing catchability, since attracted animals may not find the way into the traps due to their heavy vertical movement or because they are drifting away from the trap. The maximum tidal current should not exceed 1 m/s, which is the case in the sampling area off Key Largo.

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