CARICOM Fishery Research Document No. 15

THE ROLE OF DRIFTING OBJECTS IN PELAGIC FISHERIES IN THE SOUTHEASTERN CARIBBEAN

by

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ABSTRACT

The role of naturally-occurring drifting objects in fisheries for pelagic species in the southeastern Caribbean was investigated by conducting a questionnaire survey of two hundred and fifty-three fishers, fifty from each of St. Lucia, Barbados, Grenada, Tobago and fifty-three from St. Vincent. The study showed that drifting objects play an important role in large pelagic fisheries in the southeastern Caribbean by attracting fish and thereby increasing their catchability. This effect is seasonal, being between January and March in all islands, but having a more extended seasonal duration in Grenada and Tobago. The effect is most marked in water which is green or brown in colour. Fish associate with both natural and anthropogenic drifting objects, with no apparent preference within or between these groups. Fishers actively seek and fish around drifting objects. Fishers from St. Lucia, Barbados, Grenada and Tobago target flyingfish by deploying drifting FADs which they construct of naturally-occurring material. However, no fishers use drifting FADs which they deploy to target large pelagics.

The information acquired in this study indicates that the deployment of anchored FADs should succeed *in* increasing catch rates of large pelagics, and suggests that the potential for developing fisheries for large pelagics by deploying drifting FADs should be explored.

CARICOM Fisheries Management Unit, Belize City, Belize
January 1994

MAREMP was commissioned by CFRAMP to conduct this project. Project implementation was primarily by MAREMP, with input from CFRAMP. Project funding was primarily from CFRAMP, with input from MAREMP.

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INTRODUCTION

In the eastern Caribbean, pelagic fisheries are most important in the southeastern islands of St. Lucia, Barbados, St. Vincent, Grenada and Tobago. These islands exploit flyingfish *(Hirundichthys affinis),* dolphinfish *(Coryphaena hippurus),* kingfishes *(Scombridae),* wahoo *(Acanthocybium solanderi),* sharks *(Squaliformes),* billfishes *(Istiophoridae),* tunas (yellowfin *Thunnus albacores,* blackfin *Thunnus atlanticus,* skipjack *Katsuwonus pelamis,* little or bigeye *Thunnus obesus),* and more recently and to a limited extent, swordfish *(Xiphias gladius).* The fisheries are largely seasonal (December - June), primarily because of the migratory nature of many of the species. Flyingfish are caught with gill nets, hand lines or dip nets (Willoughby et al. 1988, Finlay et al. 1988, Murray et al. 1988, Oxenford et al. 1993). The large pelagics are caught by trolling around flotsam or in the open ocean, and by longlining (Mahon and Mahon 1990, Hunte et al. 1994).

Large-scale longlining was first practised in the western Atlantic by Japan, with the USA, Korea and Taiwan later participating in the fishery. Longlining by eastern Caribbean countries is a recent development used in fishing for large pelagics (Hunte 1987). In Grenada, St. Vincent, St. Lucia and Barbados, fishers have acquired modern small-scale longliners (Singh-Renton and Mahon 1993); and in Grenada and Barbados, longlining has also been adapted to local vessels (Samlalsingh et al. 1994, Hunte et al, 1994). However, the majority of fishers in the southeastern Caribbean continue to fish for large pelagics by trolling from small vessels such as canoes and pirogues (Mahon 1988).

Offshore pelagic resources are generally considered to hold the greatest potential for fishery development, and most islands of the southeastern Caribbean are attempting to increase effort in these fisheries by employing larger vessels, using longlines and by the use of fish attracting devices (FADs) (Mahon 1990a).

Anchored FADs have been the most commonly employed, and are proven to attract large numbers of fish (De Sylva 1981, Feigenbaum 1986, Rountree 1989). Drifting objects have also been used in some countries to aggregate pelagic fish and increase catch rates (Dooley 1972, Bergstrom 1983, Mahon et al. 1986). The association of small-sized tunas, including skipjack, with floating objects has been well documented (Ariz et al. 1992). Most recently, in the eastern tropical Atlantic, the large-scale commercial purse seine fleets for yellowfin tuna began to deploy floating objects to attract fish, and in 1991 this method accounted for 55 % of the catch (ICCAT 1993).

For the purposes of this study, we define a FAD as an object, either natural or artificial, deliberately placed on or in the water to attract fish. FADs may be either anchored or drifting. We refer to objects, natural or artificial, which occur on the water but have not been deliberately deployed, as "drifting objects".

Given the perceived expansion potential of pelagic fisheries in the eastern Caribbean, and the successful use of drifting FADs in many countries, particularly in the Atlantic, the principal objectives of this questionnaire study are: (1) To investigate the role of drifting objects and drifting FADs in southeastern Caribbean fisheries, and (2) to use this information to evaluate the potential for enhancing fishing success by deploying drifting FADs to aggregate fish for capture by trolling, pole and line or small purse seine.

In many parts of the world, but particularly in the Pacific, it has proved possible to obtain reliable information relevant to fisheries directly from fishers (Johannes 1985). A secondary objective of this study is to obtain a preliminary assessment of the extent to which reliable biological, oceanographic and fisheries information can be obtained from fishers in the southeastern Caribbean.

LITERATURE REVIEW

Fish-attracting devices (FADs)

The use of FADs in aggregating fish may have its origins in very early attempts to harvest fish. The technology is known to have been used in all parts of Europe as well as in Asia, Africa and the Philippines (Brandt 1972). FADs were first introduced in the United States (Myatt and Myatt 1982 in Matsumoto et al. 1981) and in the Philippines (Kihara 1981 in Holland et al. 1990) in the 1970s, and in the Hawaiian islands in 1977 (Matsumoto et al. 1981). They can range from trees to plastics, natural or artificial, whether old or new. They include structures which are suspended at the surface, or at any depth in midwater. They are usually simple, inexpensive to manufacture (except deep-water FADs) and relatively easy to deploy (De Sylva 1981).

Support for organised FAD programs initially grew from their popularity with fishers as the most practical method for increasing the availability of oceanic fish resources by "controlling" the movements of wandering schools of fish (Buckley et al. 1989). Several suggestions have been made for why FADs aggregate fish. These include: protection for fish from predators (De Sylva 1981); their use as spawning sites, eggs being laid under them thereby ensuring their protection (Samples and Sproul 1985); their use as navigational reference points for pelagic fish (Klima and Wickham 1971); and their use as cleaning and scraping stations where fish can remove parasites from each other (Gooding et al. 1966, De Sylva 1981). From the perspective of the fisher, their use is to concentrate pelagic fish making them easier to catch (De Sylva 1981), and as fuel-saving devices, since less time is spent in fishing, and sail power can also be used when trolling around FADs (De Sylva 1981). FADs have also been useful in promoting recreational fishing. They could therefore boost the Caribbean tourist industry, which is a valuable earner of foreign exchange.

Increased catchability and reduced fishing costs may increase fishers participation in pelagic fishing, thereby reducing pressure on presently over-exploited reef fish in the Caribbean (De Sylva 1982).

Association of pelagic fish with FADs

Research into the association of pelagic fish with drifting objects has been extensive. The relevant literature will be reviewed under four headings: types of drifting objects encountered and species which associate with them; proportion of catch taken around drifting objects; seasonal variation in associations and occurrence of species around drifting objects; and strategies for locating and fishing around drifting objects and FADs.

Types of drifting objects and species which associate with them

Pelagic fish frequently gather around drifting material in the open sea, and commercial and sport fishers regard the immediate vicinity of drifting material as a potentially rich area for trolling (Gooding et al. 1966). Fish have been reported gathered around floating algae, coconuts and pumice (Senta 1965 in Gooding et al. 1966), floating logs (Inoue, Amano and Iwasaki 1963, Kimura 1954, Yabe and Mori 1950 in Gooding et al. 1966), coconut fronds and slabs of cork (Soemarto 1960), and rafts (Kojima 1960, Heyerdahl 1950, Evans 1955 in Gooding et al. 1966). Many juvenile fish even gather under jelly-fish (Mansueti 1963 in Gooding et al. 1966). Dead turtles, drifting marine algae, trees and other wood debris have also been known to attract fish (Hunter and Mitchell 1968).

In the Pacific Ocean, off the coast of some of the Philippine islands, anchored floating bamboo rafts, termed "payaos" or "payaws", have been used for many years by fishers to aggregate tuna (Murdy 1980). In one study, after the "payao" was left in the water for seven hours, 36.3 mt of tuna were caught in nets (Murdy 1980). Similar results have been obtained in another study in the Philippines, where a "payaw" was used to attract yellowfin and skipjack tuna (Aguilar 1988). Also in the Philippines, a tree called "luan" is used to make logs which attract skipjack and other species of tuna (De Sylva 1981).

The Pacific Islands have been the focus of extensive research on the attraction of fish to FADs. Rafts, placed off the leeward coast of Hawaii and near to the Equator in the Central Pacific, attracted adult and juvenile yellowfin tuna, skipjack tuna and amberjacks, and juvenile dolphinfish, wahoo and sharks (Gooding and Magnuson 1966).

Buoys, deployed off the coast of Hawaii and also off the coasts of American Samoa, Palau, Guam and the Marianas, were successful in attracting dolphinfish, wahoo, and yellowfin and skipjack tuna (Matsumoto et al. 1981). In another study in American Samoa, buoys were used to attract large schools of yellowfin and skipjack tuna (Buckley et al. 1989). Information on the aggregation of fish around buoys was also obtained from a study off the coast of Hawaii, where a significant increase in the catch of tuna was reported (Scott 1985). More recently in Hawaii, deployed FADs are reported to have attracted skipjack and yellowfin tuna, dolphinfish and wahoo (Holland et al. 1990).

Off the coast of Japan, research in the Satsunan Sea revealed that skipjack and yellowfin tuna, wahoo and dolphinfish were the most abundant fish found associated with drift logs (Yabe and Mori 1950). De Sylva (1981) also documented the attraction of dolphinfish, amberjacks and clupeids to bamboo rafts in Japan. Japanese pole-and-line fisheries, and American purse seine and live-bait fisheries, exploit the tendency of yellowfin and skipjack tuna to associate with logs, algae and other drifting objects (Uda 1933, McNeely 1961 in Hunter 1967); and Kojima (1955

1956 1960a 1960b and 1961 in Hunter 1967) reported that moored rafts of bamboo or palm fronds are used to attract dolphinfish in seine fisheries in Japan.

Mid-water FADs have also been successfully deployed in Japanese waters (Bergstrom 1983). The traditional types are made of palm leaves or of knitted bamboo baskets filled with branches of box-tree, peach tree, azalea and / or bush clover, and successfully attract cuttlefish.

Naturally occurring drifting objects are also known to attract large numbers of fish in Japanese waters. Of the 1551 fish caught near driftwood in one study, 1500 were small yellowfin tuna (Yabe and Mori 1950).

Indonesian fishers use two types of palm-frond rafts to attract clupeids, wahoo and jacks (Hardenberg 1950 in Hunter 1967). This was corroborated by Bergstrom (1983), who reported that palm fronds inserted in rope made from coconut fibres, called "rumpon", attracted sardines, oil mackerel and jacks in Indonesian waters.

In the offshore waters of southern California, drifting kelp plants have successfully attracted both adult and juvenile halfmoon and splitnose rockfish, as well as pipefish, jacks, mackerel and sablefish (Mitchell and Hunter 1970). Flotsam present in the waters off southern California was also successful in attracting yellowfin and skipjack tuna (Greenblatt 1979).

In Central America, in the offshore waters of the Pacific coast, yellowfin tuna, mackerel, black skipjack and oceanic skipjack were found associating with floating logs and plant debris (Hunter 1967). Also in Central America, over 12,000 fishes belonging to 12 families and 32 species, but primarily Carangidae and Pomacentridae, were reported to be captured beneath floating objects over a four-month period, off the coast of Costa Rica (Hunter 1967). These two families formed most of the catch taken around eight objects moored near the Costa Rican coast; and schools of dolphinfish, triggerfish and black skipjack are also reported to be caught around balsa rafts and sheets of black plastic in offshore waters of Costa Rica (Hunter 1968).

Much work on the association of fish with drifting objects has been carried out in the Indian Ocean. For example, along the east coast of south India, bundles of branches and leaves of screwpine and of a small leguminous shrub called "kavali" were tied to three ropes of unequal length to attract flyingfish (Bergstrom 1983). In India, mid-water FADs made of coconut leaves consistently attract large numbers of fish. The "payaw" (bamboo raft), as well as other types of rafts, have also been used successfully in the Indian Ocean, where they attracted large schools of tuna (Watanabe et al. 1988). In Sri Lanka, mangrove wood has served as an attractant for schools of fish (Bergstrom 1983). Mangrove and coconut trees, as well as bundled twigs, are used in Sabah, east Malaysia to attract fish (Bergstrom 1983).

Cayre (1991), in a study done off the coast of the Comoros Islands in the Mozambique Channel, reported large schools of tuna associating with FADs. In the Maldives Islands, a tyre FAD, and buoys which had been placed in mid-water, attracted skipjack and yellowfin tuna, dolphinfish, rainbow runner *(Elagatis bipinnulatus),* frigate mackerel *(Decapterus macarellus)* and little tunny *(Euthynnus alleteratus)* (Bergstrom 1983).

Tree trunks, coconut leaves, wooden boxes and floats with buoys were found to attract skipjack and yellowfin tuna in waters off the coast of Sao Tome (Batalyants 1992). In Malta, moored cork-slabs are used to attract dolphinfish (Galea 1961 in Hunter 1967). Anchored floats and brushwood are also used to attract fish in the Kannizzati fishery in Malta (Bergstrom 1983).

The Atlantic coast of North America has also been an area of extensive research on the use of FADs. Streamer-type FADs attracted round scad and jacks in the waters off the coast of South Carolina. Of the total catch, 99.3% were large pelagics (Wickham et al. 1973). Also in the Atlantic Ocean off South Carolina, 18 FADs, deployed in 14 m of water, attracted bait fish which formed the major part of the catch (70%), while barjacks and amberjacks (Carangidae) were also caught (Rountree 1990).

Many fish belonging to the Carangidae, Monacanthidae, Balistidae and Antennaridae comprised the catch found in sargassum in the Florida Current (Dooley 1972). American tuna fishers caught as many as 26000 tuna near one drifting log in the Atlantic Ocean in two days (Hunter 1968).

In the Gulf of Mexico, off the coast of Mississippi, during the period 1974-1977, PVC pipes were successful in attracting pelagic fish (Bergstrom 1983). In the waters at the northeastern end of the Gulf of Mexico, artificial tent-shaped FADs made of vinyl attracted scads, Spanish sardine and jacks (Wickham and Russell 1974). Mackerel, scad, herring, amberjacks and rainbow and blue runners have been reported associated with anchored FADs in the same location (Be Sylva 1981). Subsequent studies, again in the northeastern Gulf of Mexico, resulted in tuna, kingfish, Spanish mackerel and dolphinfish being caught around FADs (De Sylva 1981). Increased catches of fish around prism-shaped and pyramid-shaped vinyl FADs have also been reported in the Gulf of Mexico (Bergstrom 1983).

The Caribbean has been the focus of increasing research on the association of pelagic fish with naturally-occurring drifting objects, as well as with objects deliberately deployed (FADs). In Brazil, buoys are used to attract many species of fish (Scott 1985). Bergstrom (1983) reported that generally, in the Caribbean, free-drifting vessels attract dolphinfish and wahoo. More specifically, Caribbean Z-traps made of reed have been used as midwater FADs in the waters off Jamaica, and have increased catches of large pelagics (Workman et al. 1985)

In the U.S. Virgin Islands, cero mackerel and barracuda were caught around artificial FADs deployed off the south-southeast coast of St. Thomas (Clavijo et al. 1978). In St. Croix, tuna and mackerel were attracted to FADs placed off the northern coast (Workman et al. 1985). In a study conducted off the northeast coast of Puerto Rico, FADs were placed both offshore and nearshore (Feigenbaum et al. 1986). Both offshore and nearshore FADs attracted large numbers of fish, including barracuda, yellowfin and blackfin tuna and wahoo, with dolphinfish being particularly abundant around the offshore FADs (Feigenbaum et al. 1986). Off the northern coast of St. Croix, U.S. Virgin Islands, FADs were reported to attract greater numbers of fish during the day than during the night (Workman et al. 1985).
Dried coconut branches are used in Grenada (Steele and Oxenford 1986) and Tobago (Fabres 1986), and banana leaves in St. Lucia (Walters and Oxenford 1986), to aggregate flyingfish. In Barbados, sugarcane trash or coconut branches serve as drifting FADs, attracting large numbers of flying fish (Harding 1986, Oxenford et al. 1993). A combination of hibiscus flowers and

banana leaves is deployed in Martinique (Guillou and Oxenford 1986), while either banana leaf trash or coconut branches are used in Dominica to increase catches of flyingfish (Darroux and Oxenford 1986).

The above studies strongly confirm that drifting objects do cause pelagic fish to aggregate, thereby potentially increasing their catchability.

Proportion of catch taken around FADs

Many studies on the proportion of catch taken around FADs compared to control locations have revealed that higher catches are obtained around FADs. Off the coast of Hawaii (Brock 1985), and off the coast of American Samoa (Buckley et al. 1989), catch around FADs was twice that in control areas.

In the eastern tropical Atlantic, the average tuna catch from a large commercial purse seine was reported as 41 t under naturally occurring logs as compared with 19 t in free school areas (Ariz et al. 1992).

Off the coast of South Carolina, the catch rate of Spanish and king mackerel around FADs was 80.3% higher than in non-FAD areas (Wickham, et al. 1973); and more recently along the same coast, Rountree (1989) reports three times as many fish caught around eighteen FADs than in non-FAD areas.

In the northeastern Gulf of Mexico, catch rates around FADs were reported as 7.0 fish per hour, compared to 1.3 fish per hour in the control area (De Sylva 1981). Off the southeast of St. Thomas, U.S. Virgin Islands, the catch rate of fish around mid-water FADs was 2.83 fish per hour compared with 0.04 per hour around non-FAD sites; and the number of species at FAD sites was four times that at non-FAD sites (Clavijo et al. 1987). Off the coast of St. Kitts, strike rates around FADs ranged from 0 to 4 strikes per hour, compared with 0 to 1 per hour in non-FAD areas (Wilkins and Goodwin 1989).

These studies clearly indicate that drifting objects are successful in increasing catch rates well above those obtained in control areas.

Seasonal variation in occurrence and association of fish with FADs

Hunter (1967) reported that nearly every drifting object located close to the Gulf of Nicoya off the Pacific coast of Costa Rica had its own associated fish population. At this location, the greatest abundance of drifting objects occurred in October (1963), when rainfall was heaviest (Peterson 1960 in Hunter 1967). Results of a study done in Sagami Bay off the Pacific coast of Japan, where sargassum was found to be most abundant in spring, and least abundant in fall and late summer, revealed that species which associated with it were also more numerous in spring and less numerous in fall and summer (Uda et al. 1933 in Hunter 1967).

Off the coast of Mauritius in the Indian Ocean, the association of tuna, dolphinfish and wahoo with floating logs was reported to be seasonal, being strongest in October, November and mid-December when logs were most abundant, with another period of high association in April to June (Roullot et al. 1988).

In the Atlantic, at Onslow Bay, North Carolina, the largest number of pelagic fish and species were caught during July, August and November, when FADs were most abundant (Stephan and Lindquist 1989). Off the coast of South Carolina, pelagic species were most abundant around FADs in August (Rountree 1990).

In the Gulf of Mexico, pelagic fish were most abundant in the summer months (Chandler et al. 1985, Sanders et al. 1985). In a study of sargassum in the Florida Current, Dooley (1972) reported a significant positive correlation between seasonal variation in weed biomass and seasonal variation in numbers of fish.

These studies suggest that the association offish with drifting objects is clearly seasonal, being primarily influenced by the availability of the objects. In temperate countries, the association is greatest in summer months. In sub-tropical countries, it is greatest during the rainy season. Seasonal variation in association of fish with drifting objects in Caribbean waters has not been documented.

Strategies for locating and fishing around drifting objects

Yabe and Mori (1950) first reported that birds gathered around schools of skipjack and yellowfin tuna attracted to driftwood in the Satsunan Sea off Japan. Birds can therefore be used as a cue for locating drifting objects. For example, off the coast of Ghana, the search for schools of fish has relied heavily on the observation of birds gathered over schooling fish (Kwei 1992). A study on 1,903 tuna schools in the Azores concluded that the presence of birds was the most important FAD detection indicator (Pereira 1993). Off the northeast coast of Puerto Rico, more than 100 kg of dolphinfish, kingfish and large tuna were reported to be taken while trolling near to inshore drifting objects where birds were feeding (Feigenbaum et al. 1986). Strategies which fishers use to locate drifting objects in the Caribbean have not been documented.

Chumming is a common strategy used in fishing around drifting objects. For example, in Ghana, when a school has been located around a drifting object, sea sprays are turned on, chummers scatter live bait into the water, and the fishers begin boating the fish with a flexible pole and line (Kwei 1992). Chumming is also practised throughout the eastern Caribbean (Mahon et al. 1986). The method is similar to that used in the pole and line fishery in Japan (Uda 1933 in Hunter 1967).

Strategies other than chumming are used when fishing around deployed FADs in the Caribbean. In Grenada, "straw" (two dry coconut branches tied side by side) is placed on the water. The branches are tied to the side of the boat opposite to the direction of drift. Flyingfish aggregating under the "straw" are then caught using gillnets and sometimes dip nets (Steele and Oxenford 1986). In St. Lucia, an artificial raft made of dry banana leaves is tied alongside the boat, and leaf trash may be shredded in the water. The boat is allowed to drift and the crew position themselves in the bow, centre and stern of the boat. A surface gillnet, which is set about 30 ft. from the boat, is pulled alongside and may then be used to encircle the artificial FAD (Walters and Oxenford 1986). The flyingfish fishery of Barbados uses FADs called "screelers", which consist of sugarcane trash tightly bound together. Two or three of these "screelers" are attached to the drifting boat at equal distances apart on a line 200-500 metres long, and are slowly pulled to the boat at hourly intervals. During this time, gillnets are used to catch the flyingfish (Harding 1986). In Martinique, artificial rafts made of banana leaves, especially "macandja" banana leaves which are more waterproof and therefore float better, are tossed over the windward side and tethered to the boat. These attract the fish, which are then caught using gillnets (Guillou and Oxenford 1986). In Dominica, a raft made of dried coconut palms or banana leaf trash is thrown over the side of the boat and tethered about 20 to 30 ft. from the boat. The gillnet is set close to the boat, and as the fish gather around the raft, it is pulled alongside the boat (Darroux and Oxenford 1986).

It is evident from the above review that artificial FADs are commonly used in the southeastern Caribbean for harvesting flyingfish, but are not used in the harvest of larger pelagics. This emphasises the need for a study which documents the role of natural drifting objects in the fisheries for large pelagics in the southeastern Caribbean, and evaluates the potential for using artificial FADs in these fisheries.

METHODS

St. Lucia, Barbados, St. Vincent, Grenada and Tobago were selected for this study due to the importance of pelagic fisheries these islands. The study was conducted over a five-week period between July and August, 1993. The sampling sites in each country were selected, based on the judgment of the respective Fisheries Officers, as the pelagic fishing areas where an adequate number of fishers could be found for interview (Figure 1; Table 1).

Fishers were individually interviewed by means of a questionnaire (***Appendix 1***). The questionnaire was pre-tested on five fishers at the Bridgetown Fishing Complex, Barbados. Interviews were conducted with 253 fishers in St. Lucia, Barbados, St. Vincent, Grenada and Tobago.

The interviewees were fishers who were present at the sites at the time of the visit, and those whose residences could be located with the help of Fisheries Officers. This approach was used owing to the anticipated difficulty of locating individual fishers selected at random from existing lists, and to the non-existence of such lists in many areas.

All interviews were conducted in private by the same interviewer. The fishers were asked the questions by the interviewer. Their responses were recorded and coded.

The questionnaire consisted of three sections: (1) background information about fishers and their practices; (2) information related to natural drifting objects; (3) practices related to FADs which fishers deploy. The first section sought to obtain data on the fishers and their boats, as well as on types of fish caught, gear used, the length of time spent at sea per fishing trip and their reasons for fishing at particular times of the year. The second section addressed fishers responses regarding the occurrence of naturally-occurring drifting objects encountered at sea during fishing, and the extent to which they attract fish. The third section was included to investigate the extent to which fishers take FADs along on fishing trips, and the mechanism of their deployment.

The interviews were carried out over a period of one week in each island and the data were entered in a Lotus 123 spreadsheet. The data were analysed in Statgraphics employing Chi-Square contingency tables and Kruskal-Wallis non-parametric ANOVAs. The null hypotheses were rejected at a significance level of $p < 0.05$.

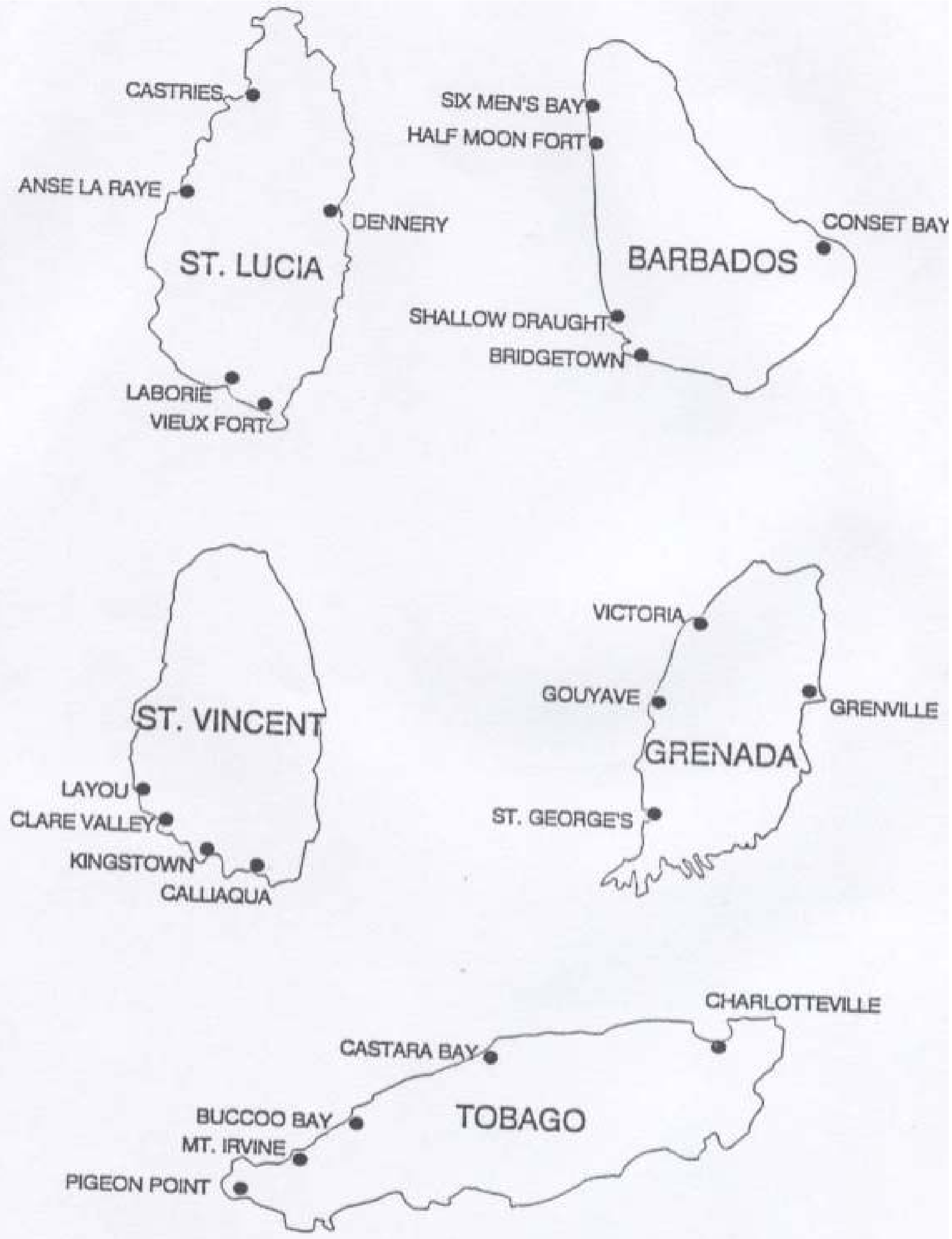

Figure 1. Sampling sites in each of the islands studied.

Table 1: Numbers of fishers interviewed by location.

COUNTRY	SITE	NO.
St. Lucia (SLU)	Dennery	10
	Anse La Raye	10
	Vieux Fort	10
	Laborie	10
	Castries	10
Sub-total		50
Barbados (BGI)	Bridgetown	10
	Shallow Draught	10
	Half Moon Fort	10
	Six Men's Bay	10
	Conset Bay	10
Sub-total		50
St. Vincent (SVG)	Layou	3
	Clare Valley	10
	Calliaqua	5
	Kingstown	35
Sub-total		53
Grenada (GRN)	Grenville	12
	Gouyave	13
	Victoria	13
	St. Georges	12
Sub-total		50
Tobago (TOB)	Mt. Irvine	10
	Castara	10
	Pigeon Point	10
	Charlotteville	10
	Buccoo	10
Sub-total		50
Grand total		253

RESULTS

Fishers and fishing practices

Significantly more of the 253 fishers interviewed fished full-time (227) than part-time (26; Table 2; $x^2_{[4]} = 39.9$, $p < 0.01$). Full-time fishermen predominated in all islands, but this proportion was lowest in Tobago (Table 2; Ql ***Appendix 1***).

Table 2: Occupational status of fishers by island (%). Island abbreviations as in Table 1. N is number of fishers.

STATUS	SLU	BGI	SVG	GRN	TOB
Full-time	96.0	92.0	94.3	100.0	66.0
Part-time	4.0	8.0	5.7	0.0	34.0
N	50	50	53	50	50

Fishers generally lived in the areas where they fished, although some from Mt. Irvine, Tobago live in the surrounding areas of Bethel, Canaan, Bon Accord and Black Rock; and some who fish from the Shallow Draught Harbour, Barbados, live in St. Philip and St. John. In St. Vincent, where the sampling sites were clustered around Kingstown (Figure 1), 66% of the fishers resided in the immediate vicinity of Kingstown, 25% resided outside of Kingstown and 10% resided on the nearby island of Bequia and operate out of Kingstown (Q2, Q3 & Q5).

The ages of fishers differed significantly among islands (Kruskal-Wallis; $H = 20.3$, $p < 0.05$), with the majority from Barbados ranging in age from 35 years to 58 years, St. Vincent from 30 years to 40 years, St. Lucia from 35 years to 60 years, Tobago from 35 years to 45 years, and Grenada from 30 years to 45 years (Figure 2a) (Q4).

The types of vessels used by fishers differed between islands (Figures 2b-d; Table 3). For example, most Barbadian fishers (86%) use launches, but they are not used in St. Lucia or Tobago. Most St. Lucian fishers (68%) use canoes, but these are not used in Barbados or Tobago. Most fishers from St. Vincent (83%), Grenada (92%) and Tobago (90%) use pirogues. (Q6).

The species targeted by fishers were grouped into three categories: (1) flyingfish; (2) large pelagics, (dolphinfish, kingfish, tuna, shark, billfish, swordfish) and (3) flyingfish and large pelagics (i.e. no preference). The category targeted differed between islands (Table 4; $X^2_{[8]} = 128.8$, $p < 0.05$). Excluding Barbados and St. Vincent, the category targeted did not differ between islands, i.e. St. Lucia, Tobago and Grenada ($x^2_{[2]} = 4.9$, $p > 0.05$), implying that the categories targeted in Barbados and St. Vincent differ from those in the other islands (Table 4; Q11l).

Fishers' preference for catching different species differed between islands (Table 5; $x^2_{[24]} = 106.7$, $p < 0.05$). Interestingly, the category targeted did not necessarily reflect the catch preference indicated. For example, most fishers from St. Lucia (88%), Grenada (70%) and

Tobago (80%) do not preferentially target large pelagics over flyingfish (Table 4), but they expressed a strong preference for catching the former (St. Lucia 92%; Grenada 98%; Tobago

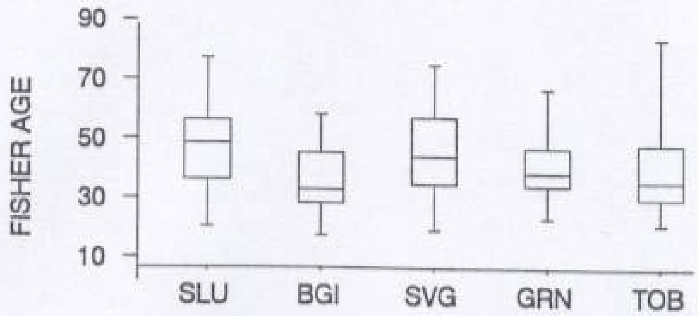

Figure 2a. The distribution of ages of fishers by island as indicated by box and whisker plots

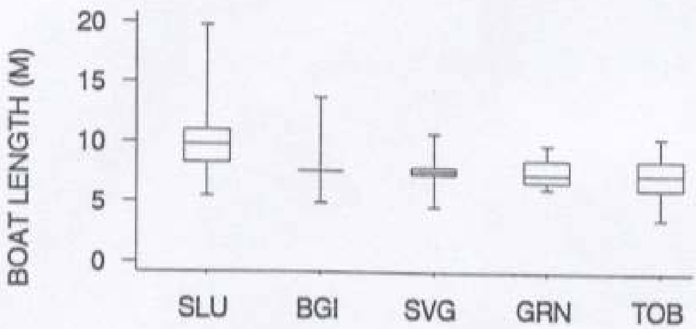

Figure 2b. The distribution of boat length by island as indicated by box and whisker plots

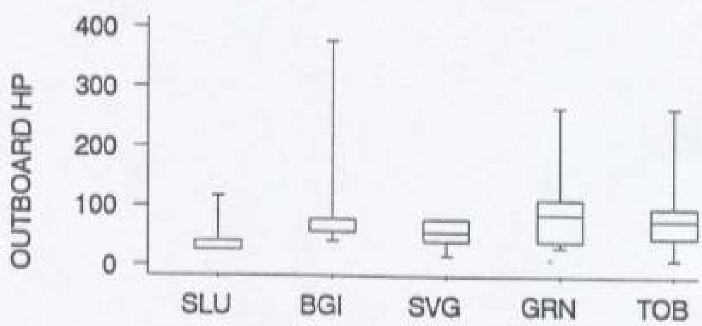

Figure 2c. The distribution of horsepower of outboard engines by island as indicated by box and whisker plots

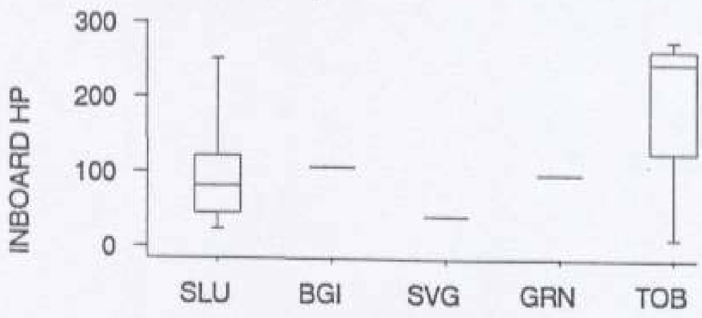

Figure 2d. The distribution of horsepower of inboard engines by island as indicated by box and whisker plots

90%; Table 5), Very few fishers expressed a preference for catching only flyingfish (6% each from St. Lucia and Tobago, 4% each from Barbados and St. Vincent, none from Grenada (Table 5; Q12).

Table 3: The characteristics of vessels used by fishers.

		SLU	BGI	SVG	GRN	TOB
Launch (%)		0.0	86.0	3.2	4.0	0.0
length	- average	-	34.2	42.8	30.0	-
	-range	-	(19-65)	(42-45)	(26-34)	-
hpower	- average	-	87.5	105.0	245.0	-
	- range	-	(22-250)	(105)	(250)	-
Canoe (%)		68.0	0.0	1.9	2.0	0.0
length	- average	24.9	-	26.0	29.0	-
	- range	(16-35)	-	(26)	(29)	-
hpower	- average	52.4	-	65.0	275.0	-
	- range	(25-75)	-	(65)	(275)	-
Pirogue (%)		30,0	8.0	83.0	92.0	90.0
length	- average	24.0	21.3	24.5	23.1	25.3
	- range	(16-28)	(18-30)	(16-45)	(12-32)	(20-32)
hpower	- average	60.7	47.5	77.3	77.8	84.4
	- range	(25-75)	(25-115)	(40-375)	(0-265)	(30-265)
Open outboard	(%)	2.0	6.0	1.9	2.0	10.0
length	- average	15.0	20.3	25.0	22.0	25.6
	- range	(15)	(19-23)	(25)	(22)	(22-28)
hpower	- average	15.0	26.7	40.0	265.0	80.6
	- range	(15)	(0-40)	(40)	(265)	(40-110)
% outboard boats with 2 engines		0.0	7.5	0.0	46.0	52.0

Fishers use different gear types to target pelagics, and the gear type used differs between islands (Table 6; $X^2_{[20]}$ - 328.6, $p < 0.05$). Most fishers from Barbados (92%), St. Lucia (84%) and Tobago (76%) use gillnets and trolling lines, most from St. Vincent (74%) use trolling lines only, and most from Grenada (66%) use longlines and gillnets (Table 6; Q13).

For most fishers in all islands, a fishing trip lasts between 9 and 12 hours, but trip length does differ significantly between islands (Figure 3; $x^2_{[12]} = 42.9$, $p < 0.05$)(Q14).

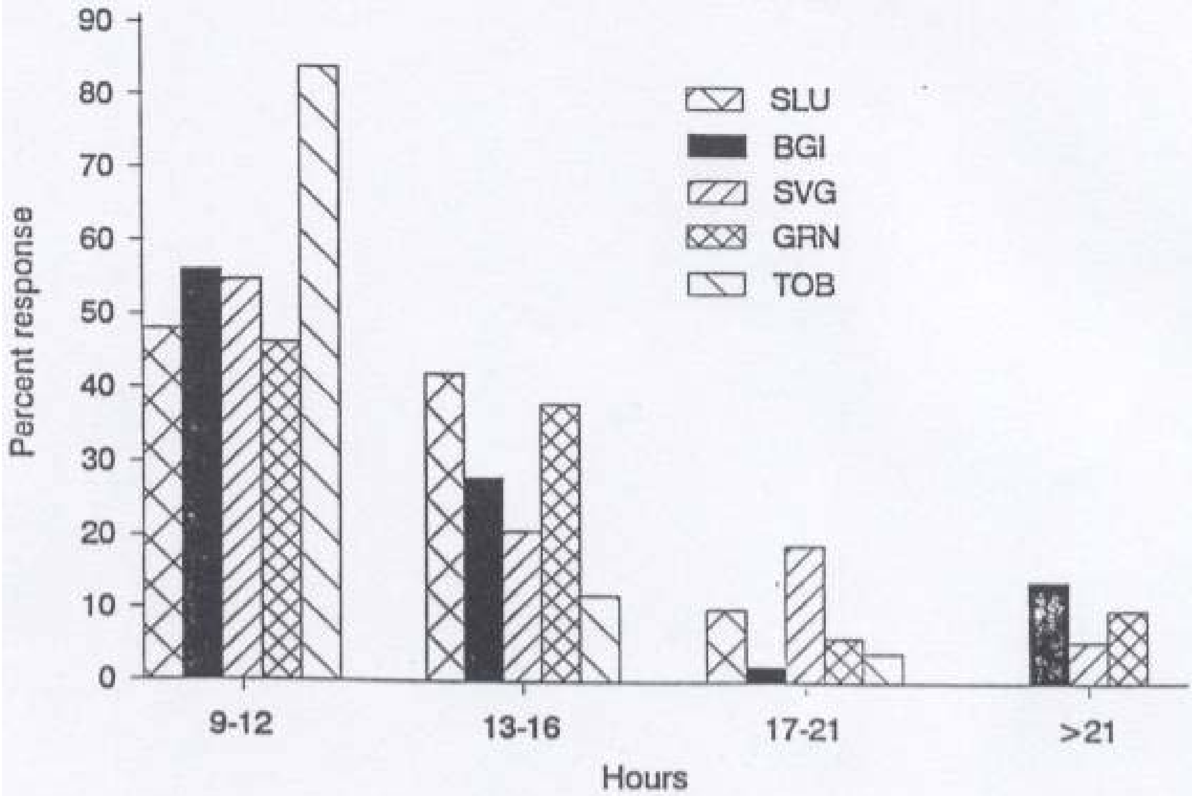

Figure 3. Duration of fishing trip by island

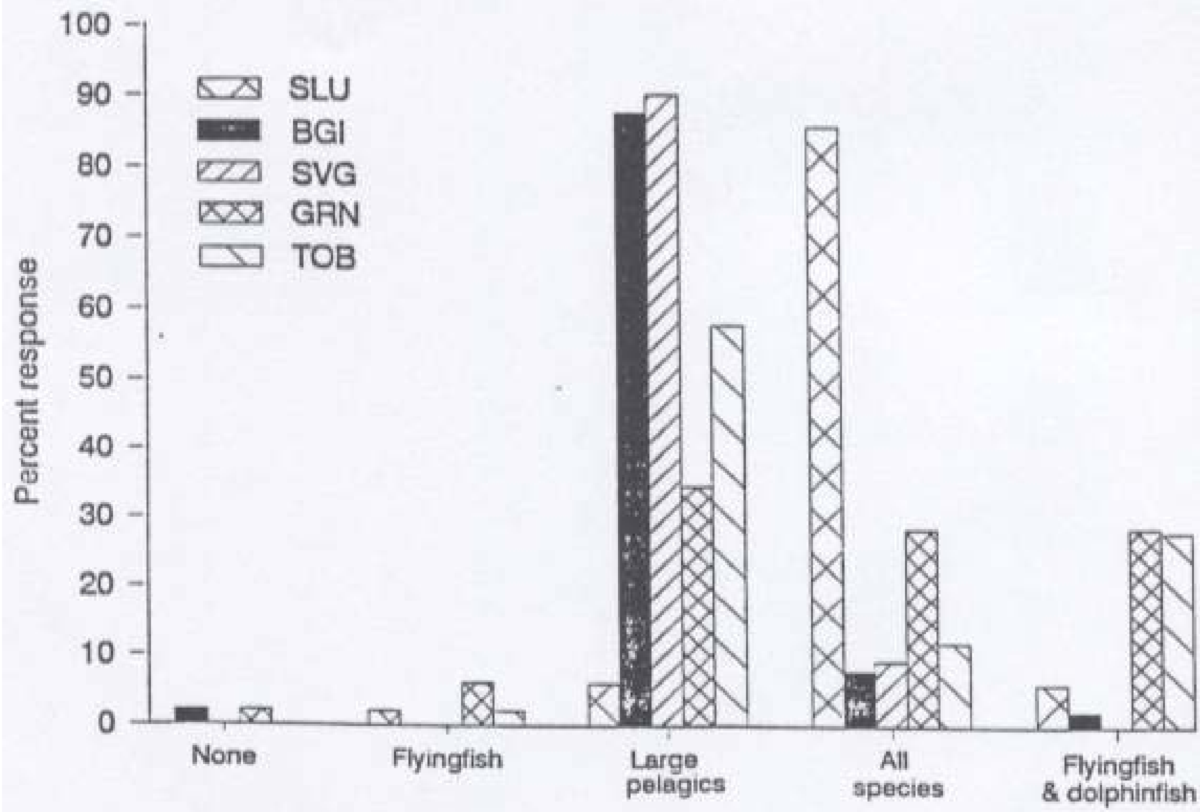

Figure 4. Fishers' perception of species groups attracted to drifting objects by island

Table 4: Species categories targeted by fishermen in different islands (%).

SPECIES	SLU	BGI	SVG	GRN	TOB
Flying fish	0.0	0.0	0.0	0.0	0.0
Large pelagics	12.0	80.0	98.1	30.0	20.0
No preference	88.0	20.0	1.9	70.0	80.0

Table 5: Preference for catching different species by island (%).

SPECIES	SLU	BGI	SVG	GRN	TOB
Flying fish	6.0	4.1	3.8	0.0	6.0
Dolphin fish	28.0	85.4	52.8	56.0	22.0
King fish	64.0	4.2	32.1	16.0	62.0
Tuna	0.0	6.3	11.3	22.0	2.0
Shark	0.0	0.0	0.0	0.0	4.0
Billfish	0.0	0.0	0.0	0.0	0.0
Swordfish	0.0	0.0	0.0	4.0	0.0
No preference	2.0	0.0	0.0	2.0	4.0

Table 6: Gear type used by fishers by island (%).

GEAR TYPE	SLU	BGI	SVG	GRN	TOB
Gillnet	4.0	0.0	3.8	2.0	6.0
Trolling	10.0	0.0	73.6	20.0	18.0
Longline & Gillnet	2.0	4.0	0.0	66.0	0.0
Gillnet & Trolling	84.0	92.0	0.0	4.0	76.0
Longline	0.0	4.0	0.0	8.0	0.0
Longline+ troll	0.0	0.0	22.6	0.0	0.0

Most fishers fished daily (Table 7), and the frequency did not differ significantly between islands ($x^2_{[20]}$ = 68.1, $p > 0.05$). A noticeable feature is that 24% of Barbadian fishers fish once per week, and 8% fish once every two weeks. This reflects the proportion of fishers using ice-boat launches which stay at sea for one to two weeks per trip (Q15).

Most fishers from Barbados (94%), St. Vincent (97%), St. Lucia (92%), Grenada (92%), and all from Tobago, fish throughout the year (Table 8), and the seasonality of fishing therefore did not differ significantly between islands (Kruskal-Wallis; $H = 4.6$, $p > 0.05$). This reflects the fact that, for most fishers, fishing is a full-time occupation (Q16).

Of those who fish at particular times of the year, the reasons for doing so differed significantly between islands ($x^2_{[8]} = 19.8$, $p < 0.05$). The reasons included that they fish during the flyingfish season (19% from Grenada, 12% from St. Lucia, *6%* from Barbados and *4%* from St. Vincent) or that the weather was good at the preferred time of the year *(4%* from Tobago and 2% from Grenada) (Q 17).

Table 7: Frequency of fishing by island (%)

FREQUENCY	SLU	BGI	SVG	GRN	TOB
Daily	80.0	64.0	73.6	71.4	76.0
4 times / wk	8.0	4.0	13.2	18.4	18.0
3 times / wk	8.0	0.0	0.0	4.1	4.0
2 times / wk	4.0	0.0	0.0	6.1	2.0
1 time / wk	0.0	24.0	13.2	0.0	0.0
1 time / 2wks	0.0	8.0	0.0	0.0	0.0

Table 8: Seasonally of fishing by island (%)

TIME OF YEAR	SLU	BGI	SVG	GRN	TOB
All year	96.2	94.0	92.0	92.0	100.0
Jan - June	3.8	0.0	8.0	8.0	0.0
July - Sept	0.0	6.0	0.0	0.0	0.0

The use of drifting objects

Most fishers in all islands look for drifting objects when fishing. Only *2%* each from Barbados and Grenada, 6% from Tobago, 4% from St. Lucia and none from St. Vincent do not look for drifting objects during fishing trips. The percentage of fishers looking for drifting objects did not differ significantly between islands ($x^2_{[4]} = 3.9$, $p > 0.05$) (Q18).

Fishers used different names for drifting objects. Most fishers from St. Lucia (94%) and St. Vincent (96%) referred to them as "bois" (the French equivalent of "log"), and most from Barbados (96%), and Tobago (94%) called them "logs". Grenadian fishers use the greatest variety of names for drifting objects. Approximately 49% called them "logs", 25% called them "warwits", 6% called them seaweed, and 4% each called them "bois", "stuff and "rafts". Eight percent stated that they encounter no drifting objects (Q19).

The drifting objects observed by fishers were classified into three categories: (1) predominantly objects of natural origin, e.g. trees, logs and wood; (2) predominantly objects of human origin, e.g. rope, pieces of net, crates, boxes, drums and mattresses; and (3) categories (1) and (2) combined. All fishers from St. Vincent and Tobago, and most from Barbados (98%), St. Lucia (94%) and Grenada (88%) considered that the drifting objects encountered were in category 3, i.e. of both human and natural origin; but the percentage responding this way differed significantly between islands ($x^2_{[12]} = 28.5$, $p < 0.05$) (Q20).

All fishers from St. Vincent and most from Barbados (98%), St. Lucia (96%), Tobago (96%) and Grenada (96%) stated that objects of both natural and human origin attract fish; the percentage stating this did not differ significantly between islands (Kruskal-Wallis; $H = 2.4$, $p > 0.05$)(Q21).

Most fishers responded that drifting objects were sometimes (as opposed to always or never) found (Table 9), but the frequency of finding objects differed significantly between islands ($x^2_{[12]}$, = 43.9, $p < 0.05$). The difference was driven primarily by St. Lucia (Table 9); when St. Lucia was excluded from the analysis, no significant difference between islands was detected ($x^2_{[9]}$, = 10.6, $p > 0.05$) (Q22).

Table 9: Fishers perceptions of the frequency of encountering drifting objects (%).

FREQUENCY	SLU	BGI	SVG	GRN	TOB
Always	28.0	0.0	1.9	8.0	2.0
Never	4.0	2.0	0.0	4.0	2.0
Sometimes	68.0	98.0	98.1	88.0	96.0

Most fishers from Barbados (68%), St. Lucia (69%), Tobago (54%) and Grenada (76%) stated that there was no particular pattern to the occurrence of drifting objects (Table 10); but most Vincentian fishers replied that drifting objects were predominantly found singly (87%). The response therefore differed significantly between islands ($x^2_{[12]}$ = 77.6, $p < 0.05$); but when St. Vincent was excluded from the analysis, no difference between islands was detected($x^2_{[9]}$ = 14.1, $p > 0.05$) (Q23).

Most fishers from Barbados (88%), St. Vincent (91%), Tobago (58%) and Grenada (35%) stated that large pelagics are most commonly attracted to drifting objects, while most St. Lucian fishers (86%) believed that all pelagic fish are equivalently attracted (Figure 4). This response differed significantly among islands ($x^2_{[16]}$ = 164.9, $p < 0.05$) (Q24).

Table 10: Fishers response to patterns of occurrence of drifting objects by island. Tide lines ("riffles"; "windrows") are zones of convergence of currents.

OCCURRENCE	SLU	BGI	SVG	GRN	TOB
Singly	20.8	30.0	86.8	18.0	38.0
Along tide lines	10.4	0.0	1.9	4.0	8.0
No particular pattern	68.8	68.0	11.3	76.0	54.0

Most fishers from Barbados (62%), St. Lucia (98%), Tobago (84%) and Grenada (84%) believed that both juvenile and adult fish are attracted to drifting objects, while most Vincentian fishers (76%) believed that adult fish are more attracted (Figure 5). The response therefore differed significantly between islands ($x_{[12]}$ = 107.3, $p < 0.05$). The difference was driven by Barbados and St. Vincent; when these islands were excluded from the analysis, no difference between islands was detected ($x^2_{[6]}$, = 8.3, $p > 0.05$) (Q25).

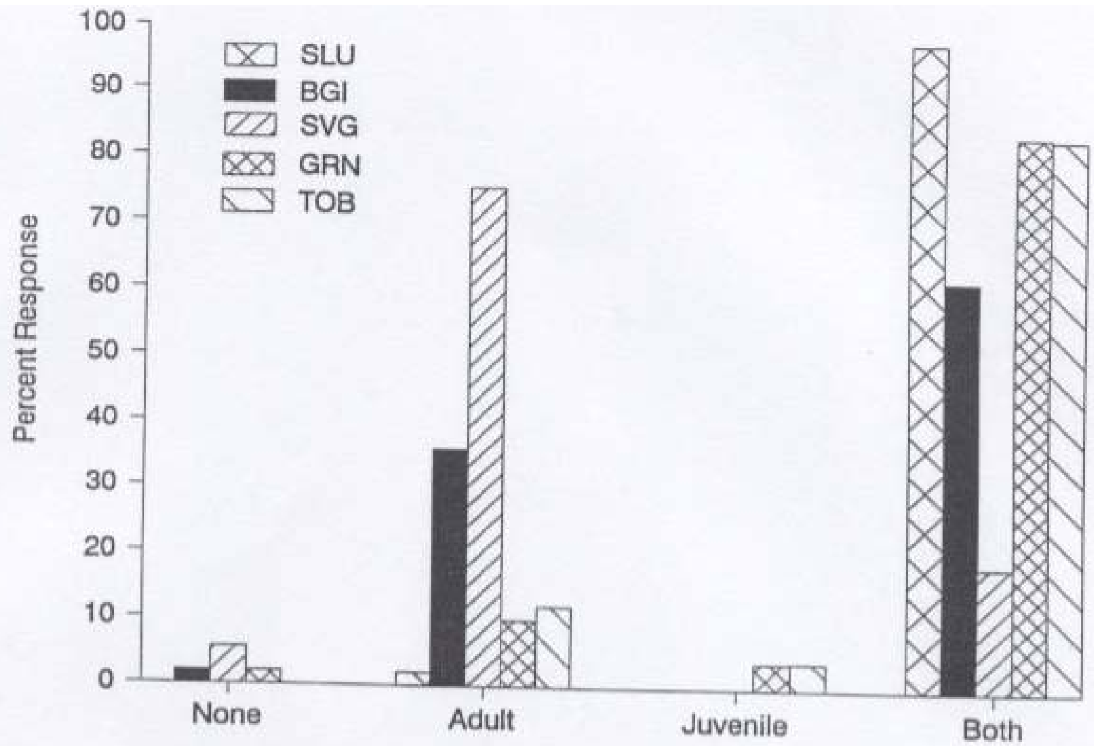

Figure 5. Fishers' perceptions of the life history stage of fish attracted to drifting objects by island

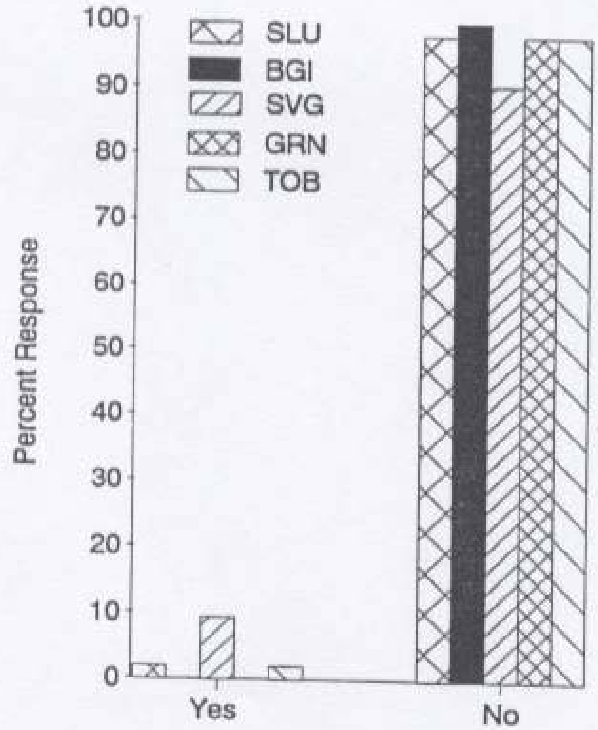

Figure 6. Fishers' selectivity of particular drifting objects by island

Most fishers from Barbados (98%), Tobago (96%), St. Vincent (91%), Grenada (81%) and St. Lucia (81%) believed that catch rates were not higher around any particular type of floating object; but the percentage responding this way differed significantly between islands ($x^2_{[28]}$ — 54.9, $p < 0.05$). The difference was driven primarily by St. Lucia and Grenada; when these islands were excluded from the analysis, no difference among islands was detected ($x^2_{[6]} = 11.1$, $p > 0.05$) (Q26).

All fishers from St. Vincent, and most from Barbados (98%), Tobago (90%), St. Lucia (92%) and Grenada (83%) did not believe that particular species were attracted to particular types of drifting objects; but the percentage believing this differed significantly between islands ($x^2_{[16]} = 26.5$, $p < 0.05$)(Q27). Some Grenadian fishers replied that flyingfish were attracted to pieces of net (4%), larger pelagics to pieces of rope (6%) and flyingfish and dolphinfish together to pieces of wood (4%) (Q27).

Fishers opinions as to which species are caught in most abundance around drifting objects differed significantly among islands ($x^2_{[20]} = 182.8$, $p < 0.05$), with 98% from St. Vincent, 78% from Barbados, 50% from Tobago, and 40% from Grenada indicating that the catch is predominantly large pelagics, but 82% from St. Lucia indicating that all species are caught in equivalent abundance around such objects (Table 11) (Q29).

Most fishers believed that drifting objects increased catch rates, with only 8% from Grenada, 6% from St. Lucia, 4% from Tobago and 2% from St. Vincent believing that they did not. This response did not differ significantly among islands ($x^2_{[8]} = 8.6$, $p > 0.05$) (Q28).

Most fishers believed that fish do associate with drifting objects to a greater extent during a particular season of the year, and this response did not differ significantly between islands (Table 12; $x^2_{[8]} = 14.5$, $p > 0.05$) (Q30). However, their opinions as to the actual season of association differed significantly among islands ($x^2_{[16]} = 71.3$, $p < 0.05$). Most fishers from Barbados, St. Vincent and St. Lucia stated that January to March is the period when most fish associate with drifting objects; but fishers from Grenada and Tobago believed that the duration of seasonal association was longer (Table 12) (Q31).

Table 11: Fishers perceptions of predominant species caught around drifting objects by island (%).

SPECIES	**SLU**	**BGI**	**SVG**	**GRN**	**TOB**
Flyingfish	12.0	0.0	1.9	8.3	6.0
Large pelagics	6.0	78.0	98.1	40.6	50.0
All species	82.0	8.0	0.0	28.2	12.0
Flyingfish &	0.0	7.0	0.0	22.9	26.0
Dolphin fish	0.0	7.0	0.0	0.0	6.0

Fishers perceptions of the time of year when drifting objects are most abundant differed significantly between islands ($x^2_{[16]} = 102.5$, $p < 0.05$) as did their perception of when drifting objects are least abundant (Table 12; $x^2_{[16]} = 84.9$, $p < 0.05$). Most from St. Lucia (91%) and Barbados (84%) believed that drifting objects were most abundant between January and March, while most from St. Vincent (62 %) felt that abundance was highest between July and

September.

Fishers from Grenada and Tobago indicated a longer duration of seasonal abundance of drifting objects (Table 12) (Q32).

All fishers from Barbados and most from St. Lucia (80%) and Grenada (58%) stated that drifting objects were least abundant between July and September, while most from St. Vincent (77%) and Tobago (60%) identified this period as January to March (Table 12) (Q33).

Fishers responses about the colour of water with which drifting objects are primarily associated differed significantly among islands (Table 13; $x^2_{[16]} = 100.2$, $p < 0.05$). All fishers from Barbados and most from St. Lucia (58%) and Grenada (55%) considered this colour to be green, while most from St. Vincent (54%) and Tobago (49%) considered it to be brown. (Q34, 35).

Table 12: Fishers perceptions of seasonal association of fish with drifting objects (%).

RESPONSE	SLU	BGI	SVG	GRN	TOB
Seasonal association	90.0	98.0	82.7	93.9	87.8
Time of year of association					
January-March	95.6	83.6	95.3	43.5	50.0
April-June	0.0	16.4	0.0	22.9	22.5
July-September	2.2	0.0	4.7	33.6	22.5
October-December	2.2	0.0	0.0	0.0	5.0
Time of year of most drifting objects					
January-March	91.1	83.6	38.4	40.0	30.2
April-June	6.6	16.4	0.0	20.0	18.6
July-September	0.0	0.0	61.6	37.8	43.1
October-December	2.3	0.0	0.0	2.2	8.1
Time of year of fewest drifting objects					
January-March	7.4	0.0	76.7	39.9	59.4
April-June	6.3	0.0	2.4	0.0	3.1
July-September	80.0	100.0	20.9	57.9	37.5
October-December	6.3	0.0	0.0	2.2	0.0

Fishers appear to have no strategy for locating drifting objects *per se,* but rather use the presence of birds as a cue to locating fish which may be associated with these objects. Most fishers from St. Vincent (98%), from Barbados (92%), from St. Lucia (84%), from Tobago (70%), and from Grenada (69%) use birds as a cue for locating fish. This proportion differs significantly between islands ($x^2_{[12]} = 60.1$, $p < 0.05$) (Q36).

Most fishers from all islands stated that they do not select a particular type of drifting object before fishing (Figure 6), but approach any object and determine whether there are fish around it. All fishers from Barbados, 98% from Tobago, Grenada and St. Lucia, and 91% from St. Vincent usually fish around the first object they encounter which has fish. Nine percent from St. Vincent and 2% from St. Lucia look for special drifting objects before fishing (Q39).

Table 13: Fishers perceptions of the relationship of water colour to drifting objects (%).

WATER COLOUR	SLU	BGI	SVG	GRN	TOB
Blue	27.9	0.0	36.0	12.7	15.6
Green	58.2	100.0	10.0	55.4	35.6
Brown	13.9	0.0	54.0	31.9	48.8

The pattern of fishing around drifting objects was similar among islands. Most fishers stayed within 36 m of the object, and usually within 18 m, circling it while catching fish (Q37).

Most fishers had difficulty in estimating the time spent fishing around a drifting object, because it varied with the abundance of fish around the object. However, most stated that they spend approximately three hours fishing around a drifting object, although some from St. Lucia (2%) stated that they spend as much as eight hours (Q38).

Most fishers from Barbados (78%), St. Lucia (95%), Tobago (64%) and Grenada (72%) believed that large predatory fish such as billfish cause other fish to disperse from around drifting objects, but most Vincentian fishers (72%) believed that nothing causes fish to disperse (Figure 7). This response differed significantly among islands ($x^2_{[20]}$ = 99.2, $p < 0.05$) (Q40).

Deployment of FADs by fishers

Most fishers from Barbados (90%), St. Lucia (56%) and Tobago (70%) always use FADs, while Vincentian fishers and most Grenadian fishers (46%) never use them (Figure 8). The practice of FAD deployment therefore differed significantly between islands ($x^2_{[12]}$ = 300.1, $P < 0.05$) (Q41). Because Vincentian fishermen do not use FADs, the remaining questions in this section are not applicable to them.

The types of FADs deployed by fishers differed significantly between islands ($x^2_{[32]}$ = 398.4, $p < 0.05$), with most Barbadian fishers (98%) using sugarcane trash, but most Tobagonian (95%), Grenadian (79%) and St. Lucian (45%) fishers using coconut branches (Table 14) (Q43).

All fishers from Barbados who deploy FADs, and most from Tobago (94%), St. Lucia (85%), and Grenada (85%) use them to target flyingfish, while 9% of St. Lucian fishers, 15% of Grenadian fishers and 5 % of Tobago fishers who deploy FADs use them to target large pelagics, but catch any fish attracted to the FADs (Table 15). This difference in the percentage of fishers targeting different species was significant between islands ($x^2_{[12]}$ = 115,2, $p < 0.05$) (Q42).

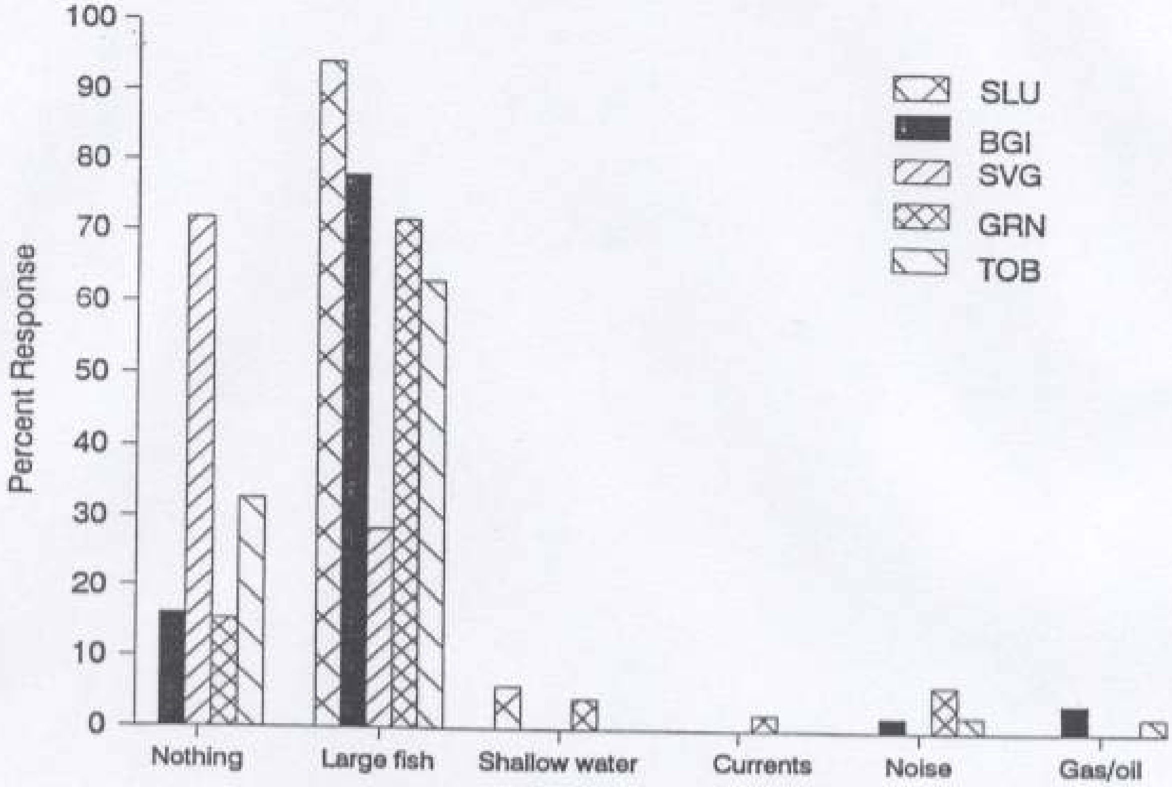

Figure 7. Fishers' perceptions of causes of fish dispersing from drifting objects by island

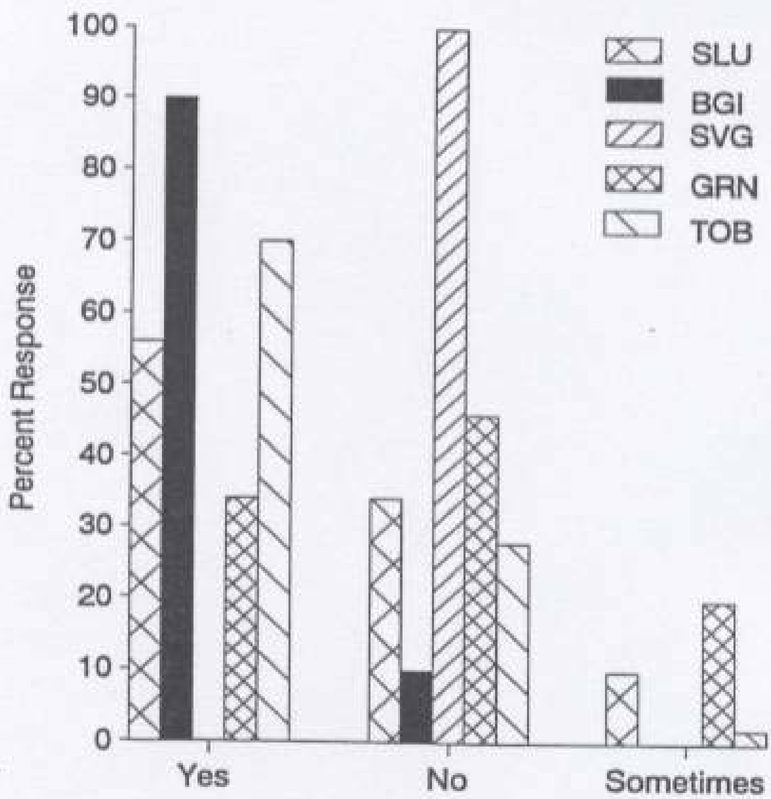

Figure 8. Percentage of fishers who deploy FADs by island

All fishers from Barbados, 92% from Grenada, 84% from St. Lucia and 83% from Tobago stated that primarily flyingfish are attracted to deployed FADs, the percentage expressing this opinion differing significantly between islands ($x^2_{[20]} = 129.7$, $p < 0.05$). A few fishers from Grenada (8%), Tobago (6%) and St. Lucia (3%) replied that these FADs attract large pelagics, while 13% from St. Lucia and 3% from Tobago believed that both flyingfish and dolphinfish are attracted to FADs, and 5% from Tobago felt that predominantly dolphinfish are attracted to FADs (Figure 9) (Q46).

Table 14: Types of FADs deployed by fishers by island (%)

TYPE OF FAD	SLU	BGI	GRN	TOB
Coconut branches	45.2	0.0	78.5	94.5
Sugarcane trash	3.0	97.8	2.0	0.0
Banana leaves	20.3	0.0	0.0	0.0
Banana & coconut leaves	20.3	0.0	0.0	0.0
Other artificial floating objects	6.1	2.2	14.3	5.5
Wooden shipping palets	2.1	0.0	7.2	0.0
Plywood	3.0	0.0	0.0	0.0

Table 15: Species targeted with FADs by island (%)

SPECIES TARGETED	SLU	BGI	GRN	TOB
Flyingfish	84.8	100.0	84.6	94.4
Large pelagics	9.1	0.0	15.4	5.6
Flyingfish & large pelagics	6.1	0.0	0.0	0.0

Fishers were unable to state the reason for their using one type of FAD in preference to another (Q47). Fishers from all islands deployed FADs similarly. The FADs are attached to the boats, sometimes on single long lines and sometimes on separate lines, and the boats are allowed to drift as fish aggregate around the FADs and enter the nets (Q48).

Most fishers using FADs fish during the day; but 1% from Tobago fish at night, and 8% from Barbados and 44% from Grenada fish both during the day and night (Table 16). The differences in diel patterns of fishing with FADs were significant between islands ($x^2_{[8]} = 83.4$, $p < 0.05$) (Q44).

Given that only Grenadian fishers (44%) and a few Barbadian fishers (8%) fish with FADs in the day and in the night, differences between islands in day and night catch rates were not considered (Q45).

All fishers from Barbados and most from St. Lucia (97%), Tobago (91%) and Grenada (83%) believed that fish do associate with FADs at particular times of the year (Q49).

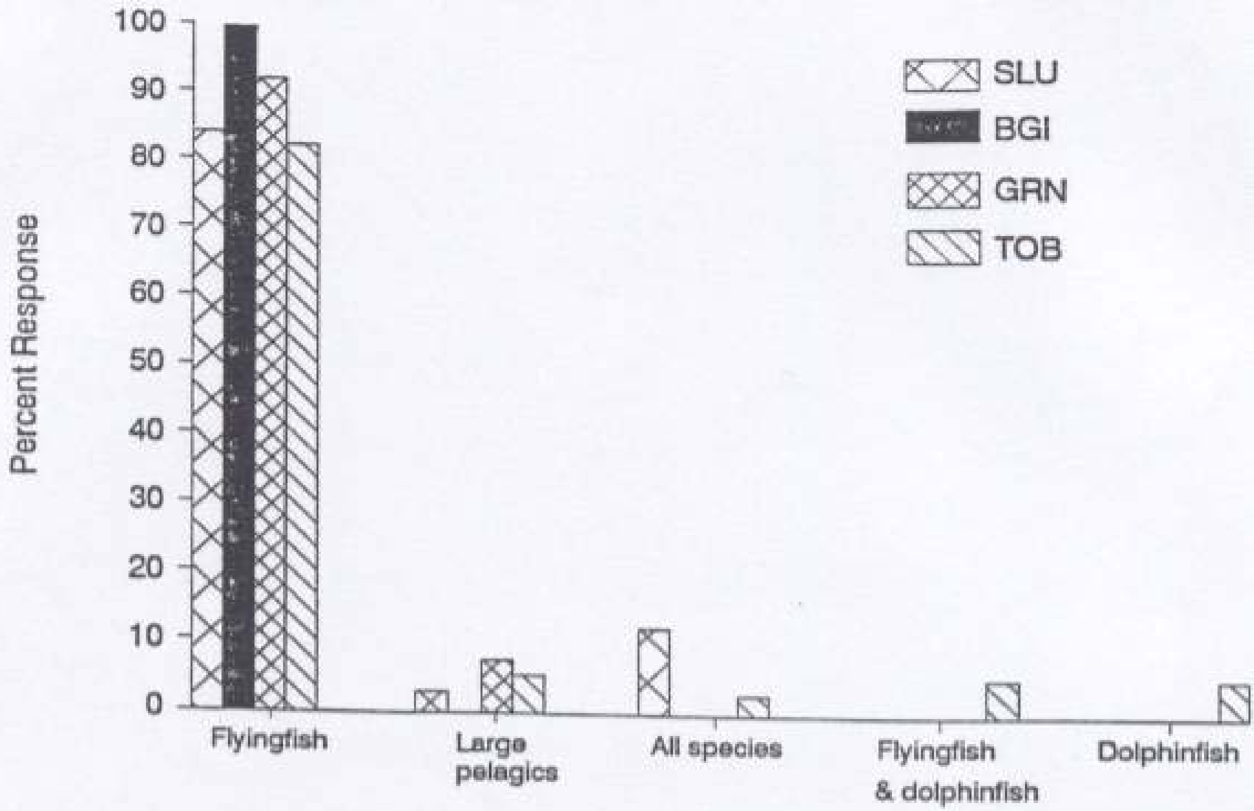

Figure 9. Fishers' perceptions of the species which are attracted to FADs by island

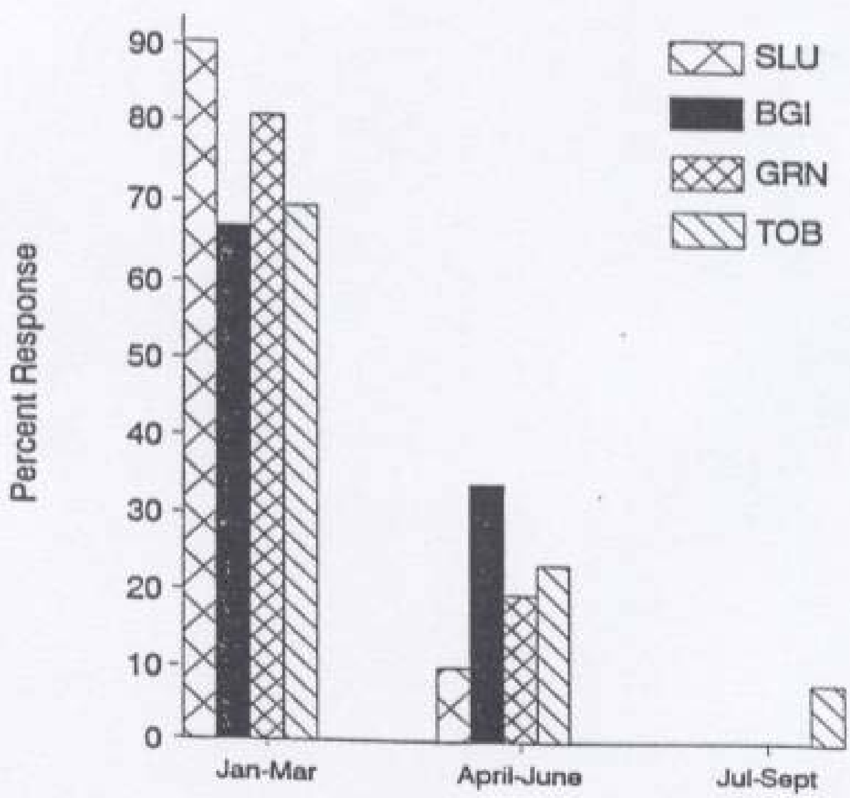

Figure 10. Fishers' perceptions of the seasonality of association of fish with FADs by island

Table 16: Diel patterns of fishing by island (%).

TIME OF DAY	SLU	BGI	GRN	TOB
Fish by day	100.0	92.0	56.0	98.0
Fish by night	0.0	0.0	0.0	2.0
Fish by day & night	0.0	8.0	44.0	0.0
Time most fish caught				
Day	-	92.0	60.0	-
Night	-	8.0	40.6	-

However, fishers from different islands differed in the particular months identified as the principal time of association of fish with FADs ($x^2_{[12]} = 106.6$, $p < 0.05$). Most fishers from St. Lucia (90%), Barbados (67%), Tobago (69%) and Grenada (81%) believed that more fish associate with FADs between January and March. However, 33% from Barbados, 23% from Tobago, 19% from Grenada and 10% from St. Lucia thought this period to be April to June, and 8 % of fishers from Tobago thought this period to be between July and September (Figure 10) (Q50).

There was a significant difference among islands in the frequency with which fishers who deploy FADs carry them on fishing trips ($x^2_{[8]} = 212.8$, $p < 0.05$). All from Barbados, 50% from Tobago, 33.3% from Grenada and 9.3% from St. Lucia take FADs on every fishing trip (Table 17) (Q51).

Fishers take FADs only at certain times of year because of seasonal variation in abundance of the species targeted by FADs. For example, all fishers from Barbados, 94% from Tobago, 85% from St. Lucia, and 85% from Grenada only target fiyingfish with FADs and therefore only take FADs during the fiyingfish season (Q52).

Table 17: Frequency of deployment of FADs by island (%).

RESPONSE	SLU	BGI	GRN	TOB
Always	9.3	100.0	33.3	50.0
Sometimes	90.7	0.0	66.7	50.0

DISCUSSION

In this study, 253 fishermen from St. Lucia, Barbados, St. Vincent, Grenada and Tobago were interviewed over a five-week period to obtain information on the role of drifting objects in pelagic fisheries and thereby assess the biological and economic feasibility of deploying drifting FADs to increase catches of pelagic fish. The fishers used in the study were active, frequent fishers, who would be expected to be knowledgeable about the fishery. For most fishers from all the islands, fishing is a full-time occupation. They generally live in the immediate vicinity of the landing sites from which they fish, but exceptions were found in Tobago, in Kingstown, St. Vincent, and to a lesser extent Bridgetown, Barbados. Most fishers interviewed use small vessels with outboard engines, but a few had larger vessels with inboard engines. Although data were not available to quantitatively assess whether the sample of fishers, gear and vessels was statistically representative of the fishing fleets, a qualitative comparison with the literature indicates that all known types and sizes of vessels were covered in the survey (Mahon 1988).

All available species of pelagics are targeted, but the species targeted by individual fishers differs somewhat within and between islands. Both the species targeted and duration of fishing trips reflect the type and size of boats used. Larger and more sea-worthy boats can venture further to sea and stay out for longer periods than smaller boats (Mahon and Singh-Renton 1992). The species targeted are also influenced by available markets. For example, in St. Vincent, fishers do not use drifting FADs, which they claim attract mainly flyingfish, because Vincentians do not consume flyingfish, nor are there market facilities for storage and processing of catch for export.

During fishing trips, most fishers from all islands seek out drifting objects, which they sometimes encounter. Fishers in the eastern tropical Atlantic are also known to seek out drifting objects which attract and aggregate tunas (Ariz et al. 1992). The types of drifting objects which are encountered are similar among islands. This is expected since the islands are close to each other and are influenced by the same currents. The islands studied are exposed to the net westward flow of the North Equatorial Current and the Guiana Current, and particularly when the Guiana Current is predominant, the islands are influenced by the waters of the many large rivers discharging along the north coast of South America (Muller-Karger 1993).

Drifting objects of both natural and human origin are sought by fishers and are referred to by a variety of names. They attract and aggregate many different species of pelagic fish. The names given to the drifting objects differ considerably among islands.

Fishers were unable to distinguish the extent to which different species are attracted to different types of drifting objects. They stated only that all species are found in association with all types of objects. In contrast, the literature suggests that some species are more likely to be associated than others; and it seems unlikely that swordfish and marlins would aggregate around drifting objects (Hunter 1967, Khokiattiwong 1988, Cayre 1991, Batalyants 1992, Ariz et al, 1992).

Most fishers stated that the association of fish with drifting objects is seasonal. Most reported that fish tend to associate with drifting objects between January and March, which is also when drifting objects are most abundant. Their reports also suggest that drifting objects are more abundant year round off Grenada and Tobago than off the other islands.

This seasonal pattern of occurrence of drifting objects is consistent with the seasonality of oceanographic characteristics reported in the literature (Muller-Karger 1993). The Amazon and Orinoco Rivers, as well as other large rivers which can entrain drifting objects, flow into the Atlantic Ocean along the northeast coast of South America. The subsequent direction of movement of this water is largely determined by the seasonal variation in the effects of the North Equatorial and Guiana Currents on the region (Muller-Karger 1993). Coastal Zone Colour Scanner (CZCS) imagery and drifting buoys reveal that Amazon water most consistently and clearly affects the southeastern Caribbean between January and March, when fishers report the highest incidence of drifting objects.

In addition to being influenced by Amazon River water, Grenada and Tobago are also affected by Orinoco River discharge which travels westward or northwestward, but generally remains within the southern Caribbean (Muller-Karger 1993). This discharge also occasionally affects St. Vincent. July to November is the period of maximum discharge of the Orinoco River, with minimum discharge being between February and April. The fact that Grenada and Tobago are frequently, and St. Vincent occasionally, affected by the discharge of both the Orinoco and Amazon Rivers could explain the longer seasonal duration of occurrence of drifting objects in these islands.

Fishers observed that most drifting objects were found in water which was either green or brown. This observation, and the time of year that they primarily report drifting objects, is consistent with the seasonality of water colour in the eastern Caribbean (Khokiattiwong 1988). The waters in the vicinity of these islands change seasonally according to the relative effects of the North Equatorial Current and the Guiana Current. When unaffected by Amazon water, water from the former current is clear blue and oligotrophic. When it is affected by Amazon water through the influence of the Guiana Current, it becomes nutrient enriched and develops phytoplankton blooms which colour it green. Sediment, dissolved organic matter and particulates carried by the large rivers colour the water brown near the coast of South America. This could explain why fishers in Tobago, Grenada and St. Vincent more frequently observed that drifting objects were found in brown water than did fishers from Barbados and St. Lucia. In summary, at periods of greatest river discharge, when drifting objects are most abundant, water colour is sometimes brown and sometimes green.

The drifting objects occur singly or along fronts (Owen 1981). Fronts are locally referred to as "tidelines", "windrows" or "riffles". Fronts are known to occur off Barbados, but no data are available on their frequency. However, it is possible that they are more common from January to March, the period when current speed is strongest (Muller-Karger 1988). In fronts caused by current convergence, drifting objects from both water masses accumulate. Fishers are very knowledgeable about "riffles" and their tendency to cause the accumulation of drifting objects around which large numbers of fish aggregate.

Fishers do seek out birds as an indicator of the presence of fish and the drifting objects around which the fish aggregate. When fish aggregate around drifting objects, birds are attracted to them for food, and hence can be used as a cue to their location. This is supported by many published reports of the frequent association of birds with drifting objects around which fish aggregate (Ingham and Mahnken 1966, Kwei and Bannerman 1992, Ariz et al. 1992).

Fishers fish around the first drifting object that they encounter at which fish have aggregated. The length of time spent fishing around these objects varies among fishers from different islands, but all fishers claim to fish around a drifting object until the fish stop "biting".

Most fishers (but see St. Vincent for exception) report that large predatory fish cause small fish to disperse from around drifting objects. This observation is consistent with reports that small fish first gather around a drifting object, where they are sought by large predatory fish which cause them to disperse (De Sylva 1981).

Fishers from most islands (see St. Vincent for exception) deploy drifting FADs to target flyingfish which are attracted to them as spawning sites (Lao 1989, Oxenford et al. 1993). The FADs deployed for flyingfish are made of readily available and inexpensive material, and are carried by most fishers on all fishing trips, particularly during the flyingfish season (December-June). The materials used in making FADs are island-specific, depending on the availability of suitable material.

The most striking result of this study is that fishers in the southeastern Caribbean do not use drifting FADs to aggregate large pelagics. This may be because an assemblage of large pelagics may take several days to develop around a drifting object (Clavijo et al. 1987, Hunter and Mitchell 1976). Most fishers in the region lack the types of vessels needed to stay at sea for long enough to monitor drifting objects while fish assemblages develop. However, the use of deployed drifting FADs in artisanal and commercial fisheries in other areas of the world, and the observation that fish commonly associate with drifting objects in the southeastern Caribbean, suggest that the use of drifting FADs should be explored as an option for the development of fisheries for large pelagics in this region. A notable recent example of the successful use of drifting FADs is in the eastern tropical Atlantic, where purse seine vessels using FADs have increased their catch rates considerably. Although large commercial purse seiners may not be feasible for eastern Caribbean islands at this stage of fishery development, small vessels could possibly use drifting FADs to aggregate fish for capture by trolling or pole and line fishing. It is also possible that small vessels could be adapted to use small purse seines suitable for encircling drifting objects. Small purse seines have been successfully used to catch pelagics attracted to drifting objects in other parts of the world (Hunter et al. 1966).

The fisheries and biological-oceanographic information obtained from fishers in this study was largely consistent with information reported in the literature. The reported types of vessels, species targeted and gear used is consistent with previous studies (Mahon 1988). The association of fish with drifting objects, and the resultant increase in catch rates, is also consistent with what is known from other parts of the world, and from the limited information in the Caribbean (Gooding et al. 1966, Hunter 1967, Dooley 1972, Feigenbaum et al. 1989, Scott 1985, Watanabe et al. 1988, Rountree 1990). The seasonality of occurrence of drifting objects, as well as the colour of water in which they are found, compare favourably with what is known of the physical oceanography of the region (Muller-Karger 1990). The strategy described for locating drifting objects and for fishing around them is representative of patterns reported in other studies (Kwei and Bannerman 1992); and finally, the use of artificial FADs to increase catch described by the fishers has been well documented elsewhere (Wickham et al. 1973, De Sylva 1981, Matsumoto et al. 1981, Chandler et al. 1985, Clavijo et al. 1987, Buckley et al. 1989).

In contrast, there were some cases in which fishers were unable to give more detailed quantitative biological information. For example, the fishers were unable to distinguish among the different species of large pelagics which are attracted to FADs, they had difficulty in estimating the actual time spent fishing around FADs, and they were unable to explain their choice of using a particular type of FAD. However, considering the full range of information sought and obtained in this study, it is evident that useful and reliable fisheries and biological-oceanographic data can be obtained directly from fishers in the Caribbean.

CONCLUSION AND RECOMMENDATIONS

Drifting objects play an important role in large pelagic fisheries in the southeastern Caribbean. They attract fish, thereby increasing their catchability. This effect appears to be seasonal, generally being greatest between January and March in all islands, but is extended in Grenada and Tobago. The predominance of drifting objects, and perhaps the tendency of fish to associate with them, is greatest in water which is green or brown in colour.

Fish associate with both natural and anthropogenic objects with no apparent preference either within or between these groups. Fishers actively seek and fish around drifting objects. Moreover, fishers from St. Lucia, Barbados, Grenada and Tobago deploy drifting FADs to target flyingfish. The FADs are constructed of naturally-occurring inexpensive material. However, no fishers in the southeastern Caribbean target large pelagics using deployed drifting FADs.

The results of this study suggest that the deployment of anchored FADs should be successful in increasing catch rates of large pelagics, and hence that the potential for development of fisheries for large pelagics using drifting FADs deployed by fishers should be explored.

Development of the use of deployed drifting FADs for harvesting large pelagics could be based on trolling, or pole and line fishing, but would probably be most effective with the introduction of small purse seines. This would require larger vessels than those traditionally used in trolling for large pelagics in the Caribbean. Even if trolling and pole and line were used to fish around drifting FADs, larger vessels would be required to carry and deploy the FADs and to stay at sea for long enough for the FADs to aggregate fish. The scale of technology envisaged is intermediate between the traditional small-scale trolling practised in the eastern Caribbean and large-scale commercial purse seining practised by Venezuela. The use of deployed FADs as described above should enable the islands of the eastern Caribbean to more effectively exploit larger pelagics further offshore in their EEZs.

The final recommendation of this study is that pilot projects on both anchored and drifting FADs should be conducted in the eastern Caribbean with particular emphasis on producing quantitative data on their effects on catch rates, and hence on determining their feasibility in the exploitation of large pelagics in the region.

ACKNOWLEDGEMENTS

We would like to thank Hazel Oxenford, John Neilson, and Karl Aiken for their comments on the text. We thank Malcolm Hendry and Gerard Dharmaratne for discussion and provision of references. We also appreciate the assistance of the staff at CFRAMP, St. Vincent and the Fisheries Officers in St. Lucia, Barbados, St. Vincent, Grenada and Tobago.

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APPENDIX I

Questionnaire to determine the role of drifting objects in pelagic fisheries in the Eastern Caribbean.

SECTION 1: Background information about fishers and their practices

Date: ……………… Name of interviewee: ………………………….

1. Occupation: 1 – Full-time 2 – Part-time

2. Place of residence: …………………………………………………

3. Location: ………………………………………………………...

4. Age at last birthday: ………………………………………………..

5. In which areas do you fish? ……………………………………..

6. What type of vessel do you use?

   1 – Launch 2 – Canoe 3 – Pirogue 4 – Open outboard

7. What size is your boat? ……………………………………………

8. Do you have an outboard or inboard engine?

   0 – No Engine 1 – Outboard 2 – Inboard

9. If you use an outboard engine, how many outboards? 1 2

10. What horsepower is the engine? …………………………………...

11. What type of fish do you catch?

Flyingfish	Dolphinfish	Kingfish	Tuna
Shark	Billfish	Swordfish	Others

    1 – Flyingfish 2 – Large pelagics 3 – No preference

12. What type of fish do you prefer to catch?

    1 – Flyingfish 2 – Dolphinfish 3 – Kingfish
    4 – All Species 5 – Tuna 6 – Billfish
    7 – Swordfish

13. What type of gear do you use?

    Flyingfish ……………………………………………………..
    Dolphinfish / Kingfish / Tuna / Shark / Billfish …………………...
    Swordfish ……………………………………………………..
    1 – Gill Net 2 – Troll 3 – Longline / Gillnet
    4 – Gillnet / Troll 5 – Longline 6 – Troll / Longline
    7 – All

14. What time do you (a) leave to go on a fishing trip?
    (b) return from a fishing trip?

    1 – 9-12 hrs. 2 – 13-16 hrs. 3 – 17 – 21 hrs. 4 - > 21 hrs.

15. How often do you fish?

    1 – Everyday 2 – 4 times / wk 3 – 3 times / wk 4 – twice / wk
    5 – once / wk 6 – once / 2 wks 7 – once / 3 wks

16. During which months do you fish?

    1 – All year 2 – Jan – June 3 – July – Dec 4 – Dec - Mar

17. Why do you fish in these months?

    1 – More money 2 – Fishing season
    3 – Good weather 4 – Otherwise employed

Section II: Information related to natural drifting objects

18. Do you look for floating objects before starting to fish?

    1 – Yes 2 – No

19. What do you call these floating objects?

1 – Bois	2 – Logs	3 – Seaweed	4 – Warwits
5 – Rope	6 – FADS	7 – Stuff	8 – Raft
9 – Coconut Branch			

20. What types of floating objects do you meet?

1 – Wood, tree, log
2 – Rope, net, crate, box, drum, mattress
3 – All types

21. What kinds of objects have fish under them?

1 – Wood, tree, log
2 – Rope, net, crate, box, drum, mattress
3 – All types

22. Do you always find natural floating objects when you fish?

1 – Yes 2 – No 3 – Sometimes

23. Do you meet objects which occur singly or along tide lines?

1 – Singly 2 – Along tidelines 3 – Both

24. What fish are attracted to the floating objects?

1 – Flyingfish 2 – Large pelagics 3 – All species
4 – Flyingfish and Dolphinfish

25. Do the floating objects attract adult or junveile fish?

1 – Adult 2 – Juvenile 3 – Both

26. Which floating object attracts most fish?

1 – Net	2 – Drum	3 – Banana	4 – All
5 – Rope	6 – Plastic	7 – Straw	8 – Buoys
9 – Baskets	10 – Wood / stick	11 – Dark Objects	

27. What objects attract different species of fish?

Flyingfish	Dolphinfish	Kingfish	Swordfish
Tuna	Shark	Billfish	Other

28. Do you catch more fish around flotsam?

1 – Yes 2 – No

29. Which fish are caught more around flotsam?

Flyingfish	Dolphinfish	Shark	Tuna
Kingfish	Billfish	Swordfish	Other

1 – Flyingfish *2 – Large pelagics* *3 – All species*
4 – Flyingfish / Dolphinfish *5 – Dolphinfish*

30. Do fish associate with floating objects at any particular time of the year?

1 – Yes 2 – No

31. If yes, at what time?

1 – January – March 2 – April – June
3 – July – September 4 – October – December

32. In which month/s do you get the most floating objects?

1 – January – March 2 – April – June
3 – July – September 4 – October – December

33. In which month/s do you get the least floating objects?

1 – January – March 2 – April – June
3 – July – September 4 – October – December

34. Do you find floating objects more commonly associated with a particular color of water?

1 – Yes 2 – No

35. If yes, what colour?

1 – Blue 2 – Green 3 – Brown 4 – Clear

36. What strategy is used to locate floating objects?

37. What is your method of fishing around floating objects?

Distance from object 1 – > 20 yds. 2 – 21 – 40 yds.

38. How long do you fish around floating objects before leaving them?

1 – 1 hr. 2 – 2 hrs. 3 – 3 hrs. 4 – 4 hrs.
5 – 5 hrs. 6 – 6 hrs. 7 – > 6 hrs.

39. Do you look for a special type of object before starting to fish?

1 – Yes 2 – No

40. What might cause fish around floating objects to scatter?

0 – nothing 1 – Large predators 2 – Shallow water
3 – Currents 4 – Noise 5 – Gas / Oil

Section III: Practices related to FADs which fishers deploy

41. Do you take your own floating objects and put it in the water?

1 – Yes 2 – No 3 – Sometimes

42. Do you set out to target flying fish or big fish?

0 – None 1 – Flyingfish 2 – Large pelagics 3 – Both

43. What types do you place?

0 – None 1 – Floats 2 – Wooden shipping palets
3 – Plywood 4 – Banana leaves 5 – Coconut branches
6 – Banana & coconut leaves 7 – Sugarcane Trash

44. At what time do these objects attract?

1 – Day 2 – Night 3 – Both

45. Do you catch more fish in the day or night?

1 – Day 2 – Night

46. What types of fish do these objects attract?

Flyingfish Dolphinfish Tuna Shark
Kingfish Billfish Swordfish Other
1 – Flyingfish *2 – Large pelagics* *3 – All species*
4 – Flyingfish & Dolphinfish *5 – Dolphinfish*

47. Why do you use this type of object? 1 – Catch more fish

48. How do you use these objects? ……………………………………

49. Do you find most fish associated with floating objects in particular months?

1 – Yes 2 – No

50. If yes, in which months?

1 – January – March 2 – April – June
3 – July – September 4 – October – December

51. How often do you use your own floating objects?

0 – Never 1 – every trip 2 – only at certain times of the year

52. If only at certain times when are these times?

1 – Flyingfish season 2 – Few floaters on water 3 – Dec – June