

# Assessing Opinions on Abandoned, Lost, or Discarded Fishing Gear in the Caribbean

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## ABSTRACT

Abandoned, lost or otherwise discarded fishing gear (ALDFG) is the internationally recognized moniker for derelict fishing gear (DFG). ALDFG is any of the multitude of nets, lines, traps, and other recreational or commercial fishing equipment that is lost, abandoned or otherwise discarded in the marine environment. Little is known about the type, amount, or sources of ALDFG in the Caribbean. A survey of fishers and marine resource professionals was conducted for 14 of the distinct Caribbean States or dependent territories to develop qualitative descriptions of ALDFG in the Caribbean. Survey results indicate that majority of ALDFG was underwater (60.1%) while the remainder was on shorelines (24.6%) or remained floating at sea (15.3%). Fisheries that deploy unattended gear like traps or nets were the primary source of ALDFG. Most ALDFG was the result of inclement weather; however, poor fishing practices, and lack of convenient gear disposal infrastructure contribute to gear abandonment and at-sea discard. Recommendations of survey participants for the reduction of ALDFG include education programs and improved enforcement; however, these options do not address the primary causes of gear abandonment, loss, and discard. Additional outreach and education programs appear to be required to promote existing United Nations Environmental Program and [US] National Academies recommendations to prevent the accumulation of ALDFG by reducing fishing capacity in overcapitalized and over exploited fisheries to address both accidental and intentional gear abandonment, loss, and discard.

KEY WORDS: Derelict fishing gear, marine litter, ghost fishing, mail survey, artisanal fishing

## Los Requisitos de Información para la Evaluación de Artes de Pesca Perdidas en el Caribe

Artes de pesca perdidas, abandonadas, o desechadas (APPAD) es el nombre reconocido internacionalmente para las artes de pesca abandonadas y en ruinas. APPAD es cualquiera de la multitud de redes, líneas, trampas, y otras artes de pesca recreativa o comercial que es perdida, abandonada, o desechada en el ambiente marino. Poco se sabe sobre el tipo, la cantidad, o las fuentes de APPAD en el Caribe. Un estudio de pescadores y profesionales que trabajan con recursos marinos fue realizada para 14 países en el Caribe o territorios dependientes para desarrollar descripciones cualitativas de APPAD en el Caribe. Los resultados del estudio indican que la mayoría de APPAD fue submarino (60.1%) con el resto en las costas (24.6%) o flotando en el mar (15.3%). Las pesquerías que despliegan artes de pesca desatendido como trampas o redes fueron la fuente primaria de APPAD. La mayoría de artes de pesca abandonadas y en ruinas fueron el resultado de mal tiempo; sin embargo, prácticas pobres y la falta de un lugar adecuado para botar el equipo contribuyen el abandono y desecho de artes de pesca en el mar. Las recomendaciones de los participantes del cuestionario incluyen programas de educación y mas agentes de la ley; sin embargo, estas opciones no tratan las causas primarias de APPAD. Programas adicionales de educación parecen ser requeridos para promover las recomendaciones del Programa Ambiental de las Naciones Unidas y la Academia Nacional de los EEUU para prevenir la acumulación de artes de pesca abandonadas y en ruinas. Estas recomendaciones incluyen reduciendo la capacidad pesquera en pesquerías super-capitalizado y sobre-explotadas para tratar APPAD accidental e intencional.

PALABRAS CLAVES: Artes de pesca abandonadas y en ruinas, desechos marinos, la pesca fantasma, cuestionario por correo, pesca artesanal

## Evaluation d'Opinions sur les Engins de Pêche Abandonnés, Perdus, ou Mis au Rebu dans les Caraïbes

Engins de pêche abandonnés, perdus, ou mis au rebu » (EPAPR) est le nom internationalement reconnu pour les équipements de pêche abandonnés ou délabrés. Les EPAPR regroupent la multitude de filets, lignes, pièges, et autres équipements de pêche récréative ou commerciale, qui sont abandonnés, perdus ou mis au rebu. Peu d'informations est connu sur le type, la quantité, et la source des EPAPR dans les Caraïbes. Une enquête auprès des pêcheurs et des professionnels des ressources marines a été menée pour quatorze pays des Caraïbes et territoires dépendants afin d'obtenir des descriptions qualitatives des EPAPR dans les Caraïbes. Les résultats de cette étude ont indiqué que la majorité des EPAPR étaient sous-marins (60.1%), alors que le reste se retrouvaient sur les rives maritime (24.6 %), ou continuaient de flotter en mer (15.3%). Les pêcheries qui déploient des engins de pêche sans surveillance, tels que les pièges ou les filets, furent la principale source des EPAPR. La plupart des EPAPR furent le résultat d'intempéries ; cependant, les mauvaises pratiques de pêche et le manque d'infrastructure de mis au rebu pour les équipements de pêche contribuèrent à l'abandon et au rejet en mer des équipements de pêche. En vue de réduire le nombre d'EPAPR, les participants de ce sondage recommandèrent la mise en place de programmes d'éducation, et une application plus forte de la loi ; toutefois, ces options ne s'adressent pas aux causes primaires d'abandon, de perte, ou mis au rebu des équipements de pêche. Des programmes supplémentaires de sensibilisation et d'éducation semblent être requis afin de promouvoir les recommandations, déjà existantes, du Programme pour l'Environnement des Nations Unies et de l'Académie Nationale des Etats-Unis d'Amérique, visant à prévenir l'accumulation des EPAPR. Celles-ci incluent la réduction de la capacité de pêche dans les pêcheries surcapitalisées et trop exploitées afin de réduire le nombre accidentel et intentionnel d'équipement abandonné, perdu et ignoré.

MOTS CLÉS: Engins de pêche abandonnés, déchets marins, pêche fantôme, sondage par courrier, pêche artisanale.

## INTRODUCTION

Abandoned, lost or otherwise discarded fishing gear (ALDFG) is the internationally recognized moniker for derelict fishing gear (DFG). By any name, ALDFG is any of the multitude of nets, lines, traps, and other recreational or commercial fishing equipment that has been lost, abandoned or otherwise discarded in the marine environment (UNEP 2005). Identification of the sources and extent of ALDFG is particularly elusive in the Wider Caribbean Region (WCR) which includes 28 island and continental States and 13 dependent territories, most of which have a broad and diverse assemblage of artisanal and multispecies fisheries.

The amount of ALDFG continues to increase each year (Macfadyen *et al.* 2009, UNEP 2009), but at the root of the issue is the increased use of plastic and nylon fishing gear that when left in the marine environment persists for decades. Most ALDFG consists of material that degrades slowly, if at all, so a continuous input of these items results in a gradual build-up in the marine and coastal environment (UNEP Regional Seas Program). This trend is particularly apparent on shorelines. The International Coastal Cleanup, organized by the Ocean Conservancy removes a greater quantity of debris each year, indicating that the situation with regard to marine litter is continuously getting worse (Ocean Conservancy 2009). The accumulation of ALDFG is often less conspicuous as it is dispersed across the vast surface or depths of the oceans.

Approximately 10% of marine debris is fishing gear (Macfadyen *et al.* 2009). In most areas, including the Caribbean, the majority of shoreline debris is from land-based sources (Corbin and Singh 1993, Garrity and Levings 1993, Debrot *et al.* 1999, Ribic *et al.* 1997). Floating debris is often a combination of land-based and sea-based debris although the persistence and deleterious effects of ghost fishing drift-gill nets are particularly notorious (Matsuoka *et al.* 2005). Land-based sources account for 60 to 80 percent of the world's marine pollution (GESAMP 1991 and UNEP 2006). Marine debris in submerged habitats, where interactions with marine life maybe more likely, are largely unstudied. The few surveys that exist suggest that ALDFG is the principal type of submerged debris (Nagelkerken *et al.* 2001, Chiappone *et al.* 2002, Sheridan *et al.* 2005, Uhrin and Matthews 2008, Macfadyen *et al.* 2009 for review).

Marine litter, specifically ALDFG, poses a growing threat to marine and coastal ecosystems. Fishing gear is a major component of the marine debris problem worldwide and has been identified as one of the most biologically threatening types of marine debris (Ryan 1993, UNESCO 1994, APEC 2004). ALDFG is an important contributor to marine debris in the Caribbean (Ivar and Costa 2007). Among the reported impacts of ALDFG were: economic effects, impacts on aesthetics and tourism, human health and safety, habitat destruction, and effects on wildlife

(UNEP 2009). ALDFG kills marine mammals, seabirds, shellfish, and fish by entanglement, ingestion, or "ghost fishing", as lost fishing gear continues to function while unattended.

Derelict fishing gear has historically been considered an inevitable consequence of fishing. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) specifically excludes the loss of fishing gear from pollution regulations; although, the intentional discarding of fishing gear is specifically prohibited (UNEP 2005 for review). Use of the term "abandoned, lost or, otherwise discarded fishing gear" implies recognition of both the intentional and unintentional sources of derelict fishing gear, but there are many practical circumstances where those distinctions are blurred. Understandably there have been few attempts to distinguish the reasons for lost, abandoned, or discarded fishing gear and the individual contribution of each to the ALDFG problem. The causes of ALDFG are numerous and include: weather; operational fishing factors including cost of gear retrieval; gear conflicts; illegal, unregulated and unreported (IUU) fishing; vandalism/theft; and the cost and availability of shore-side collection facilities. Weather, operational fishing factors, and gear conflicts are probably the most significant, but the causes of ALDFG are poorly documented and not well understood. Understanding the causes of ALDFG is significant as it is likely that designing and tailoring effective measures to reduce ALDFG in particular locations requires an understanding why gear is abandoned, lost, or discarded (Macfadyen *et al.* 2009).

A recent international workshop conducted by the US Department of State in Key West, Florida concluded there was a lack of data and technical knowledge on the amount of ALDFG in the Caribbean (Etrie 2007). Given the difficulty and expense to conduct quantitative surveys of submerged marine debris, it is unlikely that direct surveys of the expansive Caribbean region will be available in the near future. Basic information on the amount of derelict fishing gear, the sources of that gear, and the risk the gear poses to marine life is needed to evaluate the scope of the issue. The international community has taken note of the problem of plastic debris and ALDFG. The United Nations Secretary General's Reports on Oceans and the Law of the Sea led directly to the problem being highlighted by the United Nations General Assembly in its resolution 55/8 of 30 October 2000. The need for international coordination coupled with enhanced education and outreach about ALDFG and related marine debris has lagged in the Caribbean (APEC 2004, US Commission on Ocean Policy 2006).

This report presents the results of a survey of fishermen, fishery managers, and fishery researchers to develop a basic description of the types and sources of ALDFG in the Caribbean. This information is intended to provide information that allows for the examination of the efficacy

**Table 1.** Survey-participant country of expertise and opinions on marine debris and ALDFG.

Country	Number of Respondents	Respondents Concerned about Marine Debris	Respondents Concerned about ALDFG	% Debris Fishing Gear	Existing Debris Programs
Anguilla	1	1	1	10	Y
Bahamas	1	1	1	.	Y
Barbados	2	2	1	30	Y/N
Belize	1	.	0	15	N
Colombia	1	1	1	.	N
Guadeloupe	8	7	6	45	Y/N
Haiti	3	2	2	24.5	Y/N
Mexico	2	2	2	20	Y
Puerto Rico	7	6	7	35.7	Y/N
St. Kitts and Nevis	1	1	1	.	N
Trinidad and Tobago	2	2	2	5	Y
US Florida	7	7	6	14.6	Y
US Virgin Islands	3	2	2	10	Y
Venezuela	1	0	0	20	N

of current instruments, programs, and initiatives that address this global threat (UNEP 2005) and to obtain the opinions of participants at a recent United States National Oceanographic and Atmospheric Administration and United States Department of State, Caribbean-wide Derelict Fishing Gear Workshop in light of previous research that suggests the issue remains largely unrecognized in the Caribbean marine community and that the source of ALDFG is largely from outside sources (Etrie, 2007, Macfadyen *et al.* 2009)

## METHODS

### Literature Search

Important information needs for the assessment of ALDFG include: 1) detailed records of gear use for specific fisheries in each country and 2) estimates of gear loss for specific fisheries or countries. There are several recent reviews of ALDFG and governance related to the issue. Macfadyen *et al.* (2009) was the most recent and most inclusive review of magnitude and composition of ALDFG literature and also identified a variety of measures that were currently in place to reduce ALDFG. UNEP Marine Litter: A Global Challenge (2009) provided current information on the marine litter issue in several regions including the Wider Caribbean, and UNEP Regional Action Plan for Marine Litter Management in the Wider Caribbean (UNEP Regional Seas Program), also provided a comprehensive review of Caribbean ALDFG. Additional references are provided herein on research specific to the Caribbean.

There was little information on the amount of gear in

Caribbean fisheries. A review of fishing practices in Latin American States provided an account for several fisheries (FAO-OSPECSA 2006), but a comprehensive account of fishing effort in the Caribbean Islands was not available.

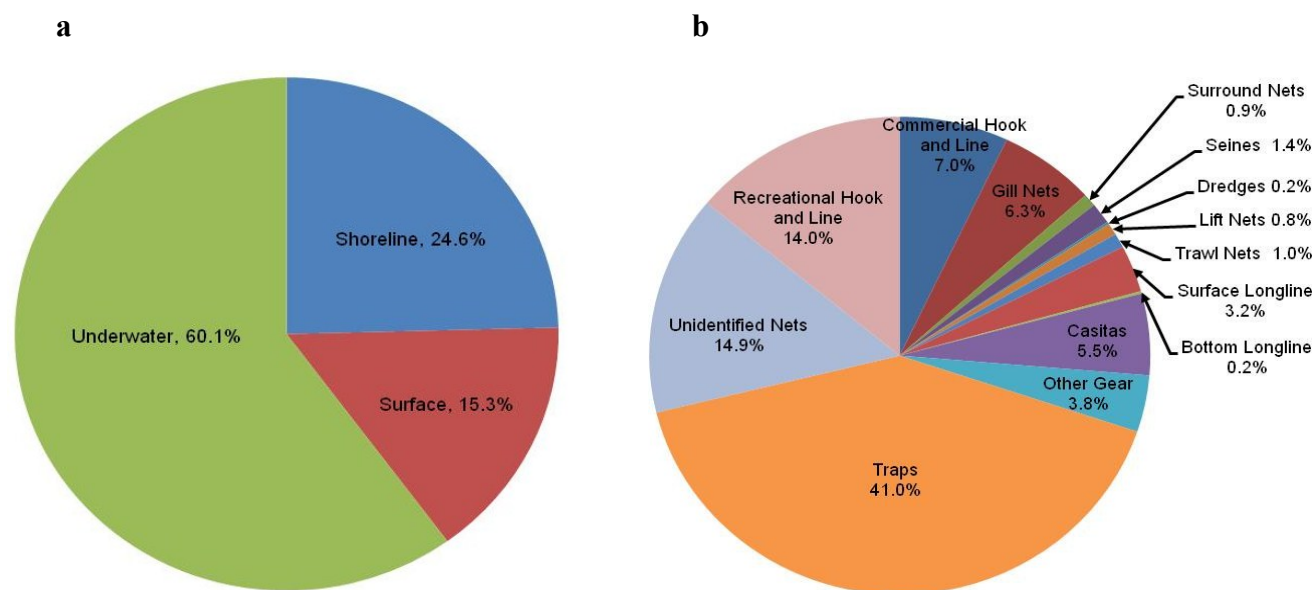
### Survey Tools

Three methods were employed to gather the survey data. The first method involved in-person collection of the data from completed surveys at the annual meeting of the Gulf and Caribbean Fisheries Institute (GCFI) in November 2008 in Guadeloupe, French West Indies. Interviewers provided written surveys in English, Spanish, or French and assisted participants when necessary. The second survey method involved emailing the survey to each GCFI member and regional experts that were identified by other participants. The third method consisted of a web-based survey response option. This was developed and made available on the [www.gcfi.org](http://www.gcfi.org) website. The questionnaire was semi-structured with most questions allowing for open ended responses. The online survey tool was developed in English, Spanish, and French.

Analysis of survey responses included descriptive statistics of categorical variables such as the percentage of locations with ALDFG or percentages of the type or reasons for lost fishing gear. Where survey responses did not total 100% of the possible responses (because of incomplete responses by survey participants), values were proportionately adjusted to equal 100%.

### Education and Outreach

Despite international recognition of the impact of marine litter and the contribution of ALDFG to the



**Figure 1.** a) Distribution of ALDFG reported by survey participants. b) Type and relative contribution of fishing gear reported as ALDFG in the Caribbean.

problem (Macfadyen *et al.* 2009 for review), many fishers, government officials, and professional scientists working in fisheries were not aware of the issue. Broad information deficiencies regarding the amount, source, and impact of ALDFG were identified by the joint United States Department of State and the National Oceanic and Atmospheric Agency Caribbean derelict fishing gear workshop (Etrie 2007). The results of this workshop were presented to the membership of GCFI in Guadeloupe at the November 2008 GCFI Conference. Additionally an informational display was manned during the week of the Conference to bring additional attention to the need for information on ALDFG.

These two outreach events provided the opportunity for GCFI members to participate in a survey concerning ALDFG in their countries and fisheries of expertise. The survey was the primary method used to collect information on ALDFG, but it also served to promote interest and ownership of ALDFG issues. Survey participants have the opportunity to continue to participate as ALDFG working-group members through GCFI web-based activities. The data generated by these surveys and summaries of the surveys are available at [www.gcfi.org](http://www.gcfi.org). The availability of country specific data on ALDFG should be an important step in capacity building and developing an international body of information for future researchers and managers to access and move specific ALDFG projects forward.

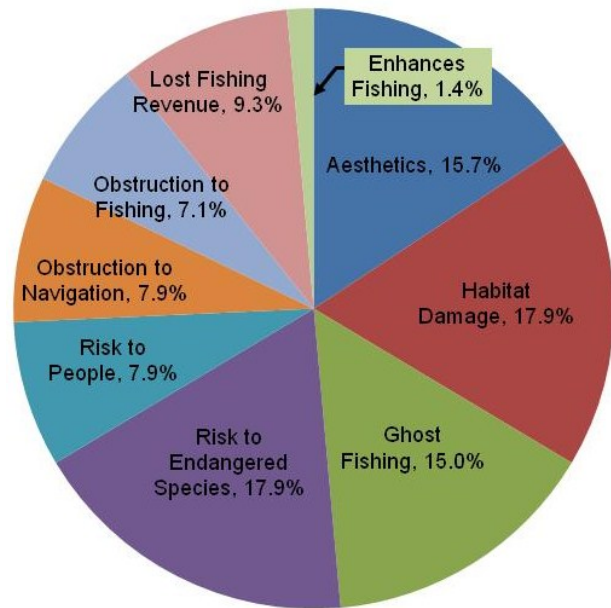
dives were made outside of this period to confirm that grouper were not present in numbers and no reproductive activity was taking place. In 2004 and 2005 roving dive surveys were used along the 1.7 km bank to locate and characterize the main aggregation area. During the 2006 and 2007 spawning seasons, belt transects (1.2km x 50m) were conducted by divers using diver propulsion vehicles

once or twice daily, to determine the grouper distribution across the reef and to estimate the spawning population size. In 2007, 2008 and 2009, in addition to transects, dives were made from mid-afternoon to sunset on and around the spawning site. Number of fish, coloration, and courtship behavior were recorded and videoed. Groupers were collected daily during the same time period each year using standard Antillian fish traps baited with bonito (*Sarda sarda*) and squid. Captured Nassau grouper were measured, sexed using a portable field ultrasound (Whiteman *et al.* 2005), and tagged through the dorsal fin pterygiophores with numerically coded external Floy dart tags. The fish were released close to the collection site using a release cage that could be opened remotely when it reached the sea floor, thereby minimizing predation (Nemeth 2006). Spawning population changes from 2004 through 2009 were compared using the number of fish observed in underwater surveys and population characteristics including sex ratio and mean size of fish collected over five years of monitoring.

## RESULTS

### Survey Participants

Survey participants included biologists (n = 17), fishery managers (n = 7), fishers (n = 5), fishery support organizations (n = 5) including fishing organizations and fishery outreach specialists, university researchers (n = 6), and Marine Protected Area managers (n = 3). Eleven participants did not provide their occupation. Survey participants represented 14 of the distinct Caribbean States or dependent territories (Table 1).

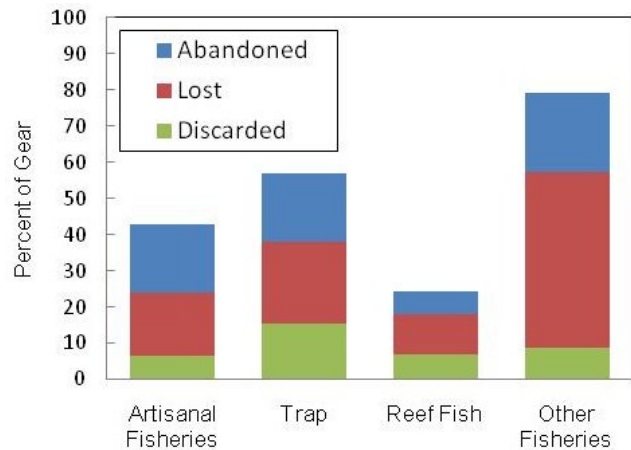


**Figure 2.** Effects of ALDFG reported by survey participants

### General Survey Results

Participants overwhelmingly (85%) recognized marine debris as an important local or regional issue. ALDFG was considered an issue among 65% of participants. When specifically asked “what percentage [of marine debris] is fishing gear”, individual responses ranged from 0 to 100%. Survey wide, participants reported an average of 20.9% of marine debris was fishing gear (Table 1). Eleven participants (17.5%) reported there were no efforts to address ALDFG in their countries. In four countries there were conflicting opinions concerning the presence or absence of programs addressing ALDFG (Table 1).

Survey participants (n=38) indicated that the majority of ALDFG was underwater (60.1%). The remainder of ALDFG tended to be gear that floats and was either on shorelines (24.6%) or remained floating at sea (15.3%) (Figure 1a). A broad range of gear types were reported as ALDFG. Thirty participants provided descriptions of the types of ALDFG. Traps were the most common (41.0%), various types of nets (25.1%), various types of hook and line gear (24.3%), additional submerged ALDFG included artificial habitats used to aggregate lobsters (commonly referred to as *casitas*) (5.5%) and dredges (0.2%). Other gear reported as ALDFG included fish attracting devices (FADs), buoys, and general fishing refuse like bait boxes and other packaging (3.8%) (Figure 1b). Traps reported as ALDFG include both lobster traps, fish traps, and traps used in both fisheries. Most other gear types reported as ALDFG were also used to target multiple species.



**Figure 3.** Percentage of ALDFG reported in each fishery

### Problems with ALDFG

Survey participants who indicated ALDFG was an issue suggested a broad range of negative impacts (Figure 2). Of the nine impacts identified, four ranked nearly equal. Habitat damage (17.9%), risk to endangered species (17.9%), and ghost fishing (15.0%) were relevant to resource protection, while the fourth impact, aesthetics (15.7%) was potentially a higher profile impact amongst the general public. The second group of four lesser impacts was decidedly economically-based and included lost fishing revenue (9.3%), obstruction to navigation (7.9%), and obstruction to fishing (7.1%); the risk to people [health] (7.9%) rounded out these secondary impacts. Two survey participants indicated that derelict fishing gear enhances fishing and was a benefit to several pelagic fisheries.

### Fishery Specific Survey Responses

Survey participants provided ALDFG estimates for nine fisheries: artisanal, lobster net, reef fish, pelagic trolling, pelagic longline, pelagic drift net, shrimp trawl, and the multispecies trap fishery. Of these nine fisheries/gears, three had a sufficient number of responses to evaluate the amount of abandoned, lost, or discarded gear in each group and a fourth category representing various net based fisheries was also included (Figure 3, Table 2a, b, and c).

Artisanal fisheries were characterized as multigear, with a combination of nets, hook and line, and traps. Characteristically these gears were poor quality because of both age and poor construction. Although individual fishers may have a small amount of gear, the artisanal fishing community as a whole may have a substantial amount of gear. Overall 42.9% of artisanal fishing gear was reported abandoned, lost, or discarded. Approximately equal portions of gear were reported abandoned (18.5%) and lost (17.5%), whereas a small portion of gear was reported as discarded (6.5%). The two principal causes for fishers

**Table 2.** Survey respondents opinions on the causes of a) abandoned gear, b) lost gear, and c) discarded gear in specific fisheries.

Causes of Abandoned Gear	Causes of Abandoned Gear in each Fishery (%)				
	Artisanal Fisheries	Trap Fisheries	Reef Fish Fisheries	Other Fisheries	Average for all Fisheries
Bad Weather	38.3	46.2	36.0	15.7	36.8
Boat Problems	7.3	5.4	6.6	15.7	7.8
Fuel Cost	1.3	0.0	1.8	0.0	0.7
Gear Damaged	51.3	48.4	48.3	58.6	50.7
Illegal Gear	1.8	0.0	0.0	0.0	0.4
Apathy	0.0	0.0	0.0	9.9	1.7
Out of Business	0.0	0.0	7.2	0.0	1.9
Responses	<i>n=6</i>	<i>n=11</i>	<i>n=8</i>	<i>n=5</i>	<i>n=30</i>

Causes of Lost Gear	Causes of Lost Gear in each Fishery (%)				
	Artisanal Fisheries	Trap Fisheries	Reef Fish Fisheries	Other Fisheries	Average for all Fisheries
Bad Weather	15.3	35.1	41.3	20.8	32.6
Unable to Locate	4.5	11.8	18.4	25.1	14.5
Missing Buoys	3.4	21.4	7.5	14.5	13.0
Stolen	7.1	11.8	16.9	6.3	12.2
Currents	5.4	3.7	9.0	14.5	7.0
Entangled	64.2	7.5	7.0	18.8	17.3
Accidents	0.0	8.7	0.0	0.0	3.3
Responses	<i>n=4</i>	<i>n=10</i>	<i>n=9</i>	<i>n=3</i>	<i>n=26</i>

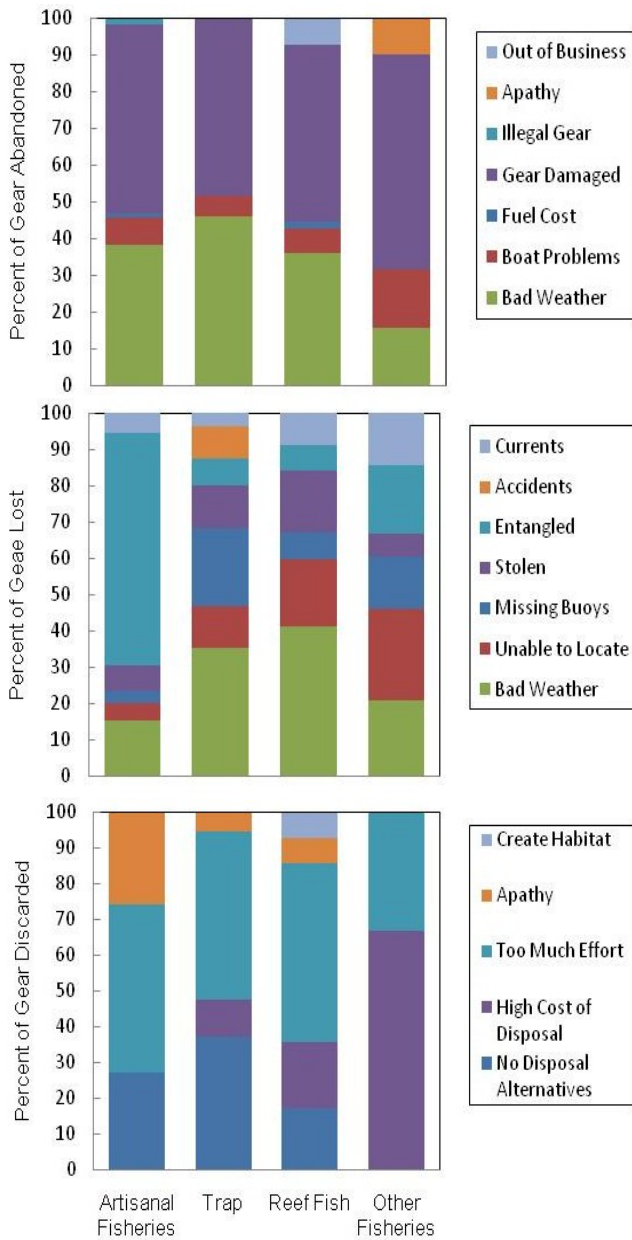
  

Causes of Discarded Gear	Causes of Discarded Gear in each Fishery (%)				
	Artisanal Fisheries	Trap Fisheries	Reef Fish Fisheries	Other Fisheries	Average for all Fisheries
No Disposal Alternatives	38.3	46.2	36.0	15.7	36.8
High Cost of Disposal	7.3	5.4	6.6	15.7	7.8
Too Much Effort	1.8	0.0	0.0	0.0	0.4
Apathy	0.0	0.0	0.0	9.9	1.7
Create Habitat	0.0	0.0	7.2	0.0	1.9
Responses	<i>n=3</i>	<i>n=8</i>	<i>n=6</i>	<i>n=3</i>	<i>n=20</i>

abandoning gear were that the gear was damaged (51.2%) or that bad weather prevented retrieval of the gear (38.3%) (Figure 4a). The primary reason for artisanal fishers losing gear was entanglement with bottom structure (64.2%). The five other causes of lost gear in order of occurrence were:

1) bad weather preventing locating the gear, the gear being stolen, currents moving or sinking the gear, missing buoys marking the gear, and being unable to locate the gear (Figure 4b). Artisanal fishers discard gear because it was too much effort to discard the gear properly (47.1%). A





**Figure 4.** Causes of ALDFG and the percent contribution of each cause for a) abandoned, b) lost, or c) discarded for each fishery.

seemingly related cause of discarded gear was apathy (25.8%). The lack of appropriate disposal alternatives for gear that was no longer usable (27.1%) was the third cause of discarded gear (Figure 4c).

Fishers that used traps were predominately targeting lobsters and reef fish. Trap-based fishers were reported to abandon (18.9%), lose (22.7%), or discard (15.3%) 56.8% of their gear. This was a relatively high percentage of ALDFG for the fisheries reported herein. The two principal causes for fishers abandoning their traps were that the traps were damaged (48.4%) or that bad weather

prevented retrieval of the traps (46.2%). Boat problems were reported as a small percentage of the cause of lost gear (5.4%) (Figure 4a). The primary reason for trap fishers losing gear was bad weather causing the traps to be lost (35.1%) and missing buoys (21.4%). The five other causes of lost traps in order of occurrence were:

- i) Being unable to locate the traps,
- ii) The traps being stolen,
- iii) The traps being entangled on bottom structure,
- iv) Accidents while retrieving the traps, and
- v) Currents moving or sinking the trap buoys (Figure 4b).

Trap fishers discard gear because it was too much effort to discard the gear properly (47.2%). Apathy accounted for a small portion of the reason for discarding traps (5.4%). The lack of appropriate disposal alternatives for gear that was no longer usable (37.2%) and the high cost of disposal (10.3%) were also reasons for discarding traps (Figure 4c).

Fishers targeting reef fish were reported to abandon (6.3%), lose (11.1), or discard (7.0%) 24.4% of their gear. This was the lowest percentage of ALDFG for the fisheries reported herein. Most reef fish gear is actively fished, with the exception of traps. The two principal causes for fishers abandoning their gear were that it was damaged (48.3%) or that bad weather prevented retrieval of the gear (35.9%). The remainder of abandoned gear was due to fishers going out of business, boat problems, or the cost of fuel needed to recover the gear (Figure 4a). The primary reason for reef fish gear being lost was bad weather (41.3%). The four other causes of lost traps in order of occurrence were:

- i) Being unable to locate the traps,
- ii) The traps being stolen,
- iii) Currents moving or sinking the trap buoys, and
- iv) Missing buoys (Figure 4b).

Reef fish gear was discarded because it was too much effort to discard the gear properly (50.0%). Apathy accounted for a small portion of the reason for discarding traps (7.1%). The lack of appropriate disposal alternatives for gear that was no longer usable (17.1%) and the high cost of disposal (18.6%) were also reasons for discarding traps. The intentional creation of artificial habitat was also given as a reason for discarding of gear (7.1%) (Figure 4c).

Other fisheries reporting ALDFG were predominately from net-based fisheries. These fisheries were reported to abandon (22.0%), lose (48.3%), or discard (8.9%) 79.2% of their gear. This indicated that most of the nets used in these fisheries were destined to become ALDFG. These other fisheries reported abandoning their gear principally when it was damaged (58.6%), but additional reasons for abandoning gear included bad weather (15.7%), boat problems (15.7%), or apathy (9.9%) (Figure 4a). The primary reason for other fisheries gear being lost was generally equally divided between six reasons:

**Table 3.** Survey participants knowledge of existing (E) ALDFG programs and recommendations (R) for additional programs.

Location	Beach Clean-ups	Underwater Cleanups	Recycling Programs	Education Programs	Lost Gear Reporting	Enforcement and Gear Loss Rules	Gear Disposal Infrastructure	ALDFG Program Funding	Prevention
Anguilla	E			R					
Bahamas							E		
Barbados				R					
Belize	E R	R		R	R				
Colombia				R		R			
Guadeloupe		R		R		R	R		
Haiti		E		R	E	R	R		
Mexico				E R			R		
Puerto Rico	E R	E R	E R	R			R	R	
St. Kitts and Nevis							R		
Trinidad and Tobago	E R	R		E R		R		R	
US Florida	E R	E R		E R		E		E R	
US Virgin Islands	E R	E R				R			
Venezuela							R		E

- i) Being unable to locate the gear,
- ii) Bad weather,
- iii) Entanglement,
- iv) Missing buoys,
- v) Currents moving or sinking the gear, and
- vi) The gear being stolen (Figure 4b).

Other fisheries gear was discarded because of the high cost of disposal (66.7%) or because it was too much effort to discard the gear properly (33.3%) (Figure 4c).

**Existing Programs and Participant Recommendations**

Survey participants representing 14 of the distinct Caribbean States or dependent territories indicated whether marine litter or ALDFG programs were in place in their area (Table 3). Table 3 represents survey participant knowledge and perception, not actual ALDFG programs. Locations with existing programs (E) were recognized in nine locations. The most recognized programs (six locations) were associated with beach cleanups and four locations reported underwater ALDFG removal [cleanups] programs. Three locations were reported to have ALDFG education programs. Florida was the only location with ALDFG funding and enforcement of gear loss rules. Puerto Rico was reported to recycle fishing gear. Venezuela was the only location to indicate gear-loss prevention efforts. The Bahamas was the only location to specifically identify gear-disposal infrastructure (Table 3).

Survey participants provided recommendations (R) for ALDFG programs they thought would be effective in their areas (Table 3). The most recommended ALDFG program

was to establish education programs (10 locations). Survey participants also supported:

- i) Developing enforcement and gear-loss rules,
- ii) Developing gear-disposal infrastructure,
- iii) Increased shoreline cleanups, and
- iv) Underwater ALDFG removal [cleanup] programs.

Few survey participants recommended gear loss reporting programs, funding programs addressing ALDFG, or ALDFG prevention programs.

**DISCUSSION**

**Survey Participants**

Participants from a broad range of disciplines were surveyed. Although fishers and fishery experts are likely required to quantify ALDFG, it is valuable to seek solutions to ALDFG from other resource managers. Designing effective measures to reduce ALDFG requires location-specific information. Social issues, economic conditions, and land-use plans may play equally important roles in the reasons for abandoned, lost, or derelict fishing gear (Macfadyen *et al.* 2009). Of the 14 locations represented in this survey only Florida, Puerto Rico, and Guadeloupe had multidisciplinary representation, which may have accounted for the high number of recommended programs in these locations (Table 3). Establishing a broad base of support and knowledge is important for developing and implementing effective measures to reduce ALDFG.



### General Survey Results

There was strong recognition of marine debris issues among those fishers and marine resources professionals that participated in this survey. However, recognition of ALDFG was not considered an issue among some survey participants. Participants that did not consider ALDFG a problem in their area include both fishers and professional researchers. The lack of universal recognition of ALDFG issues among professionals in marine resources suggested considerable education and presentation of case studies was still required. For many locations, survey participants from the same area had conflicting opinions on the presence of ALDFG programs. Beach cleanups were one of the most universally recognized marine debris programs. This recognition was likely the result of The Ocean Conservancy's Coastal Cleanup Program. Survey participants indicate the majority of ALDFG was underwater (Figure 1). Removal of submerged debris may require specialized equipment including boats and SCUBA, and is potentially cost prohibitive. There are a limited number of people with access to the equipment and resources to illicit the groundswell of participation seen for coastal programs. It seems unlikely that the participatory coastal cleanup methodology used by Ocean Conservancy to bring attention to shoreline debris would be as effective for submerged ALDFG in areas without strong recreational dive communities.

ALDFG was categorized as predominately traps, hook and line, or nets. Individual fishers generally used many, often hundreds of traps which were routinely deployed for multiday periods. The combination of high numbers of traps and the gear left unattended makes it highly susceptible to abandonment and loss, which explains why it was the most common type of ALDFG (Figure 1b). Traps specifically designed for lobsters were relatively species-specific and have limited potential for bycatch (Matthews *et al.* 2005). However, modern fish traps are extremely effective and continue to catch when lost or abandoned as ghost traps (Matsouka *et al.* 2005, ICES 2008). Many traps include wood panels or frames and become nonfishing over time. Nets were also reported as a major component of ALDFG. Although nets were numerically less abundant than traps, they are the single most destructive type of derelict fishing gear (Laist 1996) and few methods have been developed to ameliorate this impact (Valdemarsen and Suuronen 2003). Survey participants indicated that four out of five nets were destined to become ALDFG. Additional research is required to validate these survey results and determine if the results are indicative of net fishing practices in the Wider Caribbean.

The amount of fishing gear was generally known in most countries (FAO-OSPESCA 2006, Valle-Esquivel *et al.* In press). Survey results obtained by this survey were not sufficient to provide estimates of the quantity of gear used in specific countries or fisheries. For OSPESCA

countries, a summary of fishing effort estimates is available (FAO-OSPESCA 2006), but more comprehensive information is needed to relate the amount of fishing gear with gear loss rates and each fisheries contribution to ALDFG.

### Problems with ALDFG

There are many reported negative impacts of ALDFG (Figure 2). These impacts were differentiated into two major groups, impacts on natural resources or economic. Habitat damage, risk to endangered species, and ghost fishing are well known resource issues and ranked high among our survey demographic which was primarily natural resource specialists. As a lower priority, economic issues were also identified. Aesthetic issues were among the primary impacts of ALDFG, significant in that it affects both quality of life and economic issues. Aesthetics might be a primary concern to the public and tourism interests, but focusing debris program efforts on resolving aesthetic issues would need to be evaluated against resource protection measures and the other economic concerns. The other decidedly economic-based impacts included lost fishing revenue, obstruction to navigation, and obstruction to fishing. All of which highlight the more direct financial liability associated with ALDFG. Where there is a clear economic burden or cost associated with ALDFG, there may be a greater financial incentive and greater access to novel sources of funding for ALDFG programs.

### Fishery Specific Survey Responses

Artisanal fishers generally have little fishing gear and that gear was often of relatively poor quality. Despite that, the gear was of value to them. Gear was rarely discarded improperly, but when it was, the issues driving improper disposal were the cost of discarding the gear, or no appropriate discard options. More often, gear was abandoned due to weather preventing retrieval of the gear or the gear being damaged to the point where it was not retrievable. Abandonment of gear due to weather was a reoccurring problem for fishers. Additional examination of the social dynamics and infrastructure of artisanal fishing communities may be useful in developing better access to weather forecasts and thus reduce weather-related gear abandonment. Gear loss was predominantly due to entanglement with bottom structure. Nets, traps, and longlines cannot be used in areas with significant bottom structure. Over harvesting and increased competition for declining resources may drive fishers to use their gear in inappropriate habitats. Increased use of marine protected areas or no fishing zones might be of use to reduce gear entanglement and loss in these situations.

Fishers that used traps were particularly susceptible to fishing gear loss because traps were left unattended as a routine fishing practice. Approximately equal amounts of traps were reported as abandoned, lost, or discarded

(Figure 3). The differentiation between abandoned, lost, or discarded gear was less precise than for actively fished gear. Confusion with the terminology occurs as some fishers consider their traps abandoned if they are unable to retrieve the traps prior to a storm and some fishers may consider the gear lost if they are unable to find it after a storm (Figures 4a and b). Similarly, some fishers considered leaving broken traps in the water *abandonment* while other reported leaving broken traps at sea as discarded gear (Figures 4a and c). Regardless of the terminology, weather appeared to be the main cause of traps becoming DFG, but reasons for trap abandonment, loss, or discard were varied and included numerous causes ranging from negligence to theft. It is likely that many fishers do not know the cause of trap disappearance, which may influence the diversity of the causes of ALDFG in the trap fishery.

Fishers targeting reef fish reported the lowest rates of ALDFG for the fisheries discussed herein. Most survey participants considered hook and line gear associated with this fishery, but some nets and traps were also reportedly used. Hook and line gear is generally continuously attended so it is not as subject to abandonment or loss (Figure 3). As with other fisheries, weather remained an important cause of gear abandonment and loss (Figure 4a and b). Although little reef fish gear was discarded, the primary reason for discarded gear was that it was too much effort to dispose of the gear properly. There was little suggestion that at-sea gear discards were caused by high disposal costs or because there were no disposal options (Figure 4c). Monofilament fishing line is such a well documented cause of mortality for marine mammals and sea turtles that it is a little surprising that additional educational programs might still be required to prevent it from being discarded. There appears to remain a need for education concerning marine litter among the fishing community.

Other fisheries reporting ALDFG were predominately net-based fisheries. Net fisheries may have fewer pieces of gear than other fisheries, but nets are likely the most persistent and deadly type of ALDFG. Survey participants reported that 79.2% of these nets were destined to become ALDFG. Human error and the use of nets in unsuitable areas resulted in being unable to locate the gear in addition to loss of buoys, bottom-entanglement, or loss in currents. Most nets were reportedly abandoned when they were damaged or disposed of at-sea to avoid costly disposal onshore which likely coincides with the lack of disposal alternatives. Nets as ALDFG is well established, but few mechanisms have been developed to track nets from construction, through use, to disposal. Both industrial-scale fishing fleets and artisanal fishers must embrace life-of-the-net policies that strive to ensure all nets are ultimately disposed of or recycled after their functional life is over. Research has shown that ghost fishing nets reduces the number of fish available for subsequent harvest (Morgan

and Chuenpagdee 2003, Matsuoka *et al.* 2005 for review), yet this component of fishing mortality is seldom used in calculation of total allowable catch (Laist 1996, ICES 2008 for review).

#### **Existing Programs and Participant Recommendations**

Survey participants were modestly aware of the risk ALDFG poses to fisheries and the ecosystem; however, recognition of ALDFG issues lagged behind recognition of more general marine litter issues. There appears to remain a need to educate and involve more marine resource professionals in local and regional ALDFG programs. Overwhelmingly survey participants preferred addressing ALDFG through educational programs and outreach to fishers including the well recognized *FAO Code of Conduct for Responsible Fisheries* as reviewed by UNEP (2005).

Fisher education is a potential mechanism to attempt to reduce gear entanglement, the primary cause of gear loss among artisanal fishers, but gear entanglement was generally considered accidental by the fishing community as opposed to an inevitable consequence of fishing in unsuitable habitat. There was some interest in increased enforcement, but increased enforcement is not consistent with preventing the primary reported source of ALDFG, the weather. Only one survey participant suggested prevention as a mechanism to reduce ALDFG. The [US] National Research Council of the National Academies conducted an extensive review of ALDFG which identified prevention as the primary mechanism to reduce ALDFG. Preventing the loss of gear includes reduction of excess fishing capacity and is the most cost-effective, least disruptive, and most ecologically sound mechanism to prevent ALDFG (Anon. 2008). Although this approach was not identified by any respondent, the conclusions of the [US] National Research Council are likely applicable in the Caribbean where excess fishing capacity is typical in many fisheries (Jackson *et al.* 2001, World Resources Institute 2004). Recommendations to reduce excess capacity in specific fisheries would be a manageable and proactive mechanism to prevent the accumulation of ALDFG in the Caribbean and potentially improve the economic condition of those fisheries.

Prevention of gear entanglement, a principal reason for gear loss among artisanal fishers, may be possible through the judicious use of marine protected areas. Artisanal fisheries are an important fishery component in many Caribbean countries. Yet these coastal fishers were at particular risk of losing gear because of entanglement on reefs. Fishing gear unsuitable for use near reef habitat occurs when increased competition for declining resources drives fishers to use gear closer to those habitats. Use of marine protected areas has gained acceptance in many fishing communities because they affect all fishermen equally and may have the added benefit of playing a role in

sustainable fishery practices. The creation of MPAs in areas prone to gear entanglement would potentially reduce gear loss and fisher expenses.

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