REPORT TO CONGRESS

SOURCES AND IMPACTS OF DERELICT FISHING GEAR

Developed pursuant to: Section 135 of the Save Our Seas 2.0 Act, 2020 (Public Law 116-224)

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THIS REPORT IS PROVIDED PURSUANT TO THE SAVE OUR SEAS 2.0 ACT, 2020 (PUBLIC LAW 116-224) AND SECTION 135 OF THE ACT REQUIRES

Not later than 2 years after the date of the enactment of this Act, the Under Secretary shall submit to Congress a report that includes—

(1) an analysis of the scale of fishing gear losses by domestic and foreign fisheries, including—
(A) how the amount of gear lost varies among—
(i) domestic and foreign fisheries;
(ii) types of fishing gear; and
(iii) methods of fishing;
(B) how lost fishing gear is transported by ocean currents; and
(C) common reasons fishing gear is lost;
(2) an evaluation of the ecological, human health, and maritime safety impacts of derelict fishing gear, and how those impacts vary across—
(A) types of fishing gear;
(B) materials used to construct fishing gear; and
(C) geographic location;
(3) recommendations on management measures—
(A) to prevent fishing gear losses; and
(B) to reduce the impacts of lost fishing gear;
(4) an assessment of the cost of implementing such management measures; and
(5) an assessment of the impact of fishing gear loss attributable to foreign countries.

THIS REPORT RESPONDS TO THE ACT'S REQUEST.

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TABLE OF CONTENTS

		Page
I.	Executive Summary	8
II.	Introduction	14
	A. Federal Actions to Address ALDFG	16
	B. Global ALDFG Efforts	20
III.	Scale of Fishing Gear Losses [§ 135 (1)]	23
	A. Fishing Gear Types [§ 135 (1)(A)(ii)]	23
	B. Gear Loss Analysis [§ 135 (1)(A)]	28
	C. ALDFG Transport [§ 135 (1)(A), § 135 (1)(B), § 135 (5)]	67
	D. Causes of Gear Loss [§ 135 (1)(C)]	73
IV.	Impacts of ALDFG [§ 135 (2)]	84
	A. Ecological Impacts	84
	B. Economic Impacts	92
	C. Human Health Impacts	94

	D. Maritime Safety Impacts	95
	E. Impacts Attributable to Foreign Countries [§ 135 (5)]	96
V.	Evaluation of ALDFG Management Measures [§ 135 (3)]	100
	A. ALDFG Management Measures	100
	B. Regional Implementation Examples	120
	C. Data and Management Gaps	127
VI.	Recommendations for Management Measures [§ 135 (3)]	131
	A. Federal-Level Recommendations	131
	B. Regional and Fishery-Level Recommendations	134
VII.	Cost of Management Recommendations [§ 135 (4)]	138
VIII.	References	142

LIST OF ACRONYMS

ADFG	Alaska Department of Fish and Game
ALDFG	abandoned, lost, and discarded fishing gear
APEC	Asia-Pacific Economic Cooperation
BIM	Bord Iascaigh Mhara
CDFG	California Department of Fish and Wildlife
CFMC	Caribbean Fishery Management Council
CFR	U.S. Code of Federal Regulations
CI	confidence interval
CNMI	Commonwealth of the Northern Mariana Islands
DOJ	U.S. Department of Justice
EEZ	U.S. Exclusive Economic Zone
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FEP	Fishery Ecosystem Plans
GAO	U.S. Government Accountability Office
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GGGI	Global Ghost Gear Initiative
GI	gastrointestinal
GPS	global positioning system
IGO	intergovernmental organization
IMDCC	Interagency Marine Debris Coordinating Committee
IMO	International Maritime Organization
IPHC	International Pacific Halibut Commission
KIMO	Kommunernes International Miljøorganisation
MAFMC	Mid-Atlantic Fishery Management Council
MARPOL	International Convention for the Prevention of Pollution from Ships
MDP	Marine Debris Program
NEFMC	New England Fishery Management Council
NFWF	National Fish and Wildlife Foundation
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service
NPFMC	North Pacific Fishery Management Council

NRC	Natural Resources Consultants
RFID	radio frequency identification
SAFMC	South Atlantic Fishery Management Council
U&A	usual and accustomed
UNEP	United Nations Environment Programme
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USVI	U.S. Virgin Islands
WPRFMC	Western Pacific Regional Fishery Management Council

I. EXECUTIVE SUMMARY

Congress established the National Oceanic and Atmospheric Administration Marine Debris Program (NOAA MDP) as the federal lead on marine debris through the Marine Debris Act (Public Law (P.L.) 109-449), signed into law in 2006. Signed into law in 2020, the Save Our Seas 2.0 Act (P.L. 116-224) required several new studies and reports to strengthen federal approaches to the problem of marine debris, defined as persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes [33 U.S.C. § 1956(3)]. Section 135 of the Save Our Seas 2.0 Act directs the Under Secretary of Commerce for Oceans and Atmosphere to provide a Report to Congress on the sources and impacts of derelict fishing gear, also known as abandoned, lost, and discarded fishing gear (ALDFG).

This report summarizes the major sources, impacts, current remedial actions, and programs for ALDFG, and it provides recommended actions to further address the problem in the waters of the United States and its territories (see page 3 for the report requirements). The information provided here represents the state of the present knowledge in published literature. It also summarizes data from federal fisheries observer programs and information from state and federal fisheries managers that includes unpublished data and reports to augment published literature.

Sea-based sources of plastic pollution, in particular, fishing gear, or ALDFG, has been shown to be both the most prominent sea-based source and is one of the deadliest forms of marine debris for marine biota and habitats (GESAMP 2021). Once lost or discarded in the ocean, ALDFG has many negative impacts on the environment and living marine resources, as well as on economies and navigation safety. One of the most significant impacts of ALDFG is its continued catch of target fish species and other marine life after it has been lost or abandoned (ghost fishing). Gear can continue to trap and kill fish, crustaceans, marine mammals, sea turtles, and seabirds, also called ghost fishing. The inadvertent catch of target species by ALDFG can significantly impact the economics of a fishery, with up to 30% loss of harvest from ghost fishing documented in some U.S. fisheries (Antonelis et al., 2011; DelBene et al., 2019; Humborstad et al., 2003). Derelict fishing gear can cause other problems as well, including: damaging sensitive seafloor habitats, such as coral reefs and seagrass beds; causing problems for vessels by wrapping around rudders and propellers; and competing with active fishing gear by trapping economically important species. While there is no agreed upon, single global estimate for the percentage of plastic pollution in the ocean that is from ALDFG, research has demonstrated that ALDFG comprises a large percentage of all marine plastics (Lebreton et al., 2022).

The report is organized into seven different sections, with Section II providing an introduction to the federal and global efforts to address ALDFG. In the United States, the National Oceanic and Atmospheric Administration (NOAA) is the primary federal agency charged to address ALDFG. The NOAA Marine Debris Program is the lead federal program focused on preventing and removing ALDFG in U.S. waters. The NOAA National Marine Fisheries Service (NOAA Fisheries) manages U.S. fisheries in federal waters under the authority of the Magnuson-Stevens Fishery Conservation and Management Act. The NOAA Sea Grant Program works closely with the seafood industry nationwide to enhance the practical use and conservation of coastal, marine, and Great Lakes resources to create a sustainable economy and environment. In some locations, Sea Grant personnel have played an important role in ALDFG prevention and education. The NOAA Office of Marine Sanctuaries oversees a network of underwater parks throughout the United States and its territories, including 15 national marine sanctuaries and Papahānaumokuākea and Rose Atoll marine national monuments, some of which are affected by accumulations of ALDFG.

Efforts to address ALDFG on a global scale has gained momentum with the efforts of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), and the International Maritime Organization (IMO) through their multilateral forums. FAO leads much of the work on ALDFG for the United Nations. In 2019, FAO, IMO, and UNEP jointly established the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Working Group 43 to develop a report identifying extent, causes, impacts, and recommended solutions to the global problem of marine litter from sea-based sources, including ALDFG.

Many other intergovernmental organizations have authorities relating to fisheries management and in turn ALDFG. Regional fishery management organizations in particular play a major role in managing global marine fisheries and are of particular importance related to ALDFG from foreign fisheries that impact the United States and its territories.

Fishing Gear Loss Rates and Amounts of ALDFG

Section III of the report discusses the scale of fishing gear losses. Annual loss rates of U.S. pot fisheries range from <0.1% to 26% of total pots within a fishery, with the highest loss rates in the blue crab and lobster fisheries. The average loss rate for pot fisheries across all fishery management regions in the United States is 13%. Annual loss rates for U.S. gillnet fisheries range from 0.03% to 3%. Annual loss rates for U.S. longline fisheries, in terms of hooks lost per hook set, range from 0.01% to 0.55% loss of total hooks set. Annual loss rates for U.S. trawl fisheries, reported as percent of trawl hauls experiencing loss events, range from 0.0% to 3.65%.

These estimates are derived directly from data where possible, with some extrapolations where data are unavailable. Some reported losses often do not specify or quantify exactly what was lost. Therefore, these estimates include some professional judgment. Also, these estimates do not encompass all fisheries (some have no data) and therefore should be considered minimum estimates.

Comparing fishing gear loss rates and amounts in U.S. fisheries versus foreign fisheries is possible in a few instances but problematic overall because of the inconsistency in how gear loss data are collected and reported in the United States and other countries. Section III.B.4 discusses these limitations and the literature available.

Section III also discusses ALDFG transport and the causes of gear loss. ALDFG can be transported by meteorological and oceanographic drivers from its source location to other geographic areas. In some parts of the United States and its territories, ocean currents transport ALDFG long distances, depositing the ALDFG along shorelines and other sensitive habitats (Ebbesmeyer et al., 2012; McCoy et al., 2022).

To implement effective ALDFG management, including both prevention of fishing gear loss and mitigation of negative impacts of ALDFG after loss, it is critical to understand the causes of fishing gear loss, abandonment, and discard (Gilman et al., 2022; Richardson et al., 2018). The causes of ALDFG in the waters of the United States and its territories are not unique and, as in other countries and regions, vary across fisheries. Causes of fishing gear loss, abandonment, and discard have been documented in many fisheries in the United States and its territories (Bilkovic et al., 2016; Bowers, 1979; Butler and Matthews, 2015; CFMC and NOAA Fisheries, 2019a; Drinkwin and Shipley, 2021; Renchen et al., 2021; Uhrin et al., 2005; Uhrin, 2016). Causes vary by fishery but fall into the following general categories: gear snagged on an obstruction, damaged or towed away by animals, or drifted out of a vessel-accessible area; faulty, old, or damaged gear; operator error; poor weather conditions; strong currents; deep water (i.e., buoy line too short); gear not properly stowed; conflict with other gear; vandalism (stolen or destroyed); surface marking lost, sunk or malfunctioned; gear intentionally discarded overboard or abandoned; vessel conflict; equipment failure; and lack of communication between fishing vessels.

Regional examples of gear loss identified for specific U.S. fisheries where information is available include:

- Conflicts with net fishers accidentally damaging trap gear; buoy cutoffs from vessel propellers; and storms moving or damaging pots in the Gulf of Maine lobster fishery in the New England region.
- Vessel traffic conflicts and storms moving or damaging gear in the blue crab pot fisheries in the Mid-Atlantic region.
- Extreme weather patterns associated with tropical storms and hurricanes moving or damaging gear in the South Atlantic, Gulf of Mexico, Caribbean, Pacific, and Western Pacific regions; and impacts from ice movement in the Great Lakes and North Pacific.

Adverse Impacts of ALDFG

Section IV of the report discusses the impacts of ALDFG. The negative impacts of ALDFG are a growing concern in the United States and globally. ALDFG is one of the deadliest forms of marine debris for marine animals and habitats (Wilcox et al., 2016). Lost fishing gear can catch and injure or kill target and non-target species through a process known as ghost fishing (High, 1991; Lively and Good, 2018; Matsuoka, 2005; NOAA, 2015; Smolowitz, 1978); damage habitats (GESAMP, 2021; Macfadyen et al., 2009; NOAA Marine Debris Program, 2016); and pose navigation risks (Hong et al., 2017). It can also cause economic losses to fisheries and other marine-dependent industries. The inadvertent catch of target species by ALDFG can significantly impact the economics of a fishery, with up to 30% loss of harvest from ghost fishing documented in some U.S. fisheries (Antonelis et al., 2011; DelBene et al., 2019; Humborstad et al., 2003).

While the majority of ALDFG in waters of the continental United States are from U.S. fisheries, there have been some documented adverse effects from foreign sources on the U.S. East Coast (Imzilen et al., 2021; Kimak et al., 2022). Outside the continental United States, the adverse effects from ALDFG attributable to foreign fisheries is more of a concern, particularly in

Hawai'i, Alaska, and the Pacific territories (Donohue et al., 2001; Henderson, 2001; PIFSC, 2010; Suka et al., 2020).

Management Measures

Section V of the report provides an evaluation of ALDFG management measures, including regional examples. Both voluntary and regulatory management measures have been taken to prevent fishing gear loss and reduce the harmful effects of ALDFG on species, habitats, economies, and safety. These measures can be categorized by three types:

- Preventive measures that reduce the amount of fishing gear that becomes ALDFG
- Mitigation measures that reduce the harmful effects of ALDFG in situ (e.g., by reducing ghost fishing through fishing gear design)
- Remediation measures that reduce ALDFG in the environment by retrieving ALDFG from the water or shoreline.

Each type of measure is necessary in most fisheries, with the general acceptance that prevention is more cost-effective than mitigation or remediation. The measures that prevent ALDFG are first priority, followed by measures that reduce effects of ALDFG, such as biodegradable escape mechanisms for lost shellfish pots. Retrieval of ALDFG is critical in many fisheries, especially where gear loss is high and gear design precludes mitigation of ghost fishing or habitat effects. Fishing gear is lost even in the best managed fisheries, so a systematic approach to mitigating the effects of ALDFG and retrieving a significant percentage of lost ALDFG is important.

The report discusses approaching ALDFG management through the lens of fisheries management so it can be fully integrated into the management of harvest, bycatch, and habitats within the context of sustainable fisheries. Many of the well-established methods for managing fisheries related to harvest and sustainability have application to gear loss as well. There are management measures (required and voluntary) where reduction in gear loss and/or harmful effects of ALDFG is a byproduct of other management goals. Input controls, for instance, which include limits on gear numbers or limits on fishing seasons, may also serve to reduce gear loss (e.g., restricting the amount of gear being fished reduces gear loss from gear conflicts). Output controls, such as catch shares, also have been shown to reduce gear loss (e.g., reducing competition prevents fishing in sub-optimal conditions which can result in more frequent gear loss) (Citta et al., 2013; IPHC, 2022a).

Data and Management Gaps

Section V.C. of the report discusses the data and management gaps. Without a clear understanding of the scale and impacts of ALDFG, fisheries managers lack the necessary information to design effective prevention and reduction strategies or to evaluate the effectiveness of ALDFG management measures. While information about the scale of fishing gear loss and its adverse effects is available in many fisheries, there is still a significant lack of understanding of gear loss, its causes, and its effects in many fisheries.

To fully understand the amount of fishing gear that is entering U.S. marine waters and the waters of the Great Lakes, an inventory of all fishing gear used in a fishery versus the amount reported lost and the amount that is disposed of properly as end-of-life gear is required. This information is not available.

There are also significant data gaps on the causes and adverse effects of ALDFG on species, habitats, economics, and navigation/safety. Only 25 fisheries have documented causes of gear loss. Published data related to adverse effects on species were available for just 26 fisheries, and data on adverse effects on habitats were available for just six fisheries. Some of those published data do not differentiate between the effects of active fishing gear and ALDFG. Only 17 fisheries have published data on the economic effects of ALDFG. Very little information is available linking ALDFG directly to human safety or health effects. The information related to navigation safety is also sparse; USCG incident reports generally do not differentiate between active fishing gear and ALDFG if fishing gear is identified as a cause of an incident.

Finally, there are few reports focused on the direct effects of ALDFG management measures on the reduction of gear loss or reduction of adverse effects ALDFG. There is also no systematic practice to evaluate the effectiveness of existing ALDFG management. Despite the many examples of ALDFG management measures being implemented throughout the United States and its territories, there are still fisheries where existing approaches appear inadequate to address the effects of ALDFG or the scale of gear loss.

The lack of data on loss rates, adverse effects of ALDFG, and management effectiveness result in inconsistent approaches to ALDFG management. Although adverse effects of ALDFG are considered in many fisheries throughout the United States and its territories, there is not a set of overarching requirements or standards of practice to integrate ALDFG reporting, monitoring, or management into fisheries management schemes at the federal, state, or tribal levels. Despite the effectiveness of disabling mechanisms at reducing ghost fishing of lost pots, some pot fisheries still do not require escape mechanisms designed to allow trapped animals to escape if the gear is lost. The adverse effects of ALDFG on species, habitats, economics, and navigation safety in the United States and its territories also need more attention.

There is a lack of effective communication between parties addressing different aspects of ALDFG management in some regions. Major stakeholders involved in ALDFG management in the United States and its territories include fishers, fishing companies, and fishing associations; fisheries managers; ports and waste management companies; researchers; and non-governmental organizations (NGO). In some fisheries, these stakeholders are very coordinated and even meet regularly to share information and evaluate the effectiveness of ALDFG management (University of Washington Sea Grant, 2021; Drinkwin, 2016). In other fisheries, there is limited communication among the stakeholders.

Fisheries throughout the United States and its territories face a lack of infrastructure and prohibitive management structures for the convenient and affordable retrieval and proper disposal of retrieved ALDFG and end-of-life gear. These prohibitive management structures include regulatory collection prohibitions and inadequate disposal options for fishers who encounter ALDFG during active fishing (Bowling, 2016). Likewise, third parties, such as NGOs, that work to retrieve and dispose of ALDFG often face regulatory prohibitions, cumbersome permitting, and lack of disposal options (Bowling, 2016).

Recommendations

Section VI provides recommendations for management measures at the federal-level and regional and fishery-level. This Report to Congress includes recommendations for new or expanded actions to make further progress on the most pressing ALDFG management issues in the United States and its territories. The recommendations address the identified management gaps and weaknesses of the current approach to ALDFG management. Recommendations include federal-level actions and regional/fishery-level actions. For all the recommendations around ALDFG management, upfront and continual consultation and collaboration with fishers and fisher associations will serve to ensure that programs and systems put in place are feasible and supported by industry.

Federal-level recommendations include:

- Establish a National Working Group on ALDFG to develop a standardized approach to ALDFG reporting, assessment, and management.
- Establish regional ALDFG coordinating committees.
- Promote effective international management of ALDFG and reduce adverse effects caused by ALDFG from foreign fisheries.

Regional and fishery-level recommendations include:

- Develop fishery-specific ALDFG management strategies.
- Promote the establishment and support of appropriate disposal options for recovered ALDFG and end-of-life fishing gear at fishing ports in the United States and its territories.
- Establish local ALDFG reporting systems and registries appropriate to fisheries to document extent and locations of lost fishing gear to inform prevention and remediation activities.
- Establish required disabling mechanisms in all pot fisheries to allow escapement and prevent mortality of any animals trapped in ALDFG.

Cost estimates to implement these recommendations are found in Section VII of the report and are based on the costs of similar programs. Costs of increased federal advocacy at international forums can be included in current agency international work. In general, implementers of the recommendations will include Congress (for appropriations), NOAA Fisheries, NOAA MDP, state and tribal fisheries managers collaborating with fishers and/or fishers associations, researchers, ports, private industry, and NGOs. Implementation of these recommendations is subject to appropriations and, without necessary appropriations, these recommendations cannot move forward to the implementation phase.

II. INTRODUCTION

Congress established the NOAA MDP as the federal lead on marine debris through the Marine Debris Act (P.L. 109-449), signed into law in 2006. Signed into law in 2020, the Save Our Seas 2.0 Act (P.L. 116-224) requires several new studies and reports and strengthens federal approaches to marine debris, defined as persistent solid material that is manufactured or processed and directly or indirectly, intentionally, or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes [33 U.S.C. § 1956(3)]. Section 135 of the Save Our Seas 2.0 Act directs the Under Secretary of Commerce for Oceans and Atmosphere to provide a Report to Congress on the sources and impacts of derelict fishing gear, also known as abandoned, lost, and discarded fishing gear (ALDFG). This Report to Congress summarizes the major sources, impacts, current remedial actions, and programs for ALDFG, and it provides recommended actions to further address the problem in the waters of the United States and its territories.

The United States is a major commercial fishing nation ranking fifth globally in capture fishing landings (FAO, 2022a). United States fishers landed 8.4 billion pounds of seafood catch in 2020 worth $4.8 billion (NOAA Fisheries, 2022). Recreational fishing is also an important component of U.S. fishing. Recreational fishing generates 200 million saltwater fishing trips in the continental United States and Hawaiʻi, with the Atlantic Coast accounting for 68% of trips (NOAA Fisheries, 2022). In 2019, commercial and recreational fisheries supported 1.8 million jobs and $255 billion in sales in the United States (NOAA, 2022a). With this fishing effort comes accidental loss as well as intentional abandonment and discard of fishing gear.

The negative impacts of ALDFG are a growing concern in the United States and globally. ALDFG is one of the deadliest forms of marine debris for marine animals and habitats (Wilcox et al., 2016). Lost fishing gear can catch and injure or kill target and non-target species through a process known as ghost fishing (High, 1991; Lively and Good, 2018; Matsuoka, 2005; NOAA, 2015; Smolowitz, 1978); damage habitats (GESAMP, 2021; Macfadyen et al., 2009; NOAA MDP, 2016); and pose navigation risks (Hong et al., 2017). It can also cause economic losses to fisheries and other marine-dependent industries across the globe. The inadvertent catch of target species by ALDFG can significantly impact the economics of a fishery, with up to 30% loss of harvest from ghost fishing documented in some U.S. fisheries (Antonelis et al., 2011; DelBene et al., 2019; Humborstad et al., 2003).

In this report, the term ALDFG or "lost fishing gear" is used unless specifically referring to abandoned or intentionally discarded gear. The term "ghost gear" is used only for ALDFG known to be ghost fishing. This report uses the Food and Agriculture Organization of the United Nations (FAO) definition of ALDFG (FAO, 2018):

- "Abandoned fishing gear" means fishing gear over which the operator/owner has control and that could be retrieved by owner/operator but is deliberately left at sea due to force majeure or other unforeseen reasons.
- "Lost fishing gear" means fishing gear over which the owner/operator has accidentally lost control and that cannot be located and/or retrieved by owner/operator.

- "Discarded fishing gear" means fishing gear released at sea without any attempt for further control or recovery by the owner/operator.

Fishing gear is defined in Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL) and is codified within the U.S. Code of Federal Regulations (CFR):

> *Fishing gear means any physical device or part thereof or combination of items that may be placed on or in the water or on the sea-bed with the intended purpose of capturing, or controlling for subsequent capture or harvesting, marine or fresh water organisms. [33 CFR § 151.05]*

This analysis also discusses some auxiliary gear as defined in He et al. (2021). In particular, it includes fish aggregating devices (FAD), which are objects deployed in water to attract and aggregate fish to improve catch efficiency of other fishing gear, such as purse seine or troll gear (NOAA Fisheries, 2022a; He et al., 2021). FADs can be anchored to the seafloor or free-floating, and are an important consideration when addressing ALDFG.

This report attempts to draw a broad picture of ALDFG in the waters of the United States and its territories. It focuses on marine waters and the Great Lakes, while acknowledging that ALDFG does occur in freshwater lakes and rivers (GESAMP, 2021). The report is divided into sections with the first sections focused on rates, impacts, and causes of fishing loss, abandonment, and discard. These sections are organized loosely by fishery management council area with some fishery-specific information.

The information provided here represents the state of the knowledge present in published literature. It also summarizes data from federal fisheries observer programs, and information from state and federal fisheries managers including unpublished data and reports to augment published literature.

This report includes sections investigating different management strategies in place to prevent ALDFG and to prevent negative impacts of ALDFG after it enters the marine environment. These management strategies generally focus on fisheries but also include efforts to retrieve ALDFG by third parties, and programs to promote sustainable fishing and to encourage prevention of ALDFG by industry and third-party certification programs. Disposal, recycling, and reuse options for fishing gear are also explored.

This report includes a management gaps and weaknesses analysis. It then provides recommendations for reducing impacts of ALDFG in the short and long term through prevention of lost, abandoned, and discarded gear; gear modification and after-the-fact retrieval; and appropriate disposal. Where possible, the report recommends actions that have been proven feasible in the United States or in other countries. The recommendations reflect support for and recognition of the importance of commercial, recreational, and traditional fishing in the United States and its territories and they identify qualitatively the potential support, or lack of support, each strategy would garner from the fishing communities.

Included in this report are several case studies and examples from the United States and other countries of successful ALDFG management actions and programs. Case studies include programs with industry support that are succeeding in preventing harm from ALDFG. There are examples of effective funding approaches for programs and a discussion of which fisheries in the United States and its territories could adapt the programs described to fit local needs.

A. Federal Actions to Address ALDFG

The United States has been addressing ALDFG through legislation, establishment of NOAA's MDP, and collaboration with international agencies. This section summarizes those actions.

Save Our Seas 2.0 Act

The Save Our Seas Act was enacted in 2018 and the Save Our Seas 2.0 Act was enacted 2 years later in 2020. Save Our Seas articulates a policy to cooperate internationally and with domestic partners to combat marine debris, including mandating advocacy in all intergovernmental forums where the United States participates.

Save Our Seas 2.0 also requires the development of several reports and studies. Section 135 requires development of this report on sources and impacts of ALDFG including an analysis of the scale and impacts of fishing gear losses by domestic and foreign fisheries (relative to their impacts on the United States and its territories), and recommendations on management measures with cost assessments.

NOAA MDP

NOAA MDP was established in 2006 under Section 3 of the Marine Debris Act [33 U.S.C. 1952]. The Marine Debris Act established NOAA MDP, which is the primary federal program focused on preventing and removing ALDFG. The NOAA MDP strategic plan for 2021-2025 articulates overarching goals to drive its work consistent with its statutory authorizations (NOAA MDP, 2020a). NOAA MDP organizes its work around six pillars: prevention, removal, response, research, monitoring and detection, and coordination. Key activities under these pillars include the following (NOAA MDP, 2020a):

- Managing the NOAA MDP grant funding programs, which provide funding to partners for marine debris (including ALDFG) removal, prevention, and research.
- Developing state and regional marine debris action plans. All coastal states and territories either have a completed and current marine debris action plan, or are in the process of developing one. Most action plans include a section focusing on ALDFG.
- Providing regional marine debris coordinators to assist and support local partners.
- Assisting and supporting local and regional partners to respond to marine debris events caused by disasters such as hurricanes, including the development of marine debris emergency response guides.
- Conducting and supporting independent studies around priority marine debris subjects.
- Maintaining the Marine Debris Clearinghouse.

- Executing strategic communications educating the public about marine debris solutions and NOAA MDP activities.
- Acting as Chair and organizing secretariat to the Interagency Marine Debris Coordinating Committee (IMDCC).
- Engaging on marine debris in international forums in coordination with the Department of State and other federal agencies.

Other U.S. Federal Efforts

NOAA

The Marine Debris Act directed the IMDCC to coordinate federal agency responses to marine debris and ensure a comprehensive approach to the problem. The statutory federal member agencies are NOAA (Chair), U.S. Environmental Protection Agency (USEPA), U.S. Coast Guard (USCG), U.S. Navy, Department of State, and the Department of the Interior with the following participating bureaus: Bureau of Safety and Environmental Enforcement, U.S. Fish and Wildlife Service (USFWS), and National Park Service. Non-statutory member agencies include the U.S. Agency for International Development, Marine Mammal Commission, National Science Foundation, U.S. Department of Justice (DOJ) Environment and Natural Resources Division, National Aeronautics and Space Administration (NASA), and the Department of Energy (IMDCC, 2020). The IMDCC must report to Congress biennially on its work. The IMDCC meets regularly to ensure that all federal agencies, departments, and programs are working in a coordinated manner and addressing the most pressing aspects for marine debris strategically. In 2019, the U.S. Government Accountability Office reviewed federal efforts to address marine debris, and in particular, the structure, actions, and reporting of the IMDCC. The resulting GAO report recognized some effective actions that the IMDCC was currently taking and also provided some recommendations for further actions. NOAA accepted the GAO's recommendations, and NOAA and the IMDCC are implementing these recommendations. (US GAO, 2019).

NOAA has programs besides the MDP that directly remove and prevent ALDFG. NOAA Fisheries manages U.S. fisheries in federal waters, under the authority of the Magnuson-Stevens Fishery Conservation and Management Act. The Fishery Conservation and Management Act was first enacted in 1976 and amended in 1996 and 2006. It was renamed the Magnuson-Stevens Fishery Conservation and Management Act in 1996. Under this law, NOAA Fisheries conducts scientific studies to support management, writes and implements regulations, and works in other areas that affect fish, such as habitat restoration. NOAA Fisheries coordinates with regional fishery management councils and other regional and international management bodies to ensure that federal fisheries management is consistent with ten national standards. For each federally managed fishery, NOAA is responsible for developing a fishery management plan, which includes species and stock information, descriptions of the fishing fleet, and management measures. These management measures can address ALDFG in a fishery. For example, logbook data show a steep reduction in total halibut gear loss and loss ratio (loss per total haul) following the implementation of the Alaska Halibut and Sablefish Individual Fishing Quota catch share program in 1995 (IPHC, 2022a).

The NOAA Sea Grant Program works closely with the seafood industry nationwide to enhance the practical use and conservation of coastal, marine, and Great Lakes resources to create a sustainable economy and environment. In some locations, Sea Grant personnel have played an important role in ALDFG prevention and education. For example, the *Long Island Sound Marine Debris Action Plan* was led by the Connecticut and New York Sea Grant Programs, in coordination and with support from the NOAA MDP, and includes a goal to understand, prevent, and mitigate the impacts of abandoned and lost fishing gear (Connecticut and New York Sea Grant College Programs, 2022).

NOAA has conducted marine debris removal missions of ALDFG with partners in the Papahānaumokuākea Marine National Monument since 1996. How often these past efforts occurred depended on the labor, available ship time, funding and partners. From 1996 through 2018, NOAA removed a total of 923,000 metric tons of debris, primarily ALDFG (IMDCC, 2019). More recently, funding from NOAA to the National Fish and Wildlife Foundation (NFWF) is supporting large-scale ALDFG removal from coral reefs and shorelines through the Papahānaumokuākea Research and Conservation Fund (NFWF, 2023).

The NOAA Office of Marine Sanctuaries also oversees a network of underwater parks throughout the United States and its territories including 15 national marine sanctuaries and Papahānaumokuākea and Rose Atoll marine national monuments. NOAA also works closely with the USFWS on management and planning for marine monuments, such as the Pacific Remote Islands Marine National Monument. In many sanctuaries, staff or partners are involved in ALDFG prevention, education and removal efforts. For example, in the Florida Keys National Marine Sanctuary, the National Marine Sanctuary Foundation is collaborating with local dive operators to remove harmful ALDFG, while engaging the local community to prevent future debris (NOAA MDP, 2023b).

While the NOAA MDP focuses on marine debris, the USEPA Trash Free Waters Program focuses more on freshwater systems, engaging local partners to prevent trash from entering the water.

NIST

The National Institute of Standards and Technology (NIST) in the Department of Commerce established the Center for Marine Debris Research (CMDR) as a joint institute with Hawaiʻi Pacific University (HPU) in 2019. The NIST laboratory in Hawaiʻi at CMDR is part of the NIST Circular Economy Program. NIST and HPU developed optimal methods to identify the polymer composition of marine debris. Using those methods, NIST analyzed the polymer composition of the ALDFG in Hawaiʻi to better understand sources of the ALDFG and explore recycling options for the materials.

USCG

USCG is the lead agency enforcing MARPOL. Annex V of MARPOL prohibits the discharge of garbage (with some exceptions) including fishing gear and any plastics into the sea (Hodgson, 2022; IMO, 2019). The USCG Sector and District Offices enforce the provision of MARPOL

Annex V throughout the waters of the United States and its territories. USCG also responds to and keeps records of maritime incidents that involve ALDFG.

NASA

NASA supports observations and research activities that use the vantage point of space to better understand the Earth system and characterize its properties on a broad range of spatial and temporal scales, including naturally occurring and human-induced processes. NASA supports the development of new technology and platforms to enable the detection, characterization, monitoring, and tracking of marine debris, which may include ALDFG, using polarimetric and spectral information from the ultraviolet, visible, shortwave, and infrared portions of the electromagnetic spectrum. NASA currently supports three foundational research projects to assess remote detection of floating and submerged marine debris, including microplastics on the ocean surface, and how marine debris may impact satellite ocean color retrievals at different concentrations. NASA also supports a citizen science project centered around linking coastal and ocean ecology, ecology associated with marine debris, and mechanisms for advection of debris to provide in situ data for validation of satellite measurements. NASA recently invested in the development of MiDAR (multispectral imaging, detection, and active reflectance) for classifying remotely sensed signatures of marine plastic debris using differential ultraviolet reflectance and fluorescence, aimed at future space-based ocean science instruments. NASA will continue to engage citizen science related marine debris efforts through its GLOBE (Global Learning and Observation to Benefit the Environment) program.

Department of the Interior, National Park Service

Other site-based agencies, such as the National Park Service, also address ALDFG within their areas. For example, the National Park Service includes data collection on ALDFG in its South Florida and Caribbean Inventory and Monitoring program in parks in the U.S. Virgin Islands (USVI). Through these monitoring efforts, they discovered and addressed a large commercial shrimp trawl net on park shores (IMDCC, 2019).

Department of the Interior, U.S. Fish and Wildlife Service

USFWS, as land managers of wildlife refuges and monuments, addresses marine debris issues at specific sites and adopts innovative approaches to address ALDFG problems. In addition to its work with NOAA with the Papahānaumokuākea and Pacific Remote Islands marine national monument, USFWS addresses marine debris generally and ALDFG specifically on many other sites. For example, the remote island Palmyra Atoll National Wildlife Refuge is managed by the USFWS and The Nature Conservancy. An innovation program there involves coordinating with tuna fishing vessels and providers of the location data from satellite buoys attached to FADs. When a drifting FAD's position comes close to the island reef systems, the satellite buoy providers (with permission from the US Pacific Tuna Group) notify refuge personnel so that the FAD can be intercepted before it lands on sensitive nearshore reef habitats (Miller, 2022).

Department of State

The Department of State regularly engages in meetings on marine debris in multilateral forums, such as the Arctic Council, United Nations Group of 7, Group of 20, Asia-Pacific Economic Cooperation (APEC), Association of Southeast Asian Nations Regional Forum, International Maritime Organization (IMO), and the FAO. Most recently the Department of State has supported development of APEC-specific guidance documents around best practices for preventing fishing gear loss and for effective marking of fishing gear. During U.S. 2023 APEC host year, the Department of State announced $250,000 contribution to the Marine Debris Sub-Fund. The Department of State, in partnership with APEC, supported a virtual workshop in May 2022 with APEC economies to build awareness about ALDFG and best practices for preventing fishing gear loss.

DOJ

DOJ addresses ALDFG at times through civil and criminal enforcement of environmental violations involving marine debris. Agencies such as USEPA, NOAA, and USCG refer cases to DOJ. Through its authorities, DOJ has facilitated the use of funds arising from legal and regulatory actions to be used to remove ALDFG, at times in partnership with NFWF (Department of Justice, 2006).

B. Global ALDFG Efforts

United Nations

Advancing solutions to ALDFG on a global scale has gained momentum with the efforts of FAO, the United Nations Environment Programme (UNEP), and IMO through their multilateral forums. UNEP hosts the Global Partnership on Marine Litter, a voluntary partnership for international agencies, governments, and private entities to coordinate action on marine debris. UNEP collaborated with the FAO to develop the seminal report defining the problem of ALDFG in 2009 (Macfadyen et al., 2009) and it developed a toolkit for marine litter policy in 2016 which includes ALDFG (UNEP, 2016).

FAO leads much of the work on ALDFG for the United Nations. Since publishing its seminal report in 2009 (Macfadyen et al., 2009), it has supported ongoing work to address the issue in fisheries worldwide. FAO published *Voluntary Guidelines for the Marking of Fishing Gear*, which provides technical guidance to nations for their evaluation of ALDFG risks across fisheries, as well as actions to reduce ALDFG, including best practices for fishing gear marking (FAO, 2018). FAO partnered with the Global Ghost Gear Initiative (GGGI) to hold regional workshops in Latin America, the Pacific, Africa, and Asia on these best practices to prevent and reduce ALDFG in global fisheries (FAO, 2020).

The IMO of the United Nations is responsible for the safety and security of shipping and the prevention of marine pollution from ships. IMO is the lead organization with authority under MARPOL. MARPOL Annex V (entered into force in 1988) is the main international convention covering prevention of pollution from shipping. Under Annex V, vessels are prohibited from discharging fishing gear into the marine environment, unless there are safety concerns for the vessel, crew, or the equipment. The setting of fishing gear that remains in the water actively fishing – such as some nets and FADs – is not considered discharge. Annex V further requires vessels to report any losses of fishing gear known to have a significant adverse impact on the environment. Provision of port waste reception facilities is an important element of IMO's work and is recognized as critical to prevent illegal dumping of trash, including ALDFG, into the ocean. In 2021, IMO adopted a *Strategy to Address Marine Plastic Litter from Ships,* which includes actions to prevent and address the abandonment or discard of fishing gear (IMO, 2021).

In 2019, FAO, IMO, and UNEP jointly established the Joint GESAMP Working Group 43 to develop a report identifying extent, causes, impacts, and recommended solutions to the global problem of marine litter from sea-based sources, including ALDFG. Following two interim reports to FAO and IMO, the final report of the first phase of the Working Group was published in October 2021 (GESAMP, 2021). The final report consolidates most of what is known globally about the types, causes, and impacts of ALDFG. It identifies global data gaps including distinguishing species entanglement impacts of ALDFG from active fishing gear, understanding population-scale impacts of ALDFG, and quantifying ALDFG from recreational and commercial fisheries (GESAMP, 2021).

FAO and IMO are also cooperating on the GloLitter Partnership Project, which is engaging developing countries in reducing marine plastic litter and ALDFG from the maritime transport and fisheries sectors. Working in partnership with countries from five regions, the program has produced several reports to raise awareness amongst partnering countries and fishing stakeholders on how to prevent and reduce ALDFG through onboard practices, reporting and retrieval, and policy and regulatory development (Drinkwin, 2022; Giskes et al., 2022; Hodgson, 2022).

NGOs

GGGI, a program of the Ocean Conservancy, is a multisector alliance of over 100 organizations, businesses, and governments that brings seafood stakeholders together to address ALDFG at all points along the seafood supply chain. GGGI has published a *Best Practices Framework for the Management of Fishing Gear* that provides management strategies to prevent harm from ALDFG directed at 10 different seafood supply stakeholders, including fisheries managers (GGGI, 2021). The United States officially joined the GGGI in 2020.

Intergovernmental Organizations (IGO)

Many other IGOs have authorities that influence fisheries management and in turn ALDFG. Gilman (2015) identified global and regional bodies able to develop binding mechanisms for marine fisheries. Regional fishery management organizations in particular play a major role in managing global marine fisheries and can support efforts to address ALDFG from foreign fisheries that impact the United States and its territories. The role of regional fishery management organizations and other IGOs with fisheries authorities will be further discussed in subsequent sections on fisheries management approaches to prevent and manage ALDFG.

The United States engages in many of these forums with representatives from NOAA Fisheries and the Department of State. NOAA MDP also engages internationally on preventing and managing ALDFG in a variety of forums:

- With funding provided by the United States-Mexico-Canada Agreement Implementation Act (signed in December 2019), NOAA MDP is supporting projects that document, prevent, and remove ALDFG in the Gulf of Maine, the Pacific Coast, Gulf of Mexico, and Mexican Caribbean. NOAA MDP is supporting the GGGI-led North American Net Collection Initiative project to develop a fishing net recycling program with partners in Mexico and California. The project engages Mexico fishery managers, artisanal fishers, and private companies in collecting and transforming old fishing gear into high value consumer goods. The project also includes identifying probable areas of ALDFG accumulation in Mexico, surveying fishers on causes and solutions to ALDFG, and training fisheries managers in best practices to prevent and manage ALDFG.
- NOAA MDP serves on the steering committee of the Global Partnership on Marine Litter, which is a multistakeholder international partnership and has UNEP support. The Global Partnership on Marine Litter includes representatives from key international bodies and other entities that address ALDFG and is an important global forum on the issue of marine debris and plastic pollution.
- NOAA MDP serves on U.S. delegations to meetings of the APEC Oceans and Fisheries Working Group. NOAA MDP and Department of State help direct efforts through APEC to implement the high-level APEC Roadmap on Marine Debris and provide input to guide work of the Oceans and Fisheries Working Group to understand and address many aspects of the marine debris issue, including ALDFG. In May 2022, the Department of State helped the GGGI to host a 3-day virtual workshop with APEC member economies focusing on regionally appropriate best practices to manage and prevent ALDFG. Also part of this effort is the development of two reports to aid APEC fisheries managers: *Managing Abandoned, Lost or Discarded Fishing Gear and Aquaculture Equipment in the APEC Region: Draft Baseline Report: Best Practice Guide* and a companion *Compendium for the Marking of Fishing Gear in the APEC Region*.
- NOAA MDP supports working groups of the Arctic Council to promote coordinated approaches to reduce marine debris (including ALDFG) in the Arctic region.

III. SCALE OF FISHING GEAR LOSSES [§ 135 (1)]

This section presents an analysis of the fishing effort and fishing gear in the industry, and how much of that gear becomes ALDFG. Using data obtained through a literature review and also data obtained from NOAA Observer Programs and state fishery managers, the rate of gear lost in many U.S. fisheries is presented and the amount of different gear types lost each year is estimated. Also discussed is the availability of gear loss rates from foreign fisheries and how they compare to loss rates from U.S. fisheries.

A. Fishing Gear Types [§ 135 (1)(A)(ii)]

There are many types of fishing gear used worldwide, and in general they are categorized as dredges, falling gear, gillnets and entangling nets, hooks and lines, lift nets, seine nets, surrounding nets, traps, and trawls (FAO, 2022b). Within these broad categories there are "bottom" or "demersal" gear that target species close to the seafloor, "pelagic" or "midwater" gear used for fishing somewhere in the water column above the seafloor, and "surface" gear used for fishing at the sea surface in the uppermost portion of the water column. There are *active* or *passive* gear types. Active gear types are generally mobile, moving through the water during active fishing (e.g., trawl nets, seine nets). Passive (or "static") gear is set, usually stationary, and captures target species via interception or attraction to bait or habitat (e.g., pots, gillnets) (FAO, 2002). Active fishing gear types commonly used in U.S. fisheries include trawl nets, dredges, seine, trolling lines, and drifting longlines. Common passive gear types used in U.S. fisheries include pots, gillnets, trap nets, bottom longlines, and vertical lines.

Description of Primary Gear Types Used in Fisheries of the United States

Pots and Traps

Pots are a type of trap that are essentially designed as cages. There are several variations of shapes and dimensions, but they are commonly round, square, or rectangular. Pots are used to catch shellfish, such as crabs, lobster, and shrimp, as well as finfish, such as sablefish, cod, black sea bass, and reef fish. Pots are common in both commercial and recreational fisheries. Several pot types are made of plastic or vinyl coated welded wire, such as lobster pots, blue crab pots, and recreational Dungeness crab pots. Other types of pots are made of solid steel frames that provide structure, around or within which nylon mesh web or wire mesh forms the cage. Some pots, such as lobster pots in Florida, are made of wood. Pots have one or more entrance tunnels, which commonly include a one-way (entrance only) trigger or a cone shaped entry, making exit challenging. Pots in the U.S. fisheries vary greatly in size; crab and fish pots used in the Bering Sea/Aleutian Islands fisheries can be up to 7 × 7 × 3 feet (Zhou and Kruse, 2000). Other pots, such as blue crab pots are commonly about 2 × 2 × 2 feet (Bilkovic et al., 2012).

Some pots are set with single buoys and some are set sequentially along a groundline. Pots are tethered to the sea surface by a buoyed line. Line thickness and materials vary depending on the fishery, as does buoy size and material. Often pots have a combination of multiple buoys (NOAA, 2011; McCarron and Tetreault, 2012).

Trap nets are stationary nets consisting of a series of net walls that are anchored to the seafloor and held upright in the water column by buoys and floats. They are designed to form a trap into which fish swim. Trap nets are common in the Great Lakes fisheries and may be as 45 feet high off the substrate (Wisconsin DNR, 2022).

Hook-and-Line

Hook-and-line gear is an overarching term used for utilization of line with a baited hook or lure used to attract fish and entice them to bite or swallow the hook (FAO, 2002). Hook-and-line fishing is common in commercial, recreational, and artisanal fisheries. Hook-and-line fishing with rod and reel are the most common type of recreational fishing in the United States, and a variety of hook-and-line gear types are used throughout the commercial sectors. In commercial fisheries, hook-and-line is often a term used to describe a fishing fleet, or component of a fishing fleet, that utilizes multiple types of hook-and-line gear (e.g., vertical lines, longlines, handlines).

Handlines, mechanized lines, and pole-and-line gear types include one or more hooks or lures (jigs) that are either manually or mechanically operated to move the gear in a way that attracts the targeted species to the bait or lure. Lines are commonly monofilament material. The thickness of the line depends on the target species and the environment where the fishing occurs. Lead weights are also a common component in these gear types, to ensure fishing occurs at the preferred water depth (He et al., 2021).

FADs are floating artificial structures designed to attract fish in open water areas, to increase fishing efficiency via concentration of desired species such as tunas, billfish, dolphinfish, and others. Moored (or anchored) FADs are used in fisheries in the United States, particularly in the coastal waters around the Pacific Islands, to attract fish for recreational and commercial hook-and-line fishers (Hawaiʻi Sea Grant, 2022).

Longlines are a type of hook-and-line gear. The two primary types of longlines are set and drifting longlines. All longlines include a mainline and gangions (also called branchlines or snoods) with baited hooks connected to the mainline at regular intervals. Longline length and the number of hooks vary depending on the target species, vessel capacity, and fishing environment. Each end of a longline is marked by a buoy, and often a “highflyer” to increase visibility (NOAA, 2011). Set longlines (bottom longlines or demersal longlines) are anchored to the seafloor at each end and fish directly on the seafloor or can be elevated just above the seabed (He et al., 2021).

Bottom longlines are used to target demersal fish in all the marine fisheries management regions of the United States. In the New England and Mid-Atlantic regions, bottom longlines targeting groundfish are typically about 1,500 feet long. Six of these longlines are strung together to create a longline extending about 1.5 nautical miles (NEFMC, 2022). In the South Atlantic and Gulf of Mexico regions, longlines targeting reef fish average over 5.6 nautical miles of cable mainline and 991 hooks per line (Scott-Denton et al., 2011). In the U.S. West Coast and Alaska regions, longlines can be up to 3 nautical miles long (NOAA, 2011).

Drifting longlines, also called pelagic longlines, are longlines that are not fixed to the seafloor. They are suspended in the water column, often near the sea surface by a series of floats, evenly spaced along the mainline, and they drift with the current. Vessels typically drift along with their longlines, often attached to one end (He et al., 2021). Pelagic longlines operate mostly in offshore waters targeting highly migratory species such as billfishes and tunas. Mainlines and branchlines are made of monofilament; mainlines are 25 to 45 nautical miles long, and branchlines are commonly 25-50 feet long (NOAA, 2022f). Branchlines include a swivel, weight, and clip which connects it to the mainline (He et al., 2021).

Vertical lines (also called drop lines or buoy gear) are lines set vertically with one or more hooks attached to the line at different depths. A weight is attached to the bottom of the line, and the gear is either set with a buoy and highflyer, or remains attached to the vessel (He et al., 2021). The mainline is typically monofilament, with branchlines attached to the mainline with swivels or snaps. In the Gulf of Mexico reef fishery, vessels typically operate three or more vertical lines with an average of 26 hooks per set (Scott-Denton et al., 2011).

Trolling gear is one or more lines with one or more baited hooks or lures that are towed behind a fishing vessel. Gear may be towed at the sea surface, especially when targeting pelagic species such as dolphinfish, marlin, and tunas. In other fisheries, such as those targeting salmon, heavy lead weights are attached to the bottom of the line to maintain targeted water depths. Outrigger poles are often used to increase the number of lines being fished, and to maintain ample distance between those lines. Trolling lines are often monofilament, although in the salmon fisheries in North Pacific and West Coast regions, mainlines are made of stainless steel, with monofilament leaders leading to each hook off the mainline (Oregon Sea Grant, 2003).

Gillnets

Gillnets are large, rectangular-shaped walls of netting that are held upright by a series of floats along the headline (also called corkline or floatline) and are equipped with a weighted line (leadline) along the lower end of the net. Similar to longlines, drift gillnets fish at or near the sea surface and typically remain connected to or near the fishing vessel, with a marker buoy connected to the opposite end of the net (He et al., 2021; NEFMC, 2022). Drift gillnets are a common gear type used to capture salmon and herring in West Coast and Alaska fisheries. Set gillnets are gillnets that are anchored at both ends, and often fixed to the seafloor both by the anchors and by the weighted leadline. Each end of the net is marked with a buoy, and often with a highflyer. Regionally, set gillnets are often called bottom, fixed, sink, or anchored gillnets. Sink gillnets are one of the main gear types used in the New England Multispecies (groundfish), Monkfish, and Skate fisheries, where they are typically 300 feet long and about 12 feet high, and are commonly fished in a string of 10 nets connected end-to-end (NEFMC, 2022). Set gillnets are also commonly used in nearshore fisheries, including salmon fisheries, where one end is often connected to the shoreline, with the opposite end anchored to the seabed.

Trawl Gear

Trawl nets are cone-shaped nets towed behind a vessel that herd the target species into the net. Bottom trawls refer to those that are towed across the seabed, capturing demersal species, while pelagic or midwater trawls operate off the seafloor in the water column (He et al., 2021).

Beam trawls are trawl nets that maintain their vertical and horizontal opening by a beam across the net mouth that is supported above the seafloor by wide shoes that slide over the seafloor (He et al., 2021). The footrope (often called groundgear) makes regular contact with the seafloor and is often armored with chain and rubber discs called cookies. Tickler chains hang off the groundgear and run ahead of the footrope to stir up the targeted fish and shellfish. Often boats will tow more than one beam trawl side-by-side (He et al., 2021).

Bottom otter trawls, also called just bottom trawls or otter trawls, are the most common type of trawl gear. The mouth of the net is spread open by a pair of otter boards, one on each side of the net, that are connected to the net via bridles made of cable (often called sweeps). Cable warps connect the otter doors to the vessel, and the speed of the vessel forces the otter doors outward, spreading the net mouth. Groundgear configurations vary depending on seafloor type and target species, but they often consist of chains, heavy rope, discs, and "rock hopper" gear to protect the net from damage while bobbins and/or weights help to maintain seafloor contact (He et al., 2021; NEFMC, 2022). The headline with floats maintains the preferred vertical opening. In the United States, bottom otter trawls are common in the demersal groundfish fisheries in the New England, Mid-Atlantic, West Coast, and Alaska regions. They are also the most common gear type in the shrimp trawl fisheries of the South Atlantic and Gulf of Mexico regions, where twin-rigged trawls are used regularly (NOAA, 2022c). Twin-rigged trawls or twin trawls are two trawl nets being towed side-by-side by the same vessel.

Midwater otter trawls operate similarly to bottom otter trawls, except they target species off the seafloor. Midwater trawls are much larger than bottom trawls, and do not need the same type of armoring of the footrope. Pair trawls operate similar to otter trawls, but are towed by two vessels running parallel, managing the spread of the net and eliminating the need for otter doors (He et al., 2021).

Dredges

Towed dredges are heavy cage-like structures that are towed along the soft seabed, lifting their catch out of the substrate with a blade or teeth. A bag made of iron rings, called a ring bag, trails the scraper blade and holds the captured species, which are typically clams, scallops, or oysters. One vessel may tow from one to as many as 18 dredges simultaneously (He et al., 2021). In the Atlantic scallop fishery in the New England and Mid-Atlantic regions, two large dredges about 15 feet wide are typically towed behind each vessel (He et al., 2021). Oysters are also targeted in dredge fisheries, primarily in Chesapeake Bay and in the Gulf of Mexico.

Hydraulic dredges are dredges that use high-pressure hydraulic jet pumps in front of the cutting blade to dislodge clams and from the sediment before they are captured in the cage (He et al., 2021). Hydraulic dredges are the most common gear type used in the Atlantic surfclam and ocean quahog fishery that operates in the New England and Mid-Atlantic regions (MAFMC, 2022).

Purse Seines

Purse seines are a type of surrounding net that includes a purse line used to close the bottom of the net after schooling pelagic fish have been encircled. The headline (or corkline), attached to the top of the net is floated by evenly-spaced floats along the sea surface, and the leadline is attached to the bottom of the net to maintain the lower extent of the fishing depth. The purse line runs through a series of metal rings hanging off the leadline and is used to cinch closed the lower end of the net. Purse seines target schooling pelagic species; the depth of the nets (distance from corkline to leadline) depends on the target species. In the United States, purse seines are commonly used in salmon, herring, menhaden, sardine, mackerel, and squid fisheries. They are also a common gear type in tuna fisheries of open water areas. Worldwide, purse seines account for close to one-third of the total marine landings (He et al., 2021).

Tuna purse seine nets can be up to 1 nautical mile long, and over 800 feet deep (He et al., 2021). These fisheries often utilize drifting FADs. Drifting FADs are unmoored and float freely with the currents, and are commonly used in industrial tuna fisheries. Drifting FADs are typically equipped with an electronic transmitter often with satellite tracking capability. FADs comprise a variety of materials, often including pieces of plastic netting and other non-biodegradable materials (He et al., 2021).

Plastics in Fishing Gear

The use of synthetic fibers (i.e., plastics) in fishing gear design began in the 1950s. When they were first introduced, synthetic fibers offered greater strength and durability than natural fiber ropes and they also decreased the overall weight of fishing gear (Valdemarsen, 2001). These stronger and more durable fibers also increased the catch efficiency of many gear types and have been a major factor in the evolution of fishing practices worldwide (Brandt, 1974; Valdemarsen, 2001). There are three main plastic types used in fisheries and other maritime industries: polyethylene, polypropylene, and polyamides (nylon). Commercial fishing gear is also constructed with a variety of secondary plastic types, such as polyester, high molecular weight polyethylene, and polyvinyl chloride. By weight, fishing gear can be dominated by non-plastic materials like rubber, wood and steel (FAO, 2022b).

The complicated, multi-material construction of fishing gear is an important consideration for disposal and recycling of end-of-life fishing gear and retrieved ALDFG. Before recycling fishing nets, for example, they must be taken apart and sorted by homogeneous plastic. If it is not possible to separate out the various types of plastics (e.g., fibers of different plastic types are braided together in a single line), this material must be sent to a chemical recycling or waste to energy facility.

Table III.1 identifies the general materials used in various components of commonly used fishing gear.

Table III.1. Plastic types and other materials used in components of common fishing gear used in U.S. fisheries. PET = polyethylene terephthalate (polyester); PE = polyethylene; PP = polypropylene; PA6/PA6.6 = polyamides (nylon); PVC = polyvinyl chloride; HDPE = high density polyethylene; ABS = acrylonitrile butadiene styrene; HMPE = high molecular weight polyethylene.

Gear type	Gear component	Plastic type
Longlines	Ground line	PET, PE/PP
	Buoy line	PE/PP
	Clips	Stainless steel

Gear type	Gear component	Plastic type
	Gangions	PA6
	Hooks	Steel
Pots	Float lines	PE/PP
	Sink lines	PET and PE/PP, lead
	Pots	Steel, wood, plastic
	Buoys	PVC
Trawls	Cable	Steel
	Wire	Steel, PP
	Chain	Steel
	Codend web	HDPE
	Midwater net	PA6, leaded lines
	Riblines	PET, PE, PA6
	Chafe gear	HDPE
	Floats	ABS
	Footrope	Steel, wire, hose
Gillnets	Cork line	PA6, PA6.6, PP
	Corks	PVC
	Leadline	Lead, PA6, PP
	Web	PA6
	Hanging twine	PA6 or PA6.6
	Weedline	PE/PP
Purse seine	Lead web	PA6
	Body web	PA6
	Hanging twine	PA6.6 or PA6
	Cork line	HMPE
	Corks	PVC
	Purse line	PE/PP
	Chafe gear	HDPE
	Lead line	PE and lead (easily separated)

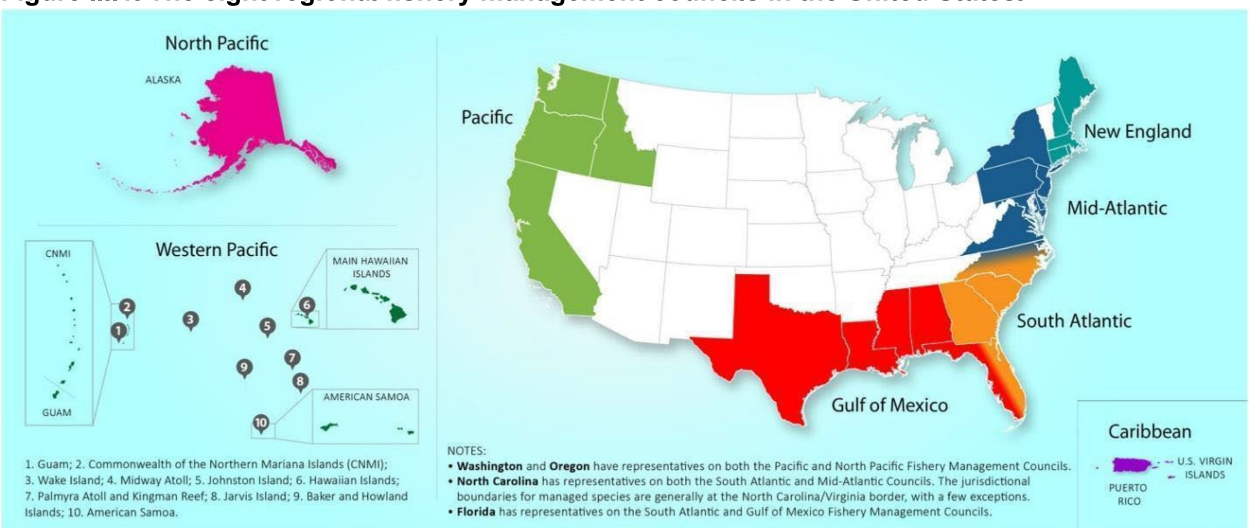
B. Gear Loss Analysis [§ 135 (1)(A)]

In this section the rates of fishing gear loss and the amounts of gear lost in U.S. fisheries is summarized. To understand the types and amounts of gear lost, it is important to understand fisheries and fisheries management in the United States. This section presents an overview of fisheries management and fishing effort in the United States and the gear that is used for that fishing. It then summarizes the documented gear loss and presents estimates of gear loss rates.

Overview of Fisheries Management in the United States

NOAA Fisheries is responsible for the management of marine fisheries within the U.S. Exclusive Economic Zone (EEZ), which covers all U.S. waters, typically from 3 to 200 nm from shore. NOAA Fisheries provides oversight of commercial, recreational, and subsistence fisheries to ensure sustainable management through partnerships with federal, regional, state, tribal, and territorial authorities. The primary purpose is to sustain and protect seafood supplies; maintain and enhance fishing opportunities; protect ecosystem health; and support fishing communities and their economies (NOAA, 2022b). There are eight regional fishery management councils responsible for fisheries management: New England, Mid-Atlantic, South Atlantic, Gulf of Mexico, Caribbean, Pacific, North Pacific, and West Pacific (Figure III.1).

Figure III.1. The eight regional fishery management councils in the United States.



Source: USRFMC, 2022.

The main law guiding U.S. fisheries management is the Magnuson-Stevens Fishery Conservation and Management Act, or Magnuson-Stevens Act (NOAA Fisheries, 2023). Other laws contribute to the fisheries management process, including the Marine Mammal Protection Act and the Endangered Species Act, which are responsible for protection of marine mammals and other species at risk and the conservation of their habitats.

Coastal resources inside state managed waters, 0-3 nm from shore,[1] are managed by state and sometimes tribal agencies. When resources are shared between state and federal boundaries, they are managed cooperatively between the states in collaboration with the Federal Government to maintain responsible management of the fish stocks and other affected species and habitats. Primary management responsibilities for cross-boundary species are determined by where most of any given fishery occurs, either federal (council) or state(s). Three Interstate Marine Fisheries Commissions (Atlantic, Gulf, and Pacific) are in place to address cross-state management issues of shared fishery resources. Each commission has a different set of specific responsibilities, such

[1] All state managed waters are 0-3 nm from shore except in Texas, Puerto Rico, and west Florida, where state waters extend to 9 nm from shore.

as develop fishery management plans (Atlantic only), recommend management measures, coordinate research activities, monitor fishing activities, and host fisheries and scientific databases.

International commissions coordinate the management of species that cross international boundaries. The Great Lakes Fishery Commission, consisting of representatives from the United States and Canada, coordinate fisheries research, control invasive species, and facilitate cooperative fishery management among the state, provincial, tribal, and federal agencies in the Great Lakes region (GLFC, 2022). The United States belongs to a number of regional fisheries management organizations, or RFMOs, which are mandated to sustainably manage shared fisheries resources in specific ocean areas. For example, the International Pacific Halibut Commission (IPHC) was established by convention between Canada and the United States to develop and maintain Pacific halibut stocks that allow optimum yield from the fishery (IPHC, 2022b).

Management Structure of U.S. Fisheries

Federal- and state-managed fisheries are spatially divided by areas, often called management areas, statistical areas, or fishing zones. They are often marked by geographic regions or features, seafloor characteristics, habitat types (including critical habitats for protected species), spawning grounds, political boundaries, and simply equal area grids. These delineated boundaries are used to monitor, manage, and regulate fishing effort and intensity within specific areas for multiple reasons related to fisheries sustainability such as species protection, harvest control, economic performance, operational safety, and conflict avoidance.

Fisheries-dependent data are critical for fisheries management and research. There are a variety of ways fishing activity is monitored throughout the United States and territorial fisheries. Self-reporting systems, typically in the form of logbook entries that are returned to the management agency after every trip, include a variety of information about gear type, location, effort, harvest, bycatch, and more. Fishery-specific instructions are incorporated into logbook designs to obtain the most accurate data possible (NRC, 2008).

In recent years, electronic logbooks, in the form of mobile phone or computer applications have become the most efficient way for data to be collected, delivered, and incorporated into databases, and in 2021 most federally managed commercial fisheries in the New England and Mid-Atlantic regions were required to use the electronic vessel trip report system (NOAA, 2022d).

Fish ticket reporting includes some variation of fishers and/or fish dealers providing management agencies with a copy of each transaction of product. Typically, this includes information such as the permit identification of the seller, species landed, weight of landings, management area where harvest occurred, landing port, total price of transaction, and more. Fish dealer data are useful in many ways, such as providing an accounting of harvest and economic information from a party outside the fishing operation while providing managers with rapid access to in-season harvest data.

Fish ticket reporting is moving to electronic platforms in many state and federal fisheries throughout the United States (NOAA, 2016; NOAA, 2022b). Specifically in Alaska, the Interagency Electronic Reporting System, a joint effort between NOAA Fisheries, IPHC, and Alaska Department of Fish and Game (ADFG), consolidates landings, production, and logbook reporting from a sole source, for many of the fisheries (ADFG, n.d. a). In addition, the use of vessel monitoring systems have increased worldwide. These systems, connected to a vessel's global positioning system (GPS) unit, monitor location and movement of fishing vessels (NOAA, 2015), and can collect timestamped positional data and video recordings of fishing operations to document effort, catch, bycatch, and other useful data (CFEMM, 2022).

Fishery observers are professionally-trained, agency-appointed at-sea monitors of commercial fishing and processing vessels. There are five federally managed regional observer programs: Greater Atlantic, Southeast, Alaska, West Coast, and Pacific Islands. Observers collect catch and discard data, and track interactions with marine mammals, sea turtles, and seabirds. These efforts help to monitor fisheries, assess populations, and inform sustainable fisheries management (NOAA, 2022e). Included as part of their duties, these observers log gear lost on the vessels, ALDFG encounters at sea, and ALDFG that the fishers bring ashore for disposal.

The sections below provide an overview of U.S. fisheries by region.

New England Region

The New England Fishery Management Council (NEFMC) along with NOAA Fisheries manages the fisheries in federal waters offshore of Connecticut, Maine, Massachusetts, New Hampshire, and Rhode Island. There are nine fisheries management plans within the NEFMC jurisdiction, two of which (Spiny Dogfish and Monkfish) are co-managed by the Mid-Atlantic Fishery Management Council (MAFMC). The others include Atlantic Sea Scallop, Northeast Multispecies (groundfish), Northeast Skate Complex, Atlantic Herring, Deep-Sea Red Crab (NEFMC, 2020). There is also an Atlantic Salmon Fisheries Management Plan under which commercial fishing is prohibited. There are two catch share programs in the New England region, they are the Northeast Multispecies Sectors, and the Northeast General Category Sea Scallop program (NOAA, 2022a). The American lobster fisheries are primarily conducted in state waters, and therefore are managed by states and the Atlantic States Marine Fisheries Commission, with NOAA Fisheries overseeing the federal waters fishery. In addition, in federal waters, a relatively small and unregulated hagfish (slime eel) fishery occurs in the Gulf of Maine. In state waters, 0-3 nm from shore, species covered under these management plans, as well as several other species targeted in coastal waters are managed by the Atlantic States Marine Fisheries Commission and/or by each individual state, depending on the cross-state nature of the species (ASMFC, 2022).

The key species for commercial fisheries in New England include American lobster, Atlantic herring, Atlantic mackerel, Bluefin tuna, cod and haddock, summer and winter flounder, monkfish, quahog clams, sea scallop, and squid. The primary gear types used to target these species in the region include pots, bottom and mid-water trawls, gillnets, longlines, handlines, and dredges (Table III.2).

Recreational fishing is popular throughout the New England region, either from shore, on for-hire vessels, or private vessels. Trips primarily occur from shore and in state waters, and the vast majority of recreational effort is conducted with rod and reel (hook and line) targeting a large variety of finfish. The primary recreational species in New England include Atlantic cod, Atlantic mackerel, bluefin tuna, bluefish, little tunny, scup, striped bass, summer flounder, and winter flounder. American lobster is targeted recreationally with pots, as are some crab species to a lesser extent.

Table III.2. Summary of species associated with the primary gear types used in the New England region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots	American lobster, Jonah crab, blue crab, red crab, hagfish, conch/whelk, American eel, tautog
Gillnet	Groundfish (Atlantic cod, flatfish, hake, etc.), monkfish, mackerel, skate, redfish, herring, and more
Longline	Groundfish, dogfish, swordfish, bigeye tuna, and more
Purse seine	Atlantic herring, menhaden, bluefin tuna
Bottom trawl	Groundfish (Atlantic cod, flatfish, etc.), monkfish, mackerel, squid, butterfish, skate
Midwater trawl	Atlantic herring, mackerel
Dredge	Sea scallop, other shellfish (urchin, mussel, etc.)
Other hook & line	Groundfish, swordfish, bigeye tuna, and more

Mid-Atlantic Region

The MAFMC along with NOAA Fisheries manages the fisheries in federal waters offshore of Delaware, Maryland, New Jersey, New York, and Virginia. There are seven fisheries management plans within the MAFMC purview, including spiny dogfish and monkfish fisheries management plans that are co-managed with the NEFMC, as well as mackerel/squid/butterfish, Atlantic bluefish, summer flounder/scup/black sea bass, surfclam and ocean quahog, and golden tilefish. The surfclam and quahog, and golden tilefish fisheries management plans operate under catch share programs which were implemented in 1990 and 2009, respectively (NOAA, 2022a). The state commercial fisheries in the Mid-Atlantic region target most of the same species as the federal fisheries, and several others that are managed by the Atlantic States Marine Fisheries Commission and/or by each individual state, depending on the cross-state nature of the species. Chesapeake Bay is in the Virginia and Maryland state waters of the Mid-Atlantic region.

The primary species for commercial fisheries in the Mid-Atlantic region are American lobster, Atlantic surf clam, blue crab, eastern oyster, menhaden, quahog clams, sea scallop, squid, striped bass, and summer flounder. The main gear types used for commercial harvest include pots, trawl gear, gillnets, longline and other hook and line, purse seine, and dredges (Table III.3).

Table III.3. Summary of species associated with the primary gear types used in the Mid-Atlantic region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots	Blue crab, American lobster, black sea bass, scup, tautog, American eel

Gear type (general)	Target species
Gillnet	Monkfish, dogfish, bluefish, weakfish, menhaden, spot, croaker, striped bass, shark, mackerel, skate, drum, and more
Longline	Groundfish, tilefish, shark, swordfish, bigeye tuna
Purse seine	Atlantic menhaden
Bottom trawl	Monkfish, flounder, hake, dogfish, scup, black sea bass, butterfish, mackerel, squid, and more
Midwater trawl	Mackerel
Dredge	Scallop, surf clam, quahog, whelk, eastern oyster
Other hook & line	Tuna, shark, swordfish, striped bass, mackerel, spotted seatrout, and more

Recreational fishing is popular throughout the Mid-Atlantic region, either from shore, on for-hire vessels, or private vessels. Trips primarily occur from shore and in state waters, and the vast majority of recreational effort is conducted with rod and reel (hook and line) targeting a large variety of finfish. The primary recreational species include Atlantic croaker, black sea bass, bluefish, scup, spot, striped bass, summer flounder, tautog, weakfish, and winter flounder (NOAA, 2022a). Crab, lobster, and other shellfish are targeted recreationally with pots.

South Atlantic Region

The waters off North Carolina, South Carolina, Georgia, and East Florida make up the South Atlantic region, where the South Atlantic Fishery Management Council (SAFMC) manages the federal fisheries in the EEZ. There are eight fishery management plans in the SAFMC: Coastal Migratory Pelagics, Dolphin/Wahoo, Golden Crab, Shrimp, Snapper/Grouper, Spiny Lobster, Sargassum, and Coral/Live Bottom Habitat. The Coastal Pelagic and Spiny Lobster fisheries management plans are jointly managed with the Gulf of Mexico Fishery Management Council. There is one catch share program in the region: the Wreckfish Individual Fishing Quota (a.k.a., Individual Transferable Quota) Program, which was established in 1992 within the Snapper/Grouper complex (NOAA, 2022a). There are 55 species in the Snapper/Grouper complex, which makes it the largest fishery in the region. The state commercial fisheries in the South Atlantic region target many of the same species as the federal fisheries, and several others that are managed by the Atlantic States Marine Fisheries Commission and/or by each individual state.

The primary species harvested by commercial fishers in the Southeast Atlantic region are snappers, groupers, blue crab, oysters, shrimp, flounders, king mackerel, swordfish, and tunas (NOAA, 2022a). The major gear types used for harvest are multiple types of hook and line, pots, bottom trawl, and dredges (Table III.4).

Table III.4. Summary of species associated with the primary gear types used in the South Atlantic region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots	Blue crab, stone crab, spiny lobster, golden crab
Gillnet	Mackerel, little tunny, summer flounder, weakfish, shark, bluefish, pompano, spot, croaker, bonita, cobia, striped bass, striped mullet, and more

Gear type (general)	Target species
Longline	Swordfish, dolphinfish, wahoo, snapper, grouper
Purse seine	Atlantic menhaden
Bottom trawl	Monkfish, flounder, hake, dogfish, scup, black sea bass, butterfish, mackerel, squid, and more
Midwater trawl	Mackerel
Dredge	Eastern oyster
Troll and other hook & line	Snapper, grouper, tuna, mackerel, striped bass, shark, bluefish, striped mullet, and more

Recreational fishing is extremely popular in the South Atlantic region. While most trips occur from shore, approximately one-third of recreational fishing are from vessels. The majority of recreational effort is conducted with rod and reel (hook and line) targeting a large variety of finfish. Pots are also used for shellfish and finfish. The primary recreational species in the region include Atlantic croaker, black sea bass, bluefish, dolphinfish, king mackerel, red drum, sharks, sheepshead, spot, spotted seatrout, Spanish mackerel (NOAA, 2022a). Crab, lobster, and other shellfish are targeted recreationally with pots.

Gulf of Mexico Region

The waters off Alabama, West Florida, Louisiana, Mississippi, and Texas make up the Gulf of Mexico region, where the Gulf of Mexico Fishery Management Council manages with NOAA Fisheries the federal fisheries under seven fisheries management plans. They include coastal migratory pelagic species, red drum, reef fish, shrimp, spiny lobster, and stone crab. The Red Snapper Individual Fishing Quota Program and the Grouper and Tilefish Individual Fishing Quota Program have been in place since 2007 and 2010, respectively (NOAA, 2022a). They are the only two catch share programs in the Gulf of Mexico.

The Reef Fish Fisheries Management Plan covers the management of 31 species of jacks, tilefish, groupers, and snappers. State fisheries in the region include most of the federally managed fisheries. The Interjurisdictional Fisheries Program is a cooperative of state and federal efforts in the Gulf of Mexico to identify management priorities for inshore and nearshore species in the region, such as blue crab, oysters, striped mullet, spotted seatrout, and others (GSMFC, 2008).

The primary species for commercial harvest in the Gulf of Mexico region are blue crab, oysters, spiny lobster, shrimp, tunas, groupers, mullets, red snapper, and menhaden. The gear types used in the region include pots, hook and line, bottom trawl, dredge, purse seine, longline, and gillnets (Table III.5).

Table III.5. Summary of species associated with the primary gear types used in the Gulf of Mexico region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots	Blue crab, stone crab, spiny lobster

Gear type (general)	Target species
Gillnet	Mackerel, spotted seatrout, flounder, drum, sheepshead, weakfish, shark, bluefish, pompano, spot, croaker, bonita, cobia, striped bass, striped mullet, and more
Longline	Tuna, shark, reef fish
Purse seine	Menhaden, sardine
Bottom trawl	Shrimp
Dredge	Eastern oyster
Troll and other hook & line	Reef fish, mackerel, cobia, and more

Like in the South Atlantic, recreational fishing is very popular in the Gulf of Mexico. Popular species targeted by recreational fishers are croaker, drum, red snapper, sheepshead, flounder, Spanish mackerel, seatrout, kingfish, and striped mullet (NOAA, 2022a). Hook-and-line gear is most common in recreational fishing for finfish, while pots are used for crab and lobsters.

Caribbean Region

The waters off Puerto Rico and the USVI make up the Caribbean region where the Caribbean Fishery Management Council (CFMC) is responsible with NOAA Fisheries for the management of fishery resources in the U.S. Caribbean EEZ. Combined, over 300 species of fish and shellfish are managed under four fisheries management plans developed by the CFMC, which include the Reef Fish Fisheries Management Plan, Spiny Lobster Fisheries Management Plan, Queen Conch Fisheries Management Plan, and Corals Fisheries Management Plan. In addition, pelagic fisheries (tunas, billfish, sharks) in the region are managed under the Consolidated Atlantic Highly Migratory Species Fisheries Management Plan.

The fisheries in the Caribbean region are a combination of commercial and subsistence fishing. They utilize mixed gear types off relatively small vessels, and portions of harvest are often taken home for consumption (CFMC, 2014). Fisheries in the coastal waters (0-3 nm from shore) of the USVI are managed by the USVI Department of Planning and Natural Resources, and in Puerto Rico, the Department of Natural and Environmental Resources manages their jurisdiction out to 9 nm from shore.

Highly migratory species are caught with hook-and-line gear, but most of the fishing effort is focused on the resources in the coastal areas. The primary species harvested in the Caribbean region include snappers, spiny lobster, parrotfish, queen conch, groupers, jacks, and wrasses. A variety of fishing methods are used, including pots, longline, other hook and line, diving, gillnets, and seine nets (Table III.6; CFMC, 2014).

Table III.6. Summary of species associated with the primary gear types used in the Caribbean region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots and traps	Spiny lobster, multiple nearshore finfish
Gillnet	Reef fish, scad
Longline	Snapper, shark

Gear type (general)	Target species
Seine net	Baitfish, snapper, other nearshore finfish
Troll and other hook & line	Tuna, mackerel, dolphinfish, reef fish (snapper, grouper, etc.)
Diving	Spiny lobster, queen conch

Recreational fisheries occur in the Caribbean region primarily targeting offshore and inshore reef fish and pelagic species such with hook-and-line gear (CFMC, 2014).

Great Lakes Region

The Great Lakes region includes the U.S. waters of Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake St. Clair, and Lake Ontario. States with jurisdiction to oversee fisheries in the Great Lakes include Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York. There are also three U.S. intertribal agencies that co-manage the natural resources with the states in their historical areas. These groups, along with the Province of Ontario and several other federal agencies that make up the Great Lakes Fishery Commission developed the Joint Strategic Plan for Management of Great Lakes Fisheries. While the day-to-day management of the fisheries is the responsibility of the states and tribes, the strategic plan allows for cross-boundary cooperation in planning, management, and research needs.

The commercial fisheries are generally small-scale in nature, and the regional tribes conduct subsistence harvesting in their treaty areas (GLFC, 2022). In addition, recreational fishing is popular throughout the Great Lakes with hook-and-line gear.

The main species of harvest in the Great Lakes are lake whitefish, yellow perch, cisco, lake trout, white bass, freshwater drum, white perch, and channel catfish. Walleye were once a popular commercial species but is now primarily a recreational species. Commercial harvest of these species is done with stationary trap nets and gillnets (Table III.7).

Table III.7. Summary of species associated with the primary gear types used in the Great Lakes region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Trap nets	Lake whitefish, yellow perch, cisco, white bass, white perch, channel catfish
Gillnet	Lake whitefish, cisco, lake trout

North Pacific (Alaska) Region

The North Pacific region covers the waters off Alaska, the only state within the region. The North Pacific is regularly the leader of all the regions in volume of fish landed (NOAA, 2022f). In federal waters, the North Pacific Fishery Management Council (NPFMC) and NOAA Fisheries manage fish stocks under six fisheries management plans: Bering Sea/Aleutian Islands groundfish, Gulf of Alaska groundfish, Bering Sea/Aleutian Islands king and Tanner crab, Alaska scallop, salmon (in the EEZ), and Arctic char. There are eight catch share programs in the federally managed fisheries, more than in any other region. There is no commercial fishing in the EEZ covering the Arctic north of the Bering Strait (NPFMC, 2022), yet there are remote state managed fisheries, primarily for subsistence, that occur in the nearshore waters of the Arctic (Menard et al., 2017).

In terms of target species and gear types, the state fisheries within 3 nm from shore, are similar to the fisheries in the EEZ. Salmon, crab, and various groundfish are important fisheries, as well as others that are not targeted in the EEZ, such as Dungeness crab, herring, and spot prawn. Subsistence fisheries are very common as they support the economies and cultures of families and communities in Alaska, especially those in remote and rural areas. These fisheries utilize, on a smaller scale, similar gear types seen in the commercial fisheries, such as longlines, gillnets, pots, and other hook-and-line gear (ADFG, n.d. b).

Key species in the fisheries of the North Pacific region include Alaska pollock, Pacific cod, Pacific halibut, salmon, sablefish, rockfish, Pacific herring, king crab, Tanner crab, Atka mackerel, and flatfish. The primary commercial gear types used are bottom trawls, mid-water trawls, gillnets, longlines, pots, purse seines, and troll (Table III.8).

Table III.8. Summary of species associated with the primary gear types used in the North Pacific region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots	King crab, Tanner crab, Pacific cod, sablefish, prawn, shrimp
Gillnet	Salmon, herring
Longline	Pacific halibut, Pacific cod, sablefish, rockfish, lingcod, and more
Purse seine	Salmon, herring
Bottom trawl	Groundfish (cod, flatfish, others), shrimp
Midwater trawl	Alaska pollock
Troll and other hook & line	Salmon, Pacific halibut, Pacific cod, sablefish, rockfish, lingcod, and more

Recreational fisheries occur all along the coastal waters of Alaska. The most popular recreational species are salmon, lingcod, halibut, rockfish, cod, sablefish, Dungeness crab, and spot prawns. Gear is predominantly hook-and-line gear, while the crab and prawn recreational fisheries are dominated by pots.

Pacific (West Coast) Region

The Pacific region includes waters off California, Washington, and Oregon. The federal fisheries in the region are managed by the Pacific Fishery Management Council and NOAA Fisheries under four management plans: Coastal Pelagic Species, Pacific Coast Salmon, Pacific Groundfish, and West Coast Highly Migratory Species. There are two catch share programs in the region: Pacific Coast Sablefish Permit Stacking Program, and Pacific Groundfish Trawl Rationalization Program (NOAA, 2022a).

Several fisheries that are conducted in state waters are managed by state and tribal governments. The Dungeness crab fishery is the most valuable fishery within the state managed fisheries in the Pacific region. The Pacific States Marine Fisheries Commission is in place between California, Oregon, and Washington to address interstate cooperation in management and fishing season adjustments to the Tri-State Dungeness Crab process (PSMFC, 2022). Within state waters there are three specific areas that are distinguished from the waters along the outer coast: Puget Sound (Washington), Columbia River (Washington and Oregon), and San Francisco Bay (California).

Several Native American tribes have treaty rights to half of the harvestable fish and shellfish in their "usual and accustomed" (U&A) areas. Treaty tribes are co-managers, with the states and Federal Government, of the fisheries that occur within their U&A areas (PSMFC, 2022).

Key species in the region include salmon, rockfish, Dungeness crab, Pacific whiting, shrimp and prawns, lobster (California), albacore tuna, flatfish, sablefish (black cod), and squid. The primary commercial gear types used in the region are bottom trawl, mid-water trawl, pots, troll, longline, purse seine, and gillnets (Table III.9).

Table III.9. Summary of species associated with the primary gear types used in the Pacific region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots	Dungeness crab, sablefish, prawn, shrimp, spiny lobster, rock crab, hagfish
Gillnet	Salmon, herring, California halibut, white sea bass, swordfish, shark
Longline	Pacific halibut, sablefish, groundfish, California halibut, white sea bass, yellowtail, swordfish
Purse seine	Coastal pelagic species (squid, sardine, anchovy, mackerel), salmon, tuna
Bottom trawl	Groundfish (rockfish, flatfish, etc.), shrimp
Midwater trawl	Pacific whiting
Troll and other hook & line	Salmon, tuna, shark, dorado, opah, California halibut, white sea bass, rockfish, lingcod, cabezon, and others

Recreational fisheries occur all along the Pacific region. The most popular recreational species are salmon, lingcod, halibut, rockfish, tuna, Dungeness crab, surfperch, mackerel, and shellfish. Gear is predominantly hook-and-line gear, while the crab, lobster, and prawn recreational fisheries are dominated by pots.

Western Pacific Region

The Western Pacific Regional Fishery Management Council (WPRFMC) manages the fisheries of the U.S. Pacific Islands that include Hawai‘i, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and the Pacific Remote Island Areas. In addition, management of the highly migratory pelagic species that cross-national boundaries requires the United States to collaborate with the regional fishery management organizations in the central Pacific: the Western and Central Pacific Fisheries Commission, and the Inter-American Tropical Tuna Commission. NOAA Fisheries follows catch limit recommendations and requirements for fishing operations targeting these species. There are five Fishery Ecosystem Plans (FEP) in the region, which are place-based rather than species-based. They are the American Samoa FEP, Hawai‘i FEP, Mariana Archipelago FEP (Guam and CNMI), Pacific Remote Island Areas FEP, and Western Pacific Pelagics FEP. In each area, NOAA Fisheries collaborates with the local government agencies to manage the FEP (NOAA, 2022b).

The offshore fisheries target pelagic species and deep-water bottomfish with a variety of hook-and-line gear including longlines, troll, handline, and pole and line. Similar types of gear are used in the nearshore waters, as are other gear types like gillnets, cast nets, pots, diving and spearfishing. In Hawaiʻi and American Samoa, the nearshore fisheries target a variety of species and are a combination of commercial, non-commercial, and subsistence (WPRFMC, 2021b). Moored FADs are deployed around the main Hawaiian Islands and used in conjunction with other gear types. Some key species for commercial fisheries in the Western Pacific region are tunas, swordfish, dolphinfish, marlin, opah, snappers, scad, and lobsters (Table III.10).

Table III.10. Summary of species associated with the primary gear types used in the Western Pacific region. Species include target species and others commonly captured by gear type; does not include all species captured.

Gear type (general)	Target species
Pots	Shrimp, crab, lobster, various finfish
Gillnet	Reef fish, scad
Longline	Tuna, swordfish, nearshore fish (snapper, jack, etc.)
Troll and other hook & line	Tuna, dolphinfish, ono, marlin, swordfish
Purse seine	Tuna
FADs	Tuna

High Seas

The U.S. high seas fleet operates in international waters of the Pacific and Atlantic Oceans under the purview of NOAA Fisheries with guidance from multiple regional fishery management organizations. The high seas fleet operating in the Atlantic, under the Consolidated Atlantic Highly Migratory Species Fisheries Management Plan, primarily use pelagic longline gear to target swordfish and bigeye tuna in international waters adjacent to the EEZ (NOAA Fisheries, 2022c). Similarly, the high seas fisheries in the Pacific are essentially an extension of the Pacific Highly Migratory Species fleet off the U.S. West Coast, where they extend effort outside the EEZ. The Pacific fleet targets tunas, billfish, sharks, and other pelagic species with longlines, gillnets, handline, pole and line, troll, and purse seine (NOAA Fisheries, 2022c). The high seas fleet in the South Pacific targets albacore tuna with troll, handline, pole and line, and longline gear in international waters outside any EEZs (NOAA Fisheries, 2022c).

In the Western Pacific, the high seas fleet includes an extension of the Hawaiʻi Deep Set and Shallow Set longline fisheries, while troll, handline, pole and line are also used. The fleet operates in and out of the EEZ, targeting a variety of tunas, billfish, sharks, and other pelagic species (NOAA Fisheries, 2022c).

The U.S. tuna purse seine fleet in the Western and Central Pacific, operating out of American Samoa, fish within the EEZs of 16 Pacific Island countries that are party to the South Pacific Tuna Treaty, targeting skipjack and yellowfin tunas. When and where it is allowed, the fleet utilizes drifting FADs to increase efficiency in harvest.

Table III.11. Summary of species associated with the primary gear types used on the high seas. Species include target species and others commonly captured by gear type; does not include all species captured.

High seas region	Gear type (general)	Target species
Atlantic	Longline	Swordfish, bigeye tuna
Pacific	Longline, hook & line, troll	Tuna, swordfish, shark, and more
Pacific	Purse seine	Tuna
Western Pacific	Longline, hook & line, troll	Tuna, billfish, shark, and more
Western/Central Pacific	Purse seine & FADs	Skipjack and yellowfin tuna
South Pacific	Longline, hook & line, troll	Albacore tuna

Gear Loss Rates [§ 135 (1)(A)(i-iii)]

Gear loss rates in this section are presented by regions. They are derived from available unpublished data from the NOAA Observer Programs as well as published data from other sources. Because the NOAA Observer Programs combine some of the regional fisheries, this section on gear loss rates is organized using these combined regions.

Annual loss rates of U.S. pot fisheries reported here range from <0.1% to 26% of total pots within a fishery, with the highest loss rates in the blue crab and lobster fisheries. The average loss rate for pot fisheries across all fishery management regions in the United States is 13%. Annual loss rates for U.S. gillnet fisheries ranged from 0.03% to 3%. Annual loss rates for U.S. longline fisheries, in terms of hooks lost per hook set, ranged from 0.01% to 0.55% loss of total hooks set. Annual loss rates for U.S. trawl fisheries, reported as percent of trawl hauls experiencing loss events, ranged from 0.0% to 3.65%.

Data Sources and Limitations

Understanding the rate of fishing gear loss is an important step in determining the scale of harm caused by ALDFG in a fishery. Unfortunately, gear loss recordkeeping is rarely required and fishers often do not voluntarily report gear loss. Even when gear loss reporting is required, not all lost gear is reported (Drinkwin et al., 2022). Without empirical reports of gear loss through reporting systems, logbook records, observer coverage, or other means, it is challenging to estimate the amount of gear loss. Peer-to-peer collaboration addressing the problems of ALDFG with fishers is often an effective way to gain insight into loss rates, and fisher surveys can be more effective when such relationships are in place.

Historical Context of Gear Loss

Natural Resources Consultants (NRC) conducted one of the first comprehensive assessments of lost fishing gear in the United States in 1990, estimating gear loss rates in major U.S. marine fisheries including fisheries in the Great Lakes region. However, fisheries management strategies have changed dramatically in some fisheries in the United States since 1990. Some fisheries have progressed from a derby-style approach, where seasons are opened and fishers compete for their catch until the fleet-wide allowable catch is achieved, to a more measured approach. These changes occurred for many reasons including increased efficiencies and safety within a fleet;

fleet and effort compression in response to conservation issues around overharvesting; and bycatch concerns (Birkenbach et al., 2017). In many fisheries, this has resulted in fewer vessels and less gear operating in certain fishing areas (Citta et al., 2013). Because of these and other changes since 1990 (e.g., fishing gear design and better technology for weather forecasting, navigation, and widespread use of GPS), strict reliance on the fishing gear loss rates estimated in NRC (1990) is not appropriate.

Methods for Calculating Gear Loss Rates

The purpose of this section is to evaluate all available information to estimate the rate of gear loss within the different fisheries across the waters of the United States and its territories, and to estimate the total amount of fishing gear, by gear type, that is lost each year. Where published gear loss rates were not available or outdated, the rates were calculated specifically for this report using data from the federal fisheries observer programs, state fisheries data, and data from fisheries managers, researchers, and NGOs active in ALDFG management. Gear loss rates are presented as either a percentage of gear lost per year, percentage of fishing trips with gear loss events, or percentage of hauls with a gear loss event. Total amounts of gear loss annually in a fishery are estimated using the gear loss rates and data on the total amount of gear used, or fishing effort, in a fishery. The methods for developing annual gear loss rates and estimates for amount of gear lost per year are described here.

Observer data for gear loss and ALDFG encounters were requested from each of the five NOAA Observer Programs for the years 2011-2020. Data requests were developed based on information provided by each observer program lead. Issues related to Magnuson-Stevens Act confidentiality requirements and differences in data collection methods between regions were considered, and requests were developed to be as consistent as possible across all regions.

The five regional fisheries observer programs in the United States overlap with the jurisdiction of the fishery management councils: Greater Atlantic (New England and Mid-Atlantic regions), Southeast (South Atlantic, Gulf of Mexico, and Caribbean regions), Northwest (Washington, Oregon, and Northern California), West Coast (primarily California), North Pacific (Alaska) and Pacific Islands (Western Pacific region). There are no federally observed fisheries in the Great Lakes region. Federal fishery observers collect catch and bycatch data during commercial fishing trips to support science, conservation, and management under the authority of the Magnuson-Stevens Act. Data collection in most programs includes a record of fishing gear loss and, in fewer programs, a record of ALDFG encountered during active fishing. How those data are recorded is not consistent in all programs. Not all federal fisheries include observer programs, and the level of observer coverage varies between fisheries and gear types. Some fisheries have observer coverage on 100% of fishing trips while other fisheries may have observer coverage on 2% of trips.

Fishery observer data were received from the NOAA Greater Atlantic, South Atlantic, North Pacific, Northwest, and Pacific Islands Observer Programs. Data were not available from the West Coast (California) program due to confidentiality issues related to the relatively small number of fishery participants in observed fisheries.

The available observer gear loss data varied between programs. Therefore, many of the estimated gear loss rates developed from the observer data are reported as a percentage of hauls with gear loss events, where gear lost could be an entire gear unit or just pieces of a gear unit. For example, in the North Pacific groundfish pot fishery, if gear was lost during a haul (which could include multiple pots/haul), it was recorded as a "haul with lost gear," but the actual number of pots lost in that haul was not recorded. To demonstrate year-to-year variability in gear loss events and rates within any given fishery, the loss rates developed through analysis of NOAA Observer Program data and other agency datasets are presented with 95% confidence intervals (CIs).

The equation for estimating annual gear loss rate is:

$$\textit{Annual gear loss rate} = \textit{observed gear lost} \div \textit{observed unit effort} \quad (1)$$

For example, if an observer monitored 6,000 hooks hauled in a year, and 42 of the hooks were lost, the calculated annual loss rate is 42 ÷ 6,000 = 0.7% hooks lost per hooks hauled.

When using gear loss rates to determine the amount of gear lost annually within a fishery, there needs to be at least a general understanding of fishing effort (amount of gear used) within that fishery. Fishing effort-related datasets such as vessel trip reporting, dealer databases, fish ticket databases, and logbook databases were acquired from NOAA Fisheries and state agencies to quantify fishing effort per gear type per region.

Availability and level of detail of fishing effort statistics varies widely between fisheries. In some fisheries, the only available information is pounds of fish landed, whereas others can include number of active vessels, trips, hauls, hours fishing, and more. In addition, there are many multi-gear and multispecies fisheries, and determining effort between gear types within a fishery is sometimes challenging. Conversely, the same gear types may be used in different fisheries within the same regions. This requires first isolating the gear type, and to the extent possible, isolating the fishery. However, in some cases the loss rates for a particular gear type in a particular region may cover multiple fisheries.

Expanding gear loss rates into estimates of annual loss events or number of gear items lost per year was done using two methods. In the first method, loss rates for a single gear type or gear group within a fishery with a known percentage of observer coverage were expanded simply by using the percent of observed effort covered as a multiplier to estimate the amount of annual gear loss throughout the fishery (Equation 2).

$$\textit{Annual number of gear items lost} = \textit{observed gear lost} \div \textit{percent observer coverage} \quad (2)$$

For example, if 42 hooks were lost, and the observer coverage was 8%, the total hooks lost per year would be 42 ÷ 8% = 525 hooks lost per year.

The second method was used for cases where the percent of observer coverage was not available. In this case, the loss rates were expanded by an estimated annual amount of effort (e.g., trips, sets, hauls, landings) as shown in Equation 3.

$$\textit{Annual number of gear items lost} = \textit{observed gear lost per unit effort} \times \textit{total annual effort} \quad (3)$$

For example, if observer coverage of an unknown percent of fishing effort was 6,000 hooks hauled and 42 hooks lost, and the fleetwide effort was 75,000 hooks hauled, the calculation using Equation 3 would be 42 ÷ 6000 = 0.7% × 75,000 = 525 hooks lost per year.

To provide an understanding of year-to-year variability, loss rates calculated as part of this study include 95% CIs. The number of gear items lost per gear type annually are also presented with the ±95% CIs. Where interannual variability is high, the range between the low and high 95% CI is correspondingly high. When the data are consistent, the range between the low and high 95% CI is lower.

Published gear loss rates, calculated gear loss rates, and observed gear loss rates are summarized for each region below.

Greater Atlantic (New England and Mid-Atlantic Regions)

Most available information about ALDFG in the New England and Mid-Atlantic regions, including state waters, are from the American lobster and the blue crab pot fisheries. Published information was compiled and information was collected through communications with stakeholders involved in fisheries management and ALDFG related projects. In New England loss rates were available for the Gulf of Maine commercial lobster pot fishery, and for the Massachusetts state commercial and recreational lobster pot fisheries. In the Mid-Atlantic region, estimates of gear loss rates were available for area-specific blue crab pot fisheries, such as Chesapeake Bay in Virginia and Maryland, Mullica River – Great Bay Estuary in New Jersey, and inland waters of Delaware (Table III.12).

Calculated loss rates were developed for the federally managed fisheries through analysis of data provided by the NOAA Northeast Fisheries Observer Program using methods described previously.

The results from the review of existing ALDFG loss rate estimates and recently estimated annual loss rates from NOAA Fisheries Observer Program data and other fisheries monitoring sources are presented in Table III.12. They are presented by region, fishery or fisheries, gear type, and loss rate measurement (e.g., percent of all gear in fishery, lost trap per hauled trap, and others). The sources of loss rates are also presented.

Table III.12. Documented and estimated annual gear loss rates by fishery and gear type in the New England and Mid-Atlantic regions, including the NOAA Greater Atlantic Fishery Observer Program. *Denotes gear loss rates and amounts calculated from NOAA Observer Program data and other sources. Numbers in parentheses denote low and high estimates based on ±95% CIs.

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Gulf of Maine lobster	Pots	5%	% of total licensed pots	175,000	Pots and hardware	GOMLF, 2022
Massachusetts lobster – commercial	Pots	5%	% of pots fished per year	16,250	Pots and hardware	MADMF, 2012; Whitmore et al., 2019
Massachusetts lobster – recreational	Pots	26%	% of pots fished per year	4,928	Pots and hardware	Whitmore et al., 2019

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Delaware blue crab – recreational	Pots	12–14%	% of pots used	Not known	Pots and hardware	Delaware Sea Grant, 2022
New Jersey blue crab – commercial	Pots	20%	% of pots used	>400 per year in Mullica River-Great Bay Estuary	Pots and hardware	Sullivan et al., 2019
Chesapeake Bay blue crab	Pots	12–20%	% of pots used	>100,000	Pots and hardware	Bilkovic et al., 2016; DelBene et al., 2021; Havens et al., 2008
Offshore lobster	Pots	1.55%* (0–23.24%)	% of gear hauls with loss event	1,905* (0–28,516)	Pots and hardware	NOAA NEFOP, 2022
Deep-sea red crab	Pots	0% recorded in hauls observed*		–	Pots and hardware	NOAA NEFOP, 2022
Hagfish, conch/ whelk, black sea bass	Pots	0% recorded in hauls observed*		–	Pots and hardware	NOAA NEFOP, 2022
Monkfish, winter skate, Atlantic cod, summer flounder, spiny dogfish, and more	Gillnet (fixed-sink)	0.24%* (0.11–0.36%)	% of gear hauls with loss event	125* (104–146)	Portion or all of gillnet	NOAA NEFOP, 2022
Pollock, hake, other groundfish, and more	Gillnet (drift)	0% recorded in hauls observed*		–		NOAA NEFOP, 2022
Tilefish, groundfish, spiny dogfish, summer flounder, and more	Longline	3.32%* (0.54–6.10%)	% of hooks lost per hooks set	100,041* (16,146–183,937)	Hooks and associated line	NOAA NEFOP, 2022
Herring	Purse Seine	0% recorded in hauls observed*		–		NOAA NEFOP, 2022
Groundfish, summer flounder, black sea bass, squid, scup, and more	Otter Trawl	0.85%* (0.27–1.43%)	% of gear hauls with loss event	1,192* (374–2,011)	Portion or all of trawl gear	NOAA NEFOP, 2022
Herring, mackerel	Pair Trawl	3.65%* (1.09–6.22%)	% of gear hauls with loss event	68* (20–115)	Portion or all of trawl gear	NOAA NEFOP, 2022
Squid	Twin Trawl	1.26%* (0–2.66%)	% of gear hauls with loss event	59* (0–125)	Portion or all of trawl gear	NOAA NEFOP, 2022
Sea scallop	Bottom Trawl	2.88%* (0–6.51%)	% of gear hauls with loss event	62* (0–141)	Portion or all of trawl gear	NOAA NEFOP, 2022
Sea scallop	Dredge	1.48%* (0.46–2.51%)	% of gear hauls with loss event	5,325* (1,648–9,002)	Ring bag	NOAA NEFOP, 2022
Sea scallop	Dredge	0.09%* (0.05–0.13%)	% of gear hauls with loss event	322* (116–478)	Scallop dredge	NOAA NEFOP, 2022

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Ocean quahog and surf clam	Dredge	0% recorded in hauls observed*		–		NOAA NEFOP, 2022

Published Loss Rates

American lobster fisheries are synonymous with the New England region, and while several state managed fleets participate in the fishery, the Maine lobster fleet accounts for approximately 80% of total U.S. landings, with another 10% landed in Massachusetts. There are over 6,000 permitted lobster fishers in Maine, with a total of over 2.9 million allowable pots (MDMR, 2018). The majority of effort occurs in the coastal state waters in the Gulf of Maine, where reports from industry professionals suggest that approximately 175,000 lobster pots (5%) are lost each year (GOMLF, 2022). In Massachusetts, based on survey responses from 520 commercial lobster fishers, the estimated trap loss rate in the commercial fishery is 1.8%-4.5% of pots fished (MADMF, 2012; Whitmore et al., 2019). Surveys conducted among recreational lobster fishers in Massachusetts showed that recreational fishers lose 1.7 pots per fisher per year, or 26% of the average amount of pots fished (Table III.12); in 2015, there were an estimated 18,954 recreational pots fished in the recreational fishery, which would translate to 4,928 pots lost (Whitmore et al., 2019). In addition, Whitmore, et al. (2019) reports an updated commercial loss rate of 5% or 16,250 pots lost per year from the commercial lobster fishery in Massachusetts (Table III.12).

In the Mid-Atlantic region, most efforts related to ALDFG are centered around blue crab pots, and to a lesser extent lobster pots. In the inland waters of Delaware, not including Delaware Bay, researchers estimate that 12%-14% of the blue crab pots from the recreational fisheries are lost each year, and that on average, about one-quarter of those are not equipped with turtle bycatch reduction devices (Delaware Sea Grant, 2022.). In New Jersey, researchers and industry professionals estimate that 20% of the commercial blue crab pots fished in the Mullica River-Great Bay Estuary are lost each year (Table III.12), equaling over 400 pots lost annually (Sullivan et al., 2019).

There exists a suite of literature on ALDFG, specifically from the blue crab fisheries that occur in both Maryland and Virginia waters, in Chesapeake Bay. The most recent estimates of gear loss rates in the blue crab fisheries were provided in Bilkovic, et al. (2016). Crab pot loss rates were shown to vary between locations throughout the bay, with an overall loss rate reported as 12%-20% of gear used in the fisheries (Table III.12). This includes the waters of Maryland and Virginia, where the annual number of pots lost was estimated to be over 100,000 (Havens et al., 2008), and the estimated number of derelict pots at any given time throughout the bay is 145,000 (Bilkovic et al., 2016).

Calculated Loss Rates

Pots

Federal pot fisheries in New England and the Mid-Atlantic regions have relatively few trips with observers onboard. Therefore, the sample size is low, and the estimated gear loss rate across the pot gear fisheries is uncertain. In just over 18,000 observed hauls, there were 43 events of gear damage in whelk pots and lobster pots that resulted in the observer noting that “greater than 50% of pots are unfishable.” However, this does not necessarily indicate the loss of the gear. Pot loss was recorded by observers in the offshore lobster fishery, where a total of 12 pots were recorded as lost out of 773 observed pot hauls in 2012 through 2019. This equates to a loss rate of 1.55% (95% CI: 0.00%, 23.24%). However, it should be noted that in 2012-2016 and 2019 there were no observed loss of pots. Pot loss only occurred on observed trips in 2017 and 2018, where nine and three pots were lost, respectively (Table III.12). Based on an estimated observer coverage of 0.09%, this translates to 1,905 (95% CI: 0, 28,516) lobster pots lost in the offshore fishery each year.

In the deep-sea red crab fishery, 960 pot hauls were observed in 2018 through 2020. No gear loss was observed during those trips. In addition, no pot loss events were recorded on 47 observed hagfish pot hauls, 75 conch pot hauls, and 41 black sea bass pot hauls (Table III.12). However, this is a relatively small sample size of observed hauls within these fisheries, so the gear loss rate is uncertain. As will be discussed in subsequent sections, there are recorded gear losses from these fisheries in other regions.

Gillnets

Observer records included over 33,000 observed gillnet hauls from 2011 through 2020 (NOAA NEFOP, 2022). Of those hauls, fixed or anchored sink gillnets made up 82% of the observed hauls, while drift sink gillnets accounted for 18%, with <1% of the hauls attributed to anchored floating gillnets and drift floating gillnets. Overall, gillnet loss occurred in 0.193% of hauls observed, yet they all occurred in the fixed or anchored sink gillnets, at a gear specific rate of 0.24% (95% CI: 0.11%, 0.36%) (Table III.12). Gillnet loss events as reported here are assumed to be some portion, or all of a 300-foot-long net including other components such as leadline, floatline, lines, buoys, and anchors. The estimated number of hauls per trip was 4.57 based on observer data summaries, and when applied to the annual number of sink gillnet trips from 2011 through 2020, the estimated number of gillnets lost per year was 125 (95% CI: 104, 146) (Table III.12).

No gear loss was observed in 5,887 drift gillnet hauls. Within the fixed sink gillnet hauls, 49% were identified as hauls targeting monkfish, and those accounted for 73.4% of the gillnet loss. Winter skate targeted hauls accounted for 10% of the fixed sink gillnet hauls and 21.9% of the gillnet loss, and hauls targeting Atlantic cod made up 5.6% of the hauls and 4.7% of the gillnet loss. The remaining 35% of the hauls were primarily targeting pollock and other groundfish, dogfish, and flounders, none of which experienced net loss during hauls covered by observers. By target species, fixed sink or anchored gillnet loss rates were 0.353% on monkfish hauls, 0.501% on winter skate hauls, and 0.194% on Atlantic cod hauls. These were recorded as nets lost from nets hauled.

Bottom Longlines

The NOAA Northeast Observer Program covered 612 longline fishing trips over the course of the 2011-2020 period, during which 2,753 hooks were lost out of 82,973 observed hook hauls, for a loss rate of 3.32% (95% CI: 0.54%, 6.10%), with high variability between years. Vessel trip recording data showed an average of 1,750 hooks hauled per trip, and an average of 1,723 trips per year (NOAA GARFO, 2022). This equates to over 3.0 million hooks hauled per year, with an average annual loss rate of 100,041 (95% CI: 16,146, 183,937) hooks and associated hardware such as gangions (Table III.12).

Otter Trawls

During the years 2011 through 2020, NOAA observers were on 13,368 otter trawl trips and observed over 96,000 hauls. Gear condition entries from observers on those trips recorded "Major hang up or tear up, loss of gear" on 817 of all hauls observed, which equates to a gear loss rate of 0.85% (95% CI: 0.27%, 1.43%), equating to 1,192 (95% CI: 374, 2,011) loss events per year (Table III.12). In addition, observer records citing "Tear up exceeding gear condition code 2, but not total net destruction" appeared 529 times during the same time period. Assuming these entries reflect the likelihood of some portion of the gear becoming lost, that raises the loss occurrence rate per haul to 1.40%, suggesting that the reported gear loss amount is a low estimate.

Over that same period, observers were on 865 pair trawl trips, covering 1,861 hauls, of which 67 hauls had a major hang up with loss of gear, and one haul had a less extreme tear up. This equates to a gear loss or damage event occurring during 3.65% (95% CI: 1.09%, 6.22%) of pair trawl hauls, with an estimated number of loss events per year of 68 (95% CI: 20, 115). A total of 1,592 twin trawl hauls were observed on 119 trips from 2011 through 2020, during which 1.26% (95% CI: 0%, 2.66%) hauls experienced major hang up and gear loss, equaling 59 (95% CI: 0, 125) loss events per year. However, it should be noted that all of these events occurred in 2018, with no other observer references to gear loss in any of the other years. Finally, 765 scallop trawl hauls were observed during 145 trips from 2011 through 2019, during which 2.88% (95% CI: 0%, 6.51%) experienced major hang up and loss of gear, equating to 62 (95% CI: 0, 141) loss events per year; these events occurred in 2014 and 2015, with no other gear loss recorded during the other years (Table III.12).

Dredges

The sea scallop dredge fishery was covered by observers on 4,831 trips, with over 177,221 hauls observed from 2011 through 2020. During those trips, the observer noted "one dredge lost or totally damaged" in 0.09% (95% CI: 0.05%, 0.13%) of the observed hauls, equaling 322 (95% CI: 116, 478) lost scallop dredges per year based on the estimated hauls per year in the fishery. In addition, observer comments denoting "ring bag broken or missing" occurred on an additional 2,627 hauls, equating to 1.48% (95% CI: 0.46%, 2.51%) of observed hauls. This equates to the loss of a ring bag occurring 5,325 (95% CI: 1,648, 9,002) times per year (Table III.12). A ring bag is a series of individual iron rings connected to one another to form a bag that collects scallops, they are commonly about 15 feet wide, consisting of around 400 iron rings that are 3.5-4 inches in diameter (NEFMC, 2013; Yochum and Dupaul, 2008).

ALDFG Encountered During Observed Fishing Trips

The NOAA Observer Program included data on the number of hauls that included capture and haul-back of marine debris, categorized as metal, glass, rock, fishing gear, wood, plastic, or unknown. Much of the debris recovered was identified as ALDFG, which provides information about the relative amounts by gear type of ALDFG that is present on the seafloor. This also provides information about the frequency of interactions between ALDFG and active fishing operations.

ALDFG encountered during fishing operations generally reflects what would be expected in terms of gear type, based on Table III.12. From 2011 through 2020, out of 346,675 total gear hauls from multiple gear types, 83,229 (24%) included some type of marine debris, and 16,253 (4.7% of total) included fishing gear-related debris items. In total, 19,430 fishing gear-related debris items were hauled, as some hauls had multiple (Table III.13). Most of the ALDFG items were encountered in scallop dredges and otter trawls. Pot and trap gear accounted for 26.6% of fishing related debris recovered, and of those, 80.4% were lobster pots (Table III.14). Of the 1,035 nets found in hauls, 11.6% were gillnets (Table III.14).

Table III.13. ALDFG and other fishing related marine debris by type recorded in Greater Atlantic fishing hauls during trips with federal fisheries observers onboard, 2011-2020.

Gear type	ALDFG per haul	Total items	Dredge	Float	Line	Net	Pot	Rope	Unknown or misc.
Scallop dredge	5.91%	11,140	181	17	137	344	292	397	9,772
Otter trawl	0.91%	7,691	83	62	186	624	4,670	367	1,699
Gillnet	1.16%	461	3	2	72	51	157	31	145
Clam dredge	1.12%	63	4	3	1	7	10	12	26
Longline	1.86%	48	0	0	8	6	23	6	5
Purse seine	0.06%	16	0	5	0	0	10	1	0
Pot, trap	4.69%	11	0	0	3	3	1	0	4
Total	**5.65%**	**19,430**	**271**	**89**	**407**	**1,035**	**5,163**	**814**	**11,651**

Table III.14. Derelict pots and nets encountered in Greater Atlantic hauls with observers onboard, 2011-2020.

General gear type	Specific gear	Number of hauled items	Percent of total
Pots (n = 5,166)	Lobster pot	4,151	80.35%
	Hagfish pot	474	9.18%
	Pot unidentified	214	4.14%
	Crab pot	163	3.16%
	Fish pot	87	1.68%
	Conch/whelk pot	77	1.49%
Nets (n = 1,035)	Gillnet	599	11.60%
	Trawl net	137	2.65%
	Net unidentified	299	5.79%

Southeast (South Atlantic, Gulf of Mexico, and Caribbean Regions)

Most available information about ALDFG in the South Atlantic, Gulf of Mexico, and Caribbean regions, including state waters, are from the blue crab and spiny lobster pot fisheries. Intense weather patterns associated with tropical storms and hurricanes are one of the primary causes for ALDFG in the South Atlantic, Gulf of Mexico, and Caribbean regions, and their occurrences can cause spikes in loss rates (Uhrin et al., 2014; Arthur et al., 2020). Published information was compiled and information was collected through communications with stakeholders involved in fisheries management and ALDFG related projects. In the South Atlantic, loss rates were available for the North Carolina blue crab pot fishery and the Florida spiny lobster fishery. In the Gulf of Mexico, loss rates were available for the blue crab pot fisheries in each of the regional states, and in the Caribbean, loss rates were available for fish and lobster pot fisheries of the USVI and Puerto Rico (Table III.15).

Calculated loss rates were developed for the federally managed fisheries through analysis of data provided by NOAA Southeast Fisheries Observer Program using methods described previously. The results from the review of existing ALDFG loss rate estimates and recently estimated annual loss rates from NOAA Observer Program data and other fisheries monitoring sources are presented in Table III.15.

Table III.15. Documented and estimated annual gear loss rates by fishery and gear type in the South Atlantic, Gulf of Mexico, and Caribbean regions, including the NOAA Southeast Fisheries Observer Program. *Denotes gear loss rates and amounts calculated from NOAA Observer Program data and other sources. Numbers in parentheses denote low and high estimates based on ±95% CIs.

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
North Carolina blue crab	Pots	17%	% of pots in fishery	170,000	Pots and hardware	Voss et al., 2015
Florida spiny lobster	Pots	18% (non-hurricane yrs); 19–65% (hurricane yrs)	% of pots in fishery	85,230 89,965–307,775	Pots and hardware	Matthews and Uhrin, 2009; Uhrin et al., 2014; FFWCC, 2022b
Blue crab – Texas	Pots	25%	% of pots in fishery	6,786	Pots and hardware	Guillory et al., 2001; Arthur et al., 2020
Blue crab – Louisiana	Pots	25%	% of pots in fishery	188,031	Pots and hardware	Guillory et al., 2001; Arthur et al., 2020; Isaacs, 2020
Blue crab – Mississippi	Pots	25%	% of pots in fishery	5,461	Pots and hardware	Guillory et al., 2001; Arthur et al., 2020
Blue crab – Alabama	Pots	25%	% of pots in fishery	8,453	Pots and hardware	Guillory et al., 2001; Arthur et al., 2020
Blue crab – Florida	Pots	25%	% of pots in fishery	14,029	Pots and hardware	Guillory et al., 2001; Arthur et al., 2020
USVI fish and lobster	Pots	10%	% of pots in fishery	653	Pots and hardware	Clark et al., 2012
Puerto Rico fish and lobster	Pots	10%	% of pots in fishery	10,665	Pots and hardware	Extended rates from USVI; Clark et al., 2012

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Highly migratory species: tunas, dolphinfish, swordfish, mixed pelagic species	Pelagic longline	3.26% (3.05–3.46%)	% hooks lost per hook set	119,519 (167,887–231,150)	Hooks and associated line	NOAA Southeast Fisheries Observer Program
Shrimp	Bottom trawl	0.14%* (0–0.38%)	% trips with loss event	9.6* (0–25.1)	All or part of trawl net	NOAA Southeast Fisheries Observer Program
Gulf of Mexico reef fish	Vertical line (Bandit Gear)	0.71%* (0.09–1.33%)	% trips with loss event	283* (29–536)	Hooks and associated line	NOAA Southeast Fisheries Observer Program
Gulf of Mexico reef fish	Longline	9.54%* (0–22.27%)	% trips with loss event	49,251* (0–115,373)	Hooks and associated line	NOAA Southeast Fisheries Observer Program
South Atlantic snapper-grouper	Vertical line & longline	0.22* (0–0.60)	Loss events per sea day	43,818* (0–100,264)	Hooks and associated line	NOAA Southeast Fisheries Observer Program
South Atlantic-Gulf of Mexico shark	Longline	0.28* (0–0.64)	Loss events per sea day	752* (349–1,155)	Hooks and associated line	NOAA Southeast Fisheries Observer Program
South Atlantic-Gulf of Mexico shark research	Longline	0.10* (0.02–0.13)	Loss events per sea day	256* (72–439)	Hooks and associated line	NOAA Southeast Fisheries Observer Program

Published Loss Rates

Blue crab pots are a major source of ALDFG in the South Atlantic region. In North Carolina, more than 1 million commercial crab pots are used annually, with estimates that 17% of pots in the fishery are lost each year (Voss et al., 2015; NCDMF, 2020). Expansion of these estimates equates to the potential loss of 170,000 pots per year (Table III.15).

There are substantial gillnet fisheries in the nearshore and coastal waters of North Carolina. Gillnets, both active and abandoned, have been documented to entangle sea turtle species listed under the Endangered Species Act (Boyd, 2017). Abandoned gillnet entanglement with other species such as sharks and cobia have also been documented (NCCF, 2018). However, no estimates were found for North Carolina gillnet loss rates.

Similarly, there are substantial commercial and recreational blue crab fisheries in South Carolina, and resource managers suggest the blue crab pots are the most common type of ALDFG in the state. In Georgia and South Carolina, abandoned, lost, and discarded blue crab trap removal projects have occurred (Guillory et al., 2001). However, documentation of ALDFG in the South Carolina blue crab fishery is sparse, and no gear loss rates were found.

Other trap fisheries in the South Atlantic that contribute to ALDFG are the spiny lobster fishery and the stone crab fishery. Matthews et al. (2009) reported that, based on interviews with commercial fishers, gear loss rates range from 10% to 28% during non-hurricane years, and FFWCC (2022a) suggests that on average the loss rate during non-hurricane years is 18% of pots in the fishery. Reports from fishers have suggested that years when hurricanes occur, pot loss rates range from 19% to 65% (Uhrin et al., 2014; FFWCC, 2022b). Based on the reported 473,500 total number of pots in the fishery in 2018 (FKCFA, 2018), these loss rates could equate to an average of 85,230 pots lost per non-hurricane year, and during hurricane years, lobster pot loss could range from 89,965 to 307,775 annually (Table III.15). While there are stone crab trap removal projects coinciding with blue crab and lobster trap removal, estimates of stone crab trap loss rates in the South Atlantic region were unavailable. However, resource managers suggest it is a considerable problem (FFWCC, 2022c).

Lost and abandoned blue crab pots are a concern on both coasts of Florida, as well as in all other Gulf states (Cagle and Isaacs, 2022; FFWCC, 2022c; Guillory et al., 2001; GSMFC, 2008). Blue crab pot loss rates vary greatly depending on fishing areas and seasons. Loss rates spike significantly when hurricanes and storm surges occur; in fact, loss rates can approach 100% after large storms (Cagle and Isaacs, 2022; Guillory et al., 2001).

Based on the variety of factors causing gear loss and highly variable estimates of loss rates, Arthur et al. (2020) suggested a 25% loss rate, as a ratio of pots lost per pot within the fishery, throughout the Gulf of Mexico, as proposed by Guillory et al. (2001). Recent fisher surveys in Louisiana, conducted by Louisiana Department of Wildlife and Fisheries provides some validation of this estimate, as respondents to a survey had an average of 26% pots lost per trap owned (Isaacs, 2020). Arthur et al. (2020) suggests this loss rate for both commercial and recreational fisheries in the Gulf States, although they note that it may be an overestimate of the recreational loss and an underestimate of commercial loss. In all Gulf States combined, based on the 25% loss rate, the estimate of blue crab trap loss throughout the region is 222,671 annually (Arthur et al., 2020; Table III.15).

While the oyster dredge fisheries in the Gulf of Mexico account for 45% of the U.S. total harvest (NOAA Fisheries, 2021c), no information was found regarding the amount of loss that occurs, nor has it been documented as a problematic ALDFG type in the region.

In the fisheries of Puerto Rico and the USVI, tropical storms and hurricanes are a major contributor to ALDFG (Miguel Rolon, CFMC, personal communication). Fish pots, lobster pots, gillnets, and lines used in the commercial and artisanal fisheries are known to become derelict around the islands (Clark et al., 2012; Matthews and Glazer, 2009; Renchen et al., 2014). During a study to assess the impacts of lost, abandoned, and discarded fish traps in the USVI, members of the regional fisher association estimated that 10% of fish traps within the fishery are lost (Clark et al., 2012). From a baseline estimate of 3,899 fish traps and 2,632 lobster pots, this would equate to a loss of 653 pots total in the USVI, assuming fish traps and lobster pots are lost at the same rate (Table III.15).

A 2008 census estimated that there 868 active fishers in Puerto Rico, and the number of fish traps in the fisheries at the time were 4,574 fish traps and 3,842 lobster pots (Matos-Caraballo and Agar, 2008). In 2014 it was estimated that there were 1,000 to 1,200 active fishers in Puerto Rico (CFMC, 2016). Applying the same ratio of pots and traps to fishers from the 2008 census in the USVI, the total number of pots and traps in Puerto Rico is around 10,665. At a 10% loss rate, that equates to 1,067 pots and traps lost per year (Table III.15).

Matthews and Glazer (2009) surveyed fishers, resource managers, and researchers throughout the Caribbean and found that within the trap fisheries, 56.8% of the gear was reported as lost, abandoned, or discarded; in the reef fisheries the reported loss rate was 24.4%, and in the net-based fisheries the loss rate was 79.2%. The overall loss rate was 42.9% for all gear types combined (Matthews and Glazer, 2009).

Calculated Loss Rates

Atlantic Highly Migratory Species – Pelagic Longline

The Atlantic Pelagic Longline Observer Program, as part of the Southeast Fisheries Observer Program, covers the entire Atlantic Consolidated Highly Migratory Species Fishery that includes fisheries throughout the U.S. waters of the Atlantic, as well as international waters, targeting tunas, swordfish, dolphinfish, and other pelagic species. Annual observer coverage ranged from 9% to 13% from 2011 through 2020. Over this timespan, over 220,000 hooks were lost out of nearly 6.7 million hooks set. The average annual loss rate was 3.26% (±95% CI: 3.05%, 3.46%) hooks lost per hooks set. Based on the projected total number of hauls within the fishery, and the average number of hooks hauled per set recorded by observers, the estimated average number of hooks lost per year was 119,519 (±95% CI: 167,887, 231,150) (Table III.15).

Shrimp Trawl

The target observer coverage for the shrimp trawl fisheries is approximately 2%, which equates to approximately 1,500 sea days, with 80% of the observer coverage occurring in the Gulf of Mexico, and 20% in the South Atlantic (Scott-Denton, 2021). In 10 years of observer records covering 1,382 trips, there were two accounts of trawl net loss, one in 2016 and one in 2019 (NOAA SEFSC, 2022). Overall, this equates to trawl net loss per trip of 0.14% (±95% CI: 0, 0.38%), yet with high variability due to the relatively low occurrence rate. The estimated number of gear loss events per year, in terms of all or part of a trawl net, based on expansion of observer coverage was 9.57 (±95% CI: 0, 25.14) (Table III.15).

Gulf of Mexico Reef Fish – Vertical Line and Longline

The Gulf of Mexico Reef Fish Fishery uses bandit gear, a vertical hook-and-line system with multiple hooks on each line, and to a lesser extent longlines. Observer coverage in this fishery ranged from 0.5% to 5.4% between 2011 and 2020, covering approximately 1,485 fishing trips. Gear loss in the bottom longline fishery occurred in 13 trips of 327 observer covered trips, for a rate of 9.54% (±95% CI: 0.0%, 22.27%) trips with loss events, while the observed bandit gear trips experienced gear loss at a rate of 0.71% (±95% CI: 0.09%, 1.33%) trips with loss events. The average number of hooks lost per trip with gear loss in the longline sector was 189 (±95% CI: 78, 300), and 6,728 feet of cable (mainline), and for bandit gear 15.8 (±95% CI: 3.1, 28.5) hooks were lost per trip that experienced loss. When expanded to cover the whole Gulf of Mexico reef fish fishery, these estimates suggest that 49,251(±95% CI: 0, 115,373) hooks and associated lines are lost annually from the longline fleet, and 283 (±95% CI: 29, 536) hooks and associated lines are lost annually from the bandit gear fleet (Table III.15).

South Atlantic Snapper-Grouper – Vertical Line and Longline

The South Atlantic Snapper-Grouper fishery experiences relatively low levels of observer coverage, ranging from 0.02% to 0.32% from 2011 through 2020. Based on the data available, a total of 7 gear loss events occurred over 152 observer covered sea days, for an average loss rate of 0.22 (±95% CI: 0.0, 0.60) loss events per sea day. Based on the observed number of hooks lost per loss event, the total estimated number of hooks lost per year was 43,818 (±95% CI: 0, 100,264) (Table III.15).

South Atlantic and Gulf of Mexico Shark Fisheries – Bottom Longline

The shark fishery in the South Atlantic and Gulf of Mexico primarily uses bottom longlines, with annual observer coverage of 5%. There were 53 loss events over 286 observed sea days, for an annual average of 0.28 (±95% CI: 0.0, 0.64) loss events per sea day. The annual rate of hooks lost per loss event ranged from 4.6 to 25.0 (NOAA SEFSC, 2022). Based on extrapolation of the 5% observer coverage, and the number of hooks lost per loss event, the estimated number of hooks lost annually was 752 (±95% CI: 349, 1,155) (Table III.15).

Separate from the shark fishery is the shark research fishery, which also uses bottom longlines to target sharks. There was 100% observer coverage of the shark research fishery, in which 1,219 sea days were covered from 2011 through 2020, and 131 loss events occurred (NOAA SEFSC, 2022). The annual average loss rate, in terms of loss events per sea day, was 0.10 (±95% CI: 0.08, 0.13), and based on the number of hooks lost per loss event, the number of hooks lost per year was 256 (±95% CI: 72, 439) (Table III.15).

<u>Great Lakes Region</u>

As noted previously, there is less documentation of ALDFG in the Great Lakes region than in the other U.S. fishery regions and no fishery observer program. However, abandoned, lost, and discarded nets, primarily gillnets in the U.S. waters of Lake Superior, have been addressed through partnerships with Wisconsin Sea Grant, Great Lakes Indian Fish and Wildlife Commission, and area fisher associations (Seilheimer et al., 2018). Estimates from members of the partnership suggest that about ≤1% of gillnets used in the commercial and tribal fisheries become lost (Conklin, 2014).

The Great Lakes Enforcement Unit is tasked with enforcement oversight of the state-licensed commercial fishery, and co-oversight of tribal commercial fishing in the 1836 ceded territory. From 2012 through June 2022, the Great Lakes Enforcement Unit has documented the recovery of 25 lost and abandoned gillnets and has overseen the removal of 22 trap nets (Seth Herbst, Michigan DNR Fisheries Division, personal communication). In many cases these nets have shown evidence of having been derelict for several years, even decades, and therefore using this information to estimate annual loss rates was not possible.

<u>North Pacific (Alaska) Region</u>

Most available information about ALDFG in the North Pacific region, including state waters, were from the groundfish and crab fisheries, with gear loss records primarily associated with pot and bottom longline gear. Published information was compiled and information and data were collected through communications with fisheries managers at the NOAA Alaska Fisheries Science Center, ADFG, and the Alaska State Troopers. A review of data from these agencies provided annual gear loss estimates for the Bering Sea Aleutian Islands King and Tanner crab pot fisheries, the Norton Sound Red King crab fishery, the Pacific cod pot fishery, and the Bristol Bay salmon drift gillnet fishery (Table III.16). Fishing gear related debris has been reported encountered in trawl fisheries in Alaska for decades and a research study in 1999 identified this type of debris as "common" in benthic trawls around Kodiak Island (Hess et al., 1999). In Southeast Alaska, the NOAA MDP funded efforts have surveyed and removed Dungeness crab pots in areas around Juneau, Sitka, Petersburg, and Wrangell (Maselko et al., 2013; NRC, 2017b). However, loss rates for Dungeness crab pots in the region were not found.

Calculated loss rates were developed for the federally managed fisheries through analysis of data provided by NOAA North Pacific Observer Program using methods described previously. The results from the review of existing ALDFG loss rate estimates and recently estimated annual loss rates from NOAA Observer Program data and other fisheries monitoring sources are presented in Table III.16.

Table III.16. Documented and estimated annual gear loss rates by fishery and gear type in the North Pacific (Alaska) region, including data from the NOAA North Pacific Observer Program. *Denotes gear loss rates and amounts calculated from NOAA Observer Program data and other sources. Numbers in parentheses denote low and high estimates based on ±95% CIs.

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Bristol Bay salmon	Drift gillnet	0.18%* (0.09–0.27%)	% of active vessels	3 (0–6)	Portion of gillnet	AK State Troopers, 2022
Bristol Bay salmon	Set gillnet	0.18%* (0.09–0.27%)	% of active vessels	0.2 (0–1)	Portion of gillnet	AK State Troopers, 2022
Norton Sound red king crab	Pots	2.28% (1.26–3.31%)	% of gear hauls with loss event	89 (51–127)	Pots and hardware	ADFG, 2022a
Bering Sea and Aleutian Islands king & Tanner crab	Pots	1.32% (1.04–1.60%)	% of pots in fishery	585 (432–738)	Pots and hardware	ADFG, 2022b
Alaska statewide Pacific cod	Pots	0.61% (0.26–0.96%)	% of pots in fishery	383 (164–602)	Pots and hardware	ADFG, 2022b
Halibut	Longline	0.26% (0.22–0.30%)	% of skate lost per skate hauled	246 (184–309)	Skate: 1,800 ft line, 100 hooks & gangions	IPHC Database
Groundfish	Longline	0.36%* (0.31–0.41%)	% of gear hauls with loss event	72 (62–84)	≥1 hooks and associated line	NOAA North Pacific Observer Program Data
Groundfish	Pots	3.53%* (2.94–4.13%)	% of gear hauls with loss event	373 (309–436)	Pots and hardware	NOAA North Pacific Observer Program Data
Groundfish	Bottom & midwater trawl	0.02%* (0.01–0.26%)	% of gear hauls with loss event	7 (4–10)	Portion or all of trawl gear	NOAA North Pacific Observer Program Data

Bristol Bay Salmon – Drift and Set Gillnet

In the Bristol Bay salmon fisheries, reporting requirements are specifically in place to provide accountability for gear loss through reporting and gear marking requirements [5 AAC § 06.331]. Therefore, gear loss is known to exist, yet it is believed to be infrequent, and challenging to quantify. The Alaska State Troopers (2022) provided a list of citations related to 5 AAC § 06.331, which states that permit holders must report loss of gillnet or portion to local department within 15 hours. In total, from 2013 through 2022, there were 31 total incidents of derelict gillnets in Bristol Bay, including 29 drift gillnets, and 2 set gillnets. Based on the total number of active permits per gillnet type in Bristol Bay (Elison et al., 2022), the estimated loss rate for drift gillnets was 0.18% (±95% CI: 0.09%, 0.27%) lost net per active fisher, and 0.03% (±95% CI: 0.00%-0.06%) for set gillnets (Table III.16). Because these rates are estimated from known and identified gear loss events, they do not account for unreported loss events that may have occurred that were not found. Therefore, these rates are likely to be the minimum loss rates.

Norton Sound Red King Crab Pots

Data provided by ADFG showed pot loss from the Norton Sound Red King crab winter commercial and subsistence fisheries for the years 2009 through 2020 show that annual pot loss ranged from a low of 11 during in 2010 to a high of 212 in the 2016 and 2017, with an annual average of 89 (±95% CI: 51, 127) pots lost per year (ADFG, 2022a). Based on the number of pots pulled (hauled) over each season (ADFG, 2018), the estimated average annual loss rate was 2.28% (±95% CI: 1.26%, 3.31%) pots lost per pots pulled (Table III.16).

Bering Sea and Aleutian Islands King and Tanner Crab Pots

Data provided by ADFG showed pot loss from the Bering Sea and Aleutian Islands king and Tanner crab fisheries for the fishing years 2011/12 through 2020/21 show that annual pot loss ranged from a low of 212 during the 2016/17 season to a high of 977 in the 2020/21 season, with an annual average of 585 (±95% CI: 432, 738) pots lost (ADFG, 2022b). The loss rates, calculated as pots lost per pots fished, ranged from 0.58% to 2.06%, with a 10-year average annual loss of 1.32% (±95% CI: 1.04%, 1.60%). Average annual pot loss rates were lowest in the Bristol Bay red king crab fishery (0.4%), and highest in the Bering Sea snow crab (opilio) fishery (3.11%). Sea ice is responsible for at least part of the higher loss rates in the snow crab fishery, as effort in this fishery often occurs near the sea ice, and accounts of massive ice sheets quickly infringing on the fishing grounds have been documented (Citta et al., 2014).

Pacific Cod Pots – State Managed

Data provided by ADFG about pot loss in the state managed Pacific cod pot fleet included total number of pots in the fishery, number of pots reported lost, and number of state-issued buoy tag replacements (ADFG, 2022b). Buoy tag replacements can provide insight into gear loss; however, there are several reasons for buoy tags to become lost other than loss of the fishing gear. In the years and fishery where gear loss was reported, the reported lost pot to pot tag replacement ratio was 0.27. This was applied to the tag replacement numbers for each year that gear loss was not reported, to determine the low-end estimate of pot loss, with the upper estimate being the number of tag replacements. From 2011 through 2020, a total of 602 tag replacements were requested, and with the conversion this suggests that 164 to 602 cod pots were lost over the 10-year period. This equates to 0.26%–0.96% of total pots in the fishery; these were considered the low and high estimates, and the mean representing the estimated annual loss rate of 0.67% of total pots in the fishery (Table III.16).

Alaska Halibut – Bottom Longline

Pacific halibut targeted primarily by bottom set longlines in Alaska are under the jurisdiction of NPFMC in cooperation with IPHC. IPHC requires that gear loss events be recorded in logbook entries so that the halibut mortality associated with gear loss can be estimated (Stewart and Webster, 2021). Gear loss is measured in "effective skate," which equates to 1,800 ft of longline with 100 hooks, each attached by gangion (branchline). In the Alaskan halibut fishery, the number of effective skates lost each year from 2010 through 2019 ranged from 139.2 in 2017 to 403.8 in 2011, with an average loss of 246.3 (±95% CI: 183.7, 308.9) (Table III.16). This equates to an annual average loss of 0.26% (±95% CI: 0.22%, 0.30%) skates lost per skates hauled (IPHC, 2022b).

Groundfish Trawl

The NOAA North Pacific Observer Program provided observer data from the North Pacific groundfish fisheries, including bottom and midwater trawl, fish pots, and bottom longlines (NOAA NPOP, 2022). From 2011 through 2020, observers covered over 367,700 trawl hauls, during which 2,385 were observed to be "net ripped" and 66 had "gear lost." Per season, the highest gear loss rate, in terms of percent of hauls experiencing gear loss, was in 2012 at 0.040%, and the lowest rates were 0.005%, which appeared in 2016, 2018, and 2019. The average annual gear loss rate for trawl gear was 0.020% (±95% CI: 0.01%, 0.26%), and the estimated number of gear loss events per year was 7 (±95% CI: 4, 10) based on percent of observer coverage within the fishery (AFSC, 2014, 2015, 2016, 2017, 2018, 2019, 2021a, 2021b).

Groundfish Pots

Observers covered a total of 26,707 groundfish pot hauls (each haul including multiple pots) in the North Pacific from 2011 through 2020, and pot loss was recorded in 944 of the observed hauls. Annually these numbers ranged from 3.20% in 2017 to 5.70% in 2020, with an average loss rate of 3.53% (±95% CI: 2.94%, 4.13%). Based on percent observer coverage over those years (AFSC, 2014, 2015, 2016, 2017, 2018, 2019, 2021a, 2021b), the estimated number of pot loss events per year was 373 (±95% CI: 309, 436) (Table III.16).

Groundfish Bottom Longline

In the longline fishery, observers covered 166,953 longline hauls over the 2011-2020 period. Longline gear loss events occurred in 600 hauls, yet the amount of gear lost per loss event is unknown. These numbers ranged from a low of 0.193% in 2020 to a high of 0.483% in 2014. The average loss rate, in terms of loss event per gear haul was 0.36% (±95% CI: 0.31%, 0.41%). The number of loss events per year, estimated by the percent of observer coverage (AFSC, 2014, 2015, 2016, 2017, 2018, 2019, 2021a, 2021b), was 72 (±95% CI: 62, 84) (Table III.16).

ALDFG Encountered During Observed Fishing Trips

Other data from the NOAA North Pacific Observer Program include records of 56,193 gear hauls from trawls, longlines, and pots covering the years 2011 through 2020. Records of marine debris encounters in hauls were recorded only for crab pots in hauls. Derelict pots were found in 13,292 hauls (2.49%), the majority of which were encountered during trawl hauls (97%; n = 12,886), and only 406 occurred in longline hauls.

<u>*Pacific (West Coast) Region*</u>

Information about fishing gear loss rates and estimates of numbers of gear items lost per year in the Pacific region were available for several state managed fisheries including Dungeness crab pots in the commercial fisheries of Washington, Oregon, and California, and in the recreational sector of Puget Sound. In addition, in Puget Sound, loss rates were available for drift gillnets from the salmon fishery, and pots from the shrimp fisheries. Fisheries management summaries also provided information about lost gear in the commercial California spiny lobster pot fishery. In the federally managed fisheries, gear loss in the Pacific halibut longline fishery was available from the IPHC database (IPHC, 2022a), and the NOAA West Coast Groundfish Observer Program.

Calculated loss rates were developed for the federally managed fisheries through analysis of data provided by NOAA West Coast Groundfish Observer Program using methods described previously. The results from the review of existing ALDFG loss rate estimates and recently estimated annual loss rates from NOAA Observer Program data and other fisheries monitoring sources are presented in Table III.17.

Table III.17. Documented and estimated annual gear loss rates by fishery and gear type in the Pacific (West Coast) region, including data from the NOAA West Coast Groundfish Observer Program. *Denotes gear loss rates and amounts calculated from NOAA Observer Program data and other sources. Numbers in parentheses denote low and high estimates based on ±95% Cis.

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Washington Coast Dungeness crab – commercial	Pots	10%	% pots in fishery	10,000	Pots and hardware	PFMC, 2013; Ayres, 2022
Oregon Dungeness crab – commercial	Pots	2.78% (2.35–3.21%)	% pots in fishery	3,191 (2,686–3,696)	Pots and hardware	ODFW, 2021; 2022
California Dungeness crab – commercial	Pots	5%	% pots in fishery	6,758 (6,349–7,167)	Pots and hardware	CDFW, 2021
California Spiny lobster – commercial	Pots	13%	% pots in fishery	5,220 (5,144–5,372)	Pots and hardware	CDFW, 2019
Puget Sound Dungeness crab – commercial	Pots	4.70% (3.10–6.33%)	% pots in fishery	1,483 (953–2,103)	Pots and hardware	NRC, 2021
Puget Sound Dungeness crab – Recreational	Pots	0.031	Pots lost per fishing trip	9,299	Pots and hardware	NRC, 2021
Puget Sound Prawn/ shrimp pots – commercial	Pots	<0.1%	% pots in fishery	–	Pots and hardware	Antonelis et al., 2018

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Puget Sound Prawn/ shrimp pots – recreational	Pots	2.33%	% pots in fishery	653	Pots and hardware	Antonelis et al., 2018
Puget Sound salmon	Drift gillnet	3% (2–4%)	% of active fishers	20 (13–26)	Portion of gillnet	Antonelis, 2013; Drinkwin et al., 2023
Halibut	Longline	0.55% (0.41–0.70%)	Skate lost per skate hauled	18.3 (12.1–24.4)	Skate: 1,800 ft line, 100 hooks & gangions	IPHC Database
Groundfish	Pots	0.34%* (0.22–0.46%)	% pots lost per pot haul	232 (150–315)	Pots and hardware	NOAA West Coast Groundfish Observer Program Data
Groundfish	Longline, hook & line	0.45%* (0.35–0.54%)	Hooks lost per hooks set	76,337 (60,079–92,595)	Hooks & misc. gear	NOAA West Coast Groundfish Observer Program Data
Groundfish	Bottom trawl	0.04%* (0.03–0.06%)	Hauls with loss events	2.9 (1.8–4.0)	Portion or all of trawl gear	NOAA West Coast Groundfish Observer Program Data
Groundfish (rockfish)	Bottom & midwater trawl	0.15%* (0.00–0.38%)	Hauls with loss events	2.9 (0.0–7.6)	Portion or all of trawl gear	NOAA West Coast Groundfish Observer Program Data
California halibut	Bottom trawl	0.03%* (0.00–1.03%)	Hauls with loss events	0.5 (0.0–1.0)	Portion or all of trawl gear	NOAA West Coast Groundfish Observer Program Data
Pink shrimp	Shrimp trawl	0.02%* (0.00–0.04%)	Hauls with loss events	4 (0.0–9.5)	Portion or all of trawl gear	NOAA West Coast Groundfish Observer Program Data
Ridgeback prawn	Shrimp trawl	0.16%* (0.00–0.33%)	Hauls with loss events	4.6 (0.0–9.3)	Portion or all of trawl gear	NOAA West Coast Groundfish Observer Program Data
Groundfish	Midwater trawl	0% recorded in hauls observed		0		NOAA West Coast Groundfish Observer Program Data

Published Loss Rates

Dungeness Crab Pots

Historically, Barry (1981) estimated that 20% of the Dungeness crab pots fished in the 1978-1979 coastal Washington state commercial season were lost. More recently, the estimate for Dungeness crab pot loss on the U.S. West Coast is about 10% of pots in the fishery (PFMC, 2013), which equates to approximately 10,000 pots per year in Washington (Table III.17). Resource managers in Washington corroborate the 10% estimate based on feedback from commercial fishers (Ayres, 2022; J. Schumaker, Quinault Indian Nation Resource Manager, personal communication). Permitted, post-season recovery operations off the Washington coast have recovered an average of 560 pots per year since 2009 (Ayres, 2022), and coastal Indian tribes also conduct post-season gear recovery trips (NRC, 2018; NOAA MDP, 2021a; 2022b).

Oregon Dungeness crab fishery has reporting requirements for gear loss, an in-season gear retrieval program, and a post-season gear retrieval program (ODFW, 2021). Based on data summaries reported in ODFW (2021), and associated data provided by the Oregon Department of Fish and Wildlife, the 10-year average annual gear loss rates in the Oregon Dungeness crab fishery, from 2010 through 2019, was 4.60% (±95% CI: 4.13%, 5.06%) of total active pots in the fishery, with an average of 5,314 (±95% CI: 4,778, 5,850) pots lost per year. Since the post-season retrieval program was implemented in the 2013-2014 season, the total number of lost pots from both in-season and post-season retrievals has equaled an average of 1,808 pots retrieved per year (ODFW, 2021; 2022). When incorporating these fishery-based retrievals, the annual loss rate decreases to 2.78% (±95% CI: 2.35%, 3.21%), equating to 3,191 (±95% CI: 2,686, 3,696) pots lost per year.

In 2021, the California Dungeness crab fishery increased their fishing effort and gear loss monitoring through a series of changes within the management plan to address, primarily, the issue of large whale entanglements with fixed gear on the U.S. West Coast (CDFW, 2021). Historically, the number of pots lost per year within the fishery, as estimated by fishers was 5%-10%, which if applied to the approximate amount of gear deployed, would equate to 7,000-14,000 pots lost per year (CDFW, 2021). However, data from the recent self-reporting logbook system suggest that the loss rate may be as low as 1.5%, a number assumed by resource managers to be a low estimate due to compliance issues (i.e., under-reporting) (CDFW, 2021). In addition, replacement pot tag requests of 5,432 and 8,167 during the 2015-2016 and 2017-2018 seasons, respectively, reflect numbers similar to estimated gear loss at 5% of the pots deployed from active fishers per year. Therefore, here the annual California Dungeness crab pot loss rate is reported as 5% of the maximum amount of deployed gear from active vessels over the 5-year period from 2016 through 2020. Based on estimates of the number of active pots per season (CDFW, 2021), the 5% loss rate equates to an average of 6,758 (±95% CI: 6,349-7,167) pots lost per year (Table III.17). As part of the Risk Assessment and Mitigation Program, California Department of Fish and Wildlife (CDFG) expects to quantify annual gear loss with more precision (CDFW, 2021).

California Spiny Lobster Pots

The California spiny lobster fishery has had a 300-trap limit per commercial license since the 2017-2018 fishing season, and since then fishers have been required to report the amount of gear lost per season as part of their license requirements (CDFW, 2019). The data available during the 3-year period from 2017 through 2019 suggest an average loss rate of 12.7% of gear in the fishery, or approximately 38 lost pots per active permit. During that same time period there have been 135-141 active permits, conducting 665,436-808,724 trap pulls per year (CDFW, 2019). Based on these numbers, the estimated average is 5,220 (±95% CI: 5,144-5,372) pots lost per year, at a rate of 0.72% pots lost per trap haul (Table III.17).

Puget Sound Crab and Shrimp Pots

In the U.S. waters of the Salish Sea (Puget Sound), ALDFG from the commercial (state and tribal) and recreational Dungeness crab fisheries has been well documented through recovery efforts and research. Pot loss rates in the commercial fishery were reported as 8.6%, or 3,601 pots lost per year (Antonelis et al., 2011). However, since 2011, changes within the fishery, including what was first self-imposed, but now regulatory pot reduction strategy, the current estimated loss rate in the commercial fleet is 4.7% (±95% CI: 3.10%-6.33%) of pots in the fishery, equaling 1,483 (±95% CI: 953-2,013) pots lost per year (NRC, 2021). In the recreational Dungeness crab fishery, which typically includes around 200,000 license holders, the recent pot loss rate is estimated at 0.031 pots lost per fishing trip, equating to an average of 9,299 pots lost per year (Table III.17). This loss rate represents a slight decrease from the 0.036 pots lost per fishing trip reported in 2011, but the total number of pots lost per year is an 8.2% increase because of increased fishing effort (NRC, 2021).

The shrimp and prawn pot fisheries in Puget Sound also contribute to ALDFG in the region, but to a lesser extent in total numbers than crab pots. Within the commercial sector, gear loss is estimated to be less than 0.1% of pots in the fishery. In the recreational sector, prawn pot loss is estimated to be 2.33% of pots in the fishery, which translates to about 653 pots per year (Antonelis et al., 2018).

Puget Sound Drift Gillnet

Abandoned, lost, and discarded gillnets from the commercial salmon fleet have been a major focus for stakeholders addressing ALDFG in Puget Sound for over two decades, and a great deal of efforts have been made to remove "legacy" gillnets that were mostly deposited in the 1970s through the mid-1990s, when the fishing fleet and fishing effort were much greater than they are today (Drinkwin et al., 2023). It is estimated that 2%-4% of active fishers lose some portion of a gillnet each fishing season, which is 13-26 gillnet portions lost per year (Table III.17) based on the current fleet size (Antonelis, 2013; Drinkwin et al., 2023).

Pacific Halibut Bottom Longline

In the Pacific halibut fishery along the U.S. West Coast, bottom longlines are used. Available IPHC data show that the annual amount of effective skates (1,800 ft of longline with 100 hooks) lost between 2010 and 2019 ranged from a low of 0 in 2019, to a high of 34.6 in 2012, with an average loss of 18.3 (±95% CI: 12.1-24.4) effective skates lost per year, or 0.55% (±95% CI: 0.41%-70%) skates lost per skates hauled (Table III.17).

Calculated Loss Rates

Groundfish Fixed Gear (Pots and Longlines)

Data from the NOAA West Coast Groundfish Observer Program includes data from the West Coast groundfish fixed gear fishery, where three different primary gear types are used: longline, hook-and-line, and pots. The annual average gear loss rate in terms of hooks lost per hooks hauled for longline and hook-and-line gear combined is 0.45% (±95% CI: 0.35%-0.54%), with an estimated annual number of hooks lost of 76,337 (±95% CI: 60,079-92,595) (Table III.17). The groundfish pot fleet experienced gear loss rates, in terms of pots lost per pots hauled, of 0.34% (±95% CI: 0.22%-0.46%) over the years 2011 through 2020, and with an average annual number of loss events equaling 232 (±95% CI: 150-315). It should be noted that these are the overall loss rates for all the different sectors within the fleet, and loss rates vary slightly between the sectors (NOAA WCGOP, 2022).

Trawl Fisheries

The NOAA West Coast Groundfish Observer Program also covers groundfish bottom trawl, midwater trawl, bottom and midwater rockfish trawl, shrimp trawl, and California halibut trawl fisheries, each at varying levels of coverage. During the years 2011 through 2020, there were no observed or reported loss of mid-water trawls from the West Coast fleet, out of 9,328 haul records. For the other trawl fisheries, gear loss events were recorded per haul, but the amount of gear lost was not distinguishable. Therefore, gear loss rates are reported in terms of gear loss events per haul. In a gear loss event, there is an assumption of some portion of gear loss, whether a small section of net and hardware, or an entire net.

Over the 10-year period (2011-2020), the bottom trawl loss rate was 0.04% (±95% CI: 0.03%-0.06%) throughout the West Coast groundfish fishery, for an estimated 2.9 (±95% CI: 1.8-4.0) loss events per year. The annual loss rate was 0.029% (±95% CI: 0.00%-1.03%) in the much smaller California halibut bottom trawl fishery, with an estimated 0.5 (±95% CI: 0.0-1.0) loss events per year (Table III.17). Higher rates of gear loss were observed in the bottom and midwater groundfish fishery, with an annual loss rate of 0.15% (±95% CI: 0.00%-0.38%) hauls with loss events, equating to 2.9 (±95% CI: 0.0-7.6) loss events per year. There are two sectors of the shrimp trawl fisheries: the pink shrimp and the ridgeback prawn. From 2011 through 2020, in 27,871 observed hauls, there were five documented gear loss events, equating to a gear loss rate of 0.02% (±95% CI: 0.0%-0.04%) hauls with loss events, and an estimated 4.1 (±95% CI: 0.0-9.3). The ridgeback prawn fishery off the California coast had one loss event in 622 observed hauls from 2017 through 2020, for a loss rate of 0.16% (±95% CI: 0.00%-0.33%) hauls with loss events, and 4.6 (±95% CI: 0.0-9.3) loss events per year (NOAA WCGOP, 2022).

ALDFG Encountered During Observed Fishing Trips

NOAA West Coast Groundfish Observer Program data included records of ALDFG in hauls from 2011 through 2020, although the specific gear that was snagged was not recorded. Bottom trawls accounted for the vast majority of snagged ALDFG, with 2,787 items captured. ALDFG was captured in 3.68% of the bottom trawl hauls. ALDFG items were considerably lower in other fisheries, including 0.52% of shrimp hauls (147 items), 0.46% of midwater trawls (43 items), 0.38% of hook-and-line hauls (41 items), and 0.11% of pot hauls (15 items). In total, the West Coast observers encountered ALDFG in 2.1% of the hauls, with 3,033 items captured, of which nearly 92% came from bottom trawls.

Western Pacific Region

Information about fishing gear loss rates and estimates of numbers of gear items lost per year in the Western Pacific region is limited for the nearshore fisheries, as most attention related to ALDFG in the region is focused on the overwhelming amount of large-scale fishing gear that is deposited onto the Pacific Islands from elsewhere. NOAA Pacific Islands Region Observer Program provided data from fisheries observer trips that included amount of gear loss during gear loss events, and amount of gear accumulated during observer covered fishing trips.

The results from the review of existing ALDFG loss rate estimates and recently estimated annual loss rates from NOAA Observer Program data and other fisheries monitoring sources are presented in Table III.18.

Table III.18. Documented and annual estimated gear loss rates by fishery and gear type in the Western Pacific region, including data from the NOAA Pacific Islands Region Observer Program. *Denotes gear loss rates and amounts calculated from NOAA Observer Program data and other sources. Numbers in parentheses denote low and high estimates based on ±95% CIs.

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
American Samoa, Hawai'i deep & shallow set	Pelagic longline	0.01%* (0.002–0.018%)	Hooks lost per hooks set	5,714 (916–10,512)	Hooks & monofilament branchline	NOAA Pacific Islands Region Observer Program Data
American Samoa, Hawai'i deep & shallow set	Pelagic longline	0.009%* (0.000–0.017%)	Floats lost per floats set	250 (5–495)	Float	NOAA Pacific Islands Region Observer Program Data
American Samoa, Hawai'i deep & shallow set	Pelagic longline	0.14* (0.00–0.28)	Miles of line per 1 million hooks set	8.5 (0.0–17.0)	Float	NOAA Pacific Islands Region Observer Program Data

Published Loss Rates

There is little documentation of gear loss rates within the domestic fisheries around Hawai‘i, American Samoa, Guam, CNMI, and the Pacific Remote Islands. There are data on the cost per trip of lost fishing gear such as rods, reels, line, and lures from annual summaries of creel surveys in American Samoa. Unfortunately, the specific type and amount of gear lost are not reported. The cost of lost gear in the bottomfish fishery during 2011-2020 ranged from $2.00 to $22.00/trip, representing 2%-15% of total trip costs (WPRFMC, 2021b). The cost of lost gear in the pelagic troll fishery ranged from $2.20 to $11.50/trip, representing 3%-10% of total trip costs (WPRFMC, 2021c). These data confirm gear losses from these fisheries but do not allow for specific quantification of gear loss rates.

Calculated Loss Rates

The NOAA Pacific Islands Region Observer Program includes the Hawai‘i pelagic longline fishery and the American Samoa pelagic longline fishery. Observer coverage of the American Samoa fishery ranged from a high of 33% in 2011 to a low of 2% in 2020, but remained around 20% in the years in between. The Hawai‘i shallow set fishery, targeting swordfish, had 100% observer coverage during the timespan, while the deep set fishery, targeting tunas, consistently had just over 20% coverage from 2011 through 2019, and 15% coverage in 2020 (NOAA PIROP, 2022).

To avoid confidentiality issues, the summary of gear loss events provided by the observer program includes the aggregate of annual gear loss within all three of these fisheries, and therefore gear loss rates reported here reflect the Hawai‘i and American Samoa pelagic longline fisheries as a whole, rather than distinguishable loss rates for each group.

To calculate the total amount of observer coverage in American Samoa and Hawai‘i longline fisheries combined, the total number of hooks set was extracted from the 2020 Annual Stock Assessment Report (WPRFMC, 2021c). The total number of hooks set from the shallow set fisheries were compiled for each year from 2011 through 2020. The number of observed hooks set per year were compared to the aggregated number of hooks set in all three fisheries, to determine the actual percent of observer coverage, which equated to 26%. The observer data reported the observed number of floats set, number of hooks set, number of floats lost, number of branchlines lost (one hook per branchline), and miles of mainline lost. The annual loss rate for hooks set, measured as the percent of branchlines lost per hook set, was 0.0095% (±95% CI: 0.002%-0.018%), and the floats lost per float set loss rate was 0.0087% (±95% CI: 0-0.017%) (Table III.18).

Summary information was not available for observed length of mainline set, nor could it be estimated because the different sectors use different sizes and configurations of gear components. Therefore, the mainline loss rate was calculated as miles lost per 1 million hooks set, and equated to 0.141 miles/1 million hooks set (±95% CI: 0, 0.284%). To estimate the total amount of gear loss per year, the total amount of observed gear loss was applied to total amount of observer coverage over the 10-year period from 2011 through 2020, then the loss rates were applied to the fleetwide effort metrics, floats set and hooks set, to determine the average annual amount of loss per gear component. An estimated 250 (±95% CI: 5, 496) floats, and 5,714 (±95% CI: 916, 10,512) hooks and branchlines are lost each year, as well as 8.46 (±95% CI: 0, 17.0) miles of monofilament mainline (Table III.18).

ALDFG Encountered During Observed Fishing Trips

NOAA has detailed information on ALDFG collected on Hawai‘i longline fishing trips from 2008 through 2021, including the number and weight of specific items captured (Table III.19). Interactions with ALDFG and other plastics occurred on 1,822 longline fishing trips. These data include a subset of interactions reported earlier by Uhrin et al. (2020). On these trips, a total of 2,521 debris items were encountered, weighing approximately 397,808 lbs. Derelict nets accounted for 53.0% of the items, and 40.2% of the total weight. Other gear types included rope, which accounted for 30.0% of the items and 37.7% of the weight, as well as floats, monofilament line, and general plastics (Table III.19).

Table III.19. Summary of derelict fishing gear and plastic debris encountered during longline fishing trips in the Western Pacific region from 2008 through 2021.

Year	Trips	Floats		Monofilament		Nets		Misc. plastics		Rope	
		Count	Weight (lbs)	Count	Weight (lbs)	Count	Weight (lbs)	Count	Weight (lbs)	Count	Weight (lbs)
2008	55	1	5	4	2,222	39	8,935	1	1	22	6,310
2009	223	2	615	8	446	182	23,296	16	8,360	64	19,407
2010	239	16	4,963	80	7,366	177	19,086	16	6,331	92	15,411
2011	198	9	1,037	11	964	141	15,040	27	1,805	101	12,145
2012	95	11	4,380	8	5,300	69	10,577	8	1,855	38	10,079
2013	186	16	2,720	6	2,825	113	8,017	23	2,098	76	18,774

Year	Trips	Floats		Monofilament		Nets		Misc. plastics		Rope	
		Count	Weight (lbs)	Count	Weight (lbs)	Count	Weight (lbs)	Count	Weight (lbs)	Count	Weight (lbs)
2014	199	17	4,463	2	2,300	149	16,180	10	2,077	75	16,050
2015	115	23	3,365	5	240	82	15,097	7	2,251	51	14,226
2016	87	5	610	4	501	69	6,787	4	540	37	6,538
2017	90	6	1,505	5	1,360	68	12,148	3	1,300	43	11,044
2018	111	11	2,448	8	1,645	78	9,220	7	532	60	8,212
2019	99	14	4,393	2	60	74	8,872	4	1,860	47	6,837
2020	64	7	1,525	4	1,100	54	4,774	5	55	25	3,498
2021	57	8	320	2	5	40	1,793	2	8	24	1,502
Total	**1,818**	**146**	**32,379**	**149**	**26,334**	**1335**	**159,824**	**133**	**29,073**	**755**	**150,061**

Foreign Fishing Gear Affecting the United States and Its Territories

Foreign fishing gear ALDFG accumulating on shorelines and in nearshore areas of the United States and its territories includes trawl gear, nets, lines, and FADs (Manville, 1990; Merrell, 1980; Ribic et al., 2012b; Royer et al., 2023). While source fisheries associated with this foreign ALDFG are for the most part unknown, potential sources for accumulations of ALDFG in the North Pacific and Western Pacific regions, based on ocean circulation patterns, are trawl, longline, and net fisheries within the Asia-Pacific region, including U.S. fisheries (Lebreton et al., 2022). Possible source fisheries for FADs found in the South Atlantic, Gulf of Mexico, and Caribbean region are tuna fisheries operating off of the west coast of Africa (Imzilen et al., 2021).

While there are no published loss rates for most of these potential source fisheries, there are estimates for some. An estimated 70.6% of the 30,000 to 40,000 drifting FADs deployed in the Western and Central Pacific Ocean either were documented to have been abandoned, drifted onto beaches, or intentionally deactivated (Escalle et al., 2020a, 2020b). A portion of those beached FADs are known to beach in U.S. territories and Hawai‘i (Escalle et al., 2020a).

A loss rate of 62.5% for FADs deployed from the French fleet in the Atlantic Ocean was estimated from 2012 through 2018. This loss rate includes FADs that drifted out of permitted fishing grounds and FADs that beached (Imzilen et al., 2022). In addition, Kim et al. (2014) estimated that 38,535 tons of gillnet is lost annually from South Korean gillnet fisheries (Table III.20).

Table III.20. Documented and estimated gear loss rates by fishery and gear type from foreign fisheries.

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Pacific high seas tuna	Drifting FAD	70.6%	FADs deployed in West/ Central Pacific Ocean	21,180–28,240	FAD	Escalle et al., 2020a, 2020b
French Atlantic tuna	Drifting FAD	62.5%	FADs deployed 2012–2018	1,180	FAD	Imzilen et al., 2022

Fishery	Gear type	Loss rate	Metric	Annual quantity lost	Unit	Reference
Western Pacific fish	Gillnets			38,535	Ton	Kim et al., 2014

Richardson et al. (2017) analyzed pollution incidents reported by fisheries observers employed by the Secretariat of the Pacific Community/Pacific Islands Forum Fisheries Agency between 2003 and 2015. They identified the numbers of incidents involving discards of fishing gear and reported this information by fishery (purse seine, longline, pole and line), by flag of vessels, and by location of the incidents. This purse seine fishery included 100% observer coverage. Approximately 13% of the 10,613 pollution incidents recorded from purse seine vessels consisted of ALDFG. The percentage of pollution incidents by country of flag included Papua New Guinea (18%), Taiwan (16%), USA (15%), Korea (12%), Philippines (10%), Japan (10%), and China (8%).

The longline fishery included 5% observer coverage. Approximately 17% of 214 pollution incidents recorded from longline vessels consisted of ALDFG. The percentage of pollution incidents by country of flag included Fiji (21%), China (19%), Korea (15%), Vanuatu (13%), Tonga (11%), Taiwan (8%) and Federated States of Micronesia (4%; Richardson et al., 2017).

Amount of Annual Fishing Gear Loss [§ 135 (1)(A)(i-iii)]

Based on the gear loss estimates and estimated number of gear items lost per year presented in Tables III.12-19, the total number of gear loss events and total amount of gear lost per year throughout the U.S. marine waters and Great Lakes were estimated. Because some gear loss reporting does not note the amount of gear lost per loss event, or which specific gear components were lost out of the suite of components that make a gear item, the estimates reported here assume the minimum amount of gear is lost.

Two different longline fisheries provide a good example of this data discrepancy. In the North Pacific groundfish longline fishery, the available information allowed only an estimate of the number of gear loss events per gear haul but did not specify between the loss of one hook, versus the loss of an entire longline string and/or the associated buoys, anchors, and other hardware (NOAA NPOP, 2022). On the other hand, in the Western Pacific region, longline gear loss events were quantified by number of branchlines (with hooks), number of floats, and miles of mainline lost (NOAA PIROP, 2022).

In the gillnet gear category, there were three gillnet loss rates from three different fisheries: New England and Mid-Atlantic sink gillnets, Puget Sound salmon drift gillnets, and Bristol Bay drift gillnets. Linear length of gillnet loss was applied to gear loss events based on information available from either gear loss events, or the common size of gillnet used in the fishery. Data from gear recovery efforts in Puget Sound show that the average size of derelict gillnet removed is approximately 200 feet in length (Northwest Straits Initiative, 2022). Citations of lost gillnet reports in Bristol Bay showed that the average size of lost pieces of drift gillnets were 300 feet in length, and set gillnets were 200 feet in length (Alaska State Troopers, 2022). In the New England and Mid-Atlantic sink gillnet fishery, the industry standard size of one gillnet is 300 feet in length. These values were applied to each of the respective gillnet types to provide a rough estimate of the amount of gillnet lost.

Using available data from U.S. pot fisheries, an estimated 826,057 pots and hardware are lost each year. An estimated 43,060 ft of gillnet are lost each year. For hook-and-line fisheries (including longlines), three estimates were developed. An estimated 250 floats are lost each year from pelagic longline sets. An estimated 502,503 hooks and unknown length of associated line are lost each year. And 8 miles of monofilament line is lost each year. From dredge fisheries, an estimated 322 portions or complete scallop dredges are lost each year and 5,325 ring bags from scallop dredges are lost each year. Finally, an estimated 1,413 portions or whole trawl nets are lost each year.

Table III.21 provides a summary of the estimated minimum amount of gear loss in U.S. fisheries each year, based on available data summarized in this report.

Table III.21. Estimated minimum amount of gear loss in U.S. fisheries each year.

Gear type & components	Number of loss events	Amount of gear lost	Unit of measurement
Pots	826,057	826,057	Pots and hardware
Gillnet	148	43,060	Linear feet of gillnet
Float	250	250	Floats from pelagic longline set
Hook & line	476,308	502,503	Hooks and unknown lengths of associated line
Line	8	8	Miles of monofilament line
Dredge ring bag	5,325	5,325	Ring bags from scallop dredge
Dredge	322	322	Some portion or all of a complete scallop dredge
Trawl	1,413	1,413	Some portion or all of a complete trawl net

Comparison of Gear Losses Between United States and Foreign Fisheries [§ 135 (1)(A)(iiii)]

Global Gear Loss Rates

Comparing fishing gear loss rates and amounts in U.S. fisheries is possible in a few instances but problematic overall because of the inconsistency of how gear loss data are collected and reported in the United States and other countries. Since 2018, some researchers have attempted to characterize rates of fishing gear loss globally in commercial fisheries, using different methods and metrics. Richardson et al. (2019) estimated that 12% of trawl gear, 5.7% of fishing nets, 19% of pots and traps (not including trap nets), and 29% of fishing lines used globally are lost, abandoned, or discarded annually into the environment. Lively and Good (2018) estimated that 3 to 7 net panels/boat/year or 38,535 tons of nets/region/year and 7%-50% of traps and pots/year were lost. These global estimates can be compared only to the estimates presented in this report for pots and gillnets. Loss data for other gear types are not comparable.

Annual loss rates of United States pot fisheries reported here range from <0.1% to 26% of total pots within a fishery, with the highest loss rates in the blue crab and lobster fisheries. The average loss rate for pot fisheries across all fishery management regions in the United States is 13%. These ranges are lower than the estimated annual loss in global pot fisheries reported in

Lively and Good (2018) and Richardson et al. (2019). The U.S. pot fisheries with lower loss rates include groundfish and crab fisheries in the North Pacific (Alaska) region, Dungeness crab fisheries in the U.S. portion of the Salish Sea (Pacific region), and American lobster fisheries in the New England region. Pot fisheries in the United States with average loss rates above those reported in Richardson et al. (2019) are West Coast Dungeness crab fisheries in the Pacific region, spiny lobster fishery in the South Atlantic region, Caribbean region multispecies trap fisheries, and blue crab fisheries in the Gulf of Mexico region and Atlantic states.

Annual average gillnet loss rates in three U.S. fisheries can be compared with the estimated global averages. The average annual gillnet loss rates in the Bristol Bay drift and set gillnet fisheries (North Pacific region) and the Puget Sound salmon gillnet fishery (Pacific region) is 1.07%. This is lower than the estimate of total net loss rate in Richardson et al. (2019). The rate cannot be compared to results from Lively and Good (2018). Both the Bristol Bay gillnet fisheries had estimated annual loss rates of 0.18% (AK State Troopers, 2022) while the Puget Sound gillnet fishery had an estimated annual loss rate of 3% (Antonelis, 2013; Drinkwin et al., 2023).

Richardson et al. (2022) also estimated the total amount of fishing gear lost globally each year. Only their reporting of numbers of pots lost is comparable to the data on amount of fishing gear lost from U.S. fisheries presented in this report. Richardson et al. (2022) estimates that 25,382,742 pots and traps are lost globally each year. Using available data from U.S. pot fisheries, an estimated 826,057 pots and hardware are lost each year (Table 11.18). This estimated number of pots lost from U.S. fisheries presented in this report is 3.25% of the total number of pots and traps lost globally estimated by Richardson et al. (2022).

C. ALDFG Transport [§ 135 (1)(A), § 135 (1)(B), § 135 (5)]

ALDFG can be transported (i.e., moved) by meteorological and oceanographic drivers from its source location to other geographic areas. The geomorphology of the shoreline, bathymetry of the seafloor, wind, and ocean currents all influence ALDFG redistribution, dispersal, and accumulation (Chassignet et al., 2021; Haarr et al., 2022; Thushari and Senevirathna, 2020; Williams and Rangel-Buitrago, 2019). Characteristics such as size and buoyancy and the type and density of the plastic components of ALDFG affect its fate and transport in the marine environment (Chandran et al., 2020; Jung et al., 2018). Fishing gear made with floating plastic polymers will travel longer distances on the sea surface, whereas fishing gear made of sinking polymers will persist closer to their source on the seafloor (Jung et al., 2018). In some parts of the United States and its territories, ALDFG is transported by ocean currents long distances and is deposited along shorelines and other sensitive habitats (Ebbesmeyer et al., 2012; McCoy et al., 2022; Royer et al., 2023).

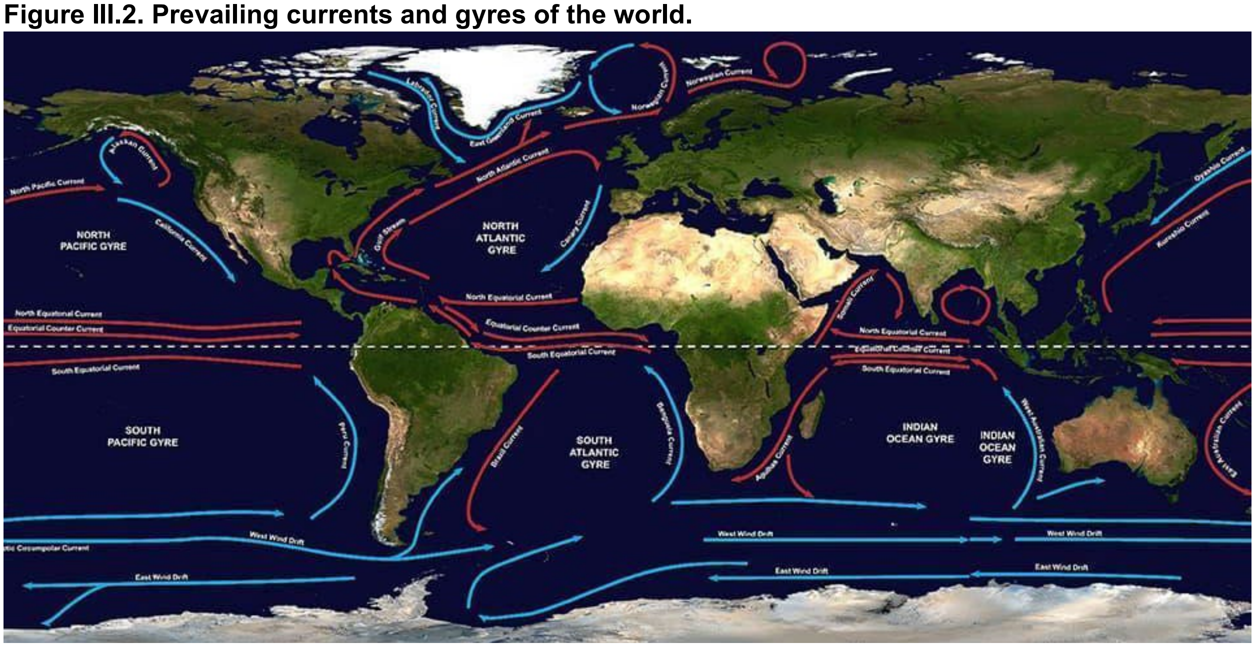
There are five identified gyres, or large systems of rotating ocean currents, in the world's ocean (NOAA NOS, 2021): the North Atlantic Gyre, the South Atlantic Gyre, the North Pacific Gyre, the South Pacific Gyre, and the Indian Ocean Gyre (Figure III.2). The Loop Current and Gulf Stream connect the waters of the Gulf of Mexico and U.S. East Coast to the North Atlantic Gyre. The converging surface currents in these gyres collect plastics such as ALDFG on the ocean surface, preventing many from escaping (Kane et al., 2020). Large mass concentrations of positively buoyant plastic waste, known as "garbage patches," have been reported within the gyres (Egger et al., 2020). Wind and waves also act on surface debris (Laxague et al., 2018).

Understanding the source fishery and location of ALDFG encountered or retrieved is critical to identifying prevention management actions and to anticipating necessary retrieval actions. There are some areas in the United States and its territories that accumulate ALDFG transported from other areas, including from foreign fisheries and from distant domestic fisheries. The Hawaiian Islands, the U.S. Pacific territories and Alaska's Aleutian Islands are located in the path of accumulated ALDFG from all over the Pacific Ocean (Lebreton et al., 2022; McCoy et al., 2022; Royer et al., 2023; Corniuk et al., 2023). The Southeast Atlantic states and even the Gulf of Mexico receive influxes of ALDFG from Africa. And within the Caribbean and Gulf of Mexico, the Loop Current and Gulf Stream operate to move ALDFG into and out of the regions.

Decades-old objects have been documented in the North Pacific Gyre, suggesting that debris may circulate for many years and remain intact (Egger et al., 2020; Ingraham and Ebbesmeyer, 2000). Lebreton et al. (2018) estimate that derelict fishing nets comprise 46% of debris by mass in portions of the North Pacific Gyre commonly referred to as the "Great Pacific Garbage Patch." These nets likely originate from several domestic and international large-scale fisheries in the Asia Pacific region, such as Japanese, Korean, and Taiwanese fleets prior to the high-seas drift net ban adopted by the United Nations General Assembly in 1992 (NOAA, 2015; UN General Assembly, 1991; Uhrin et al., 2020).

The following regional sections identify problem areas for ALDFG transport and accumulation, with a high-level discussion of the ocean currents at work that makes these areas prone to ALDFG accumulation from non-local sources.

Figure III.2. Prevailing currents and gyres of the world.



Source: NOAA NOS, 2021.

New England and Mid-Atlantic Regions

Ocean current transport of marine debris from foreign sources onto the Atlantic seaboard is generally not a significant source of ALDFG. Ribic et al. (2010) found no significant accumulations of foreign ALDFG transported by ocean currents in the New England region and Mid-Atlantic. While studies of sea-based marine debris have shown correlation with ocean currents along the Atlantic Coast, a stronger influence is proximity to fishing activity, suggesting that much of the sea-based marine debris comes from the regional or local fishing sector, rather than distant foreign fisheries (Ribic et al., 2010).

South Atlantic, Gulf of Mexico, and Caribbean Regions

Foreign fishing gear has been reported in Florida and the Gulf of Mexico from as far away as Africa and possibly Spain and Portugal (Baske and Adam, 2019; Kimak et al., 2022; Erzini et al., 2008; Sobrino et al., 2011). One possible route of drift is via the North Equatorial Current and the Caribbean Current connecting to the Loop (or Florida) Current into the Gulf of Mexico. Alternatively, ALDFG could travel up the Gulf Stream to land on the eastern Florida coastline.

The Caribbean Current is a warm ocean current that flows northwestward through the Caribbean from the east along the coast of South America and into the Gulf of Mexico (Richardson, 2005). The Loop Current brings warm water from the Caribbean into the Gulf of Mexico, loops around the Gulf in a clockwise direction and flows southeast into the Florida Strait and the Florida Current and finally joins the Gulf Stream (NOAA Coastwatch, 2021). The Loop Current generally does not reach into the Gulf of Mexico as far as the Texas coastline but does on occasion (Alvera-Azcárate et al., 2009). Though these currents and loops can bring foreign ALDFG from long distances (Baske and Adam, 2019), large accumulations of foreign ALDFG are not reported in the region.

However, there can be significant transport of ALDFG from inside the region. Hurricanes in the South Atlantic, Gulf of Mexico, and Caribbean dramatically affect surface transport of marine debris, causing massive loss of fishing gear and transport of ALDFG throughout the Gulf of Mexico and within the Caribbean (Curcic et al., 2016; Ribic et al., 2011). Locally, marine debris and ALDFG tends to accumulate more on the western Gulf of Mexico due to Gulf circulation patterns (Ribic et al., 2011).

Great Lakes Region

Surface currents influence the transport of marine debris, plastics, and ALDFG in the Great Lakes, but there have not been systematic studies linking distribution of ALDFG and circulation patterns. In Lake Erie, plastics seem to accumulate in the eastern basin, where surface currents converge, but no data related to ALDFG reflect this pattern (Driedger et al., 2015). Likewise, there are no documented accumulations of ALDFG in the Great Lakes that could be the result of transport by currents.

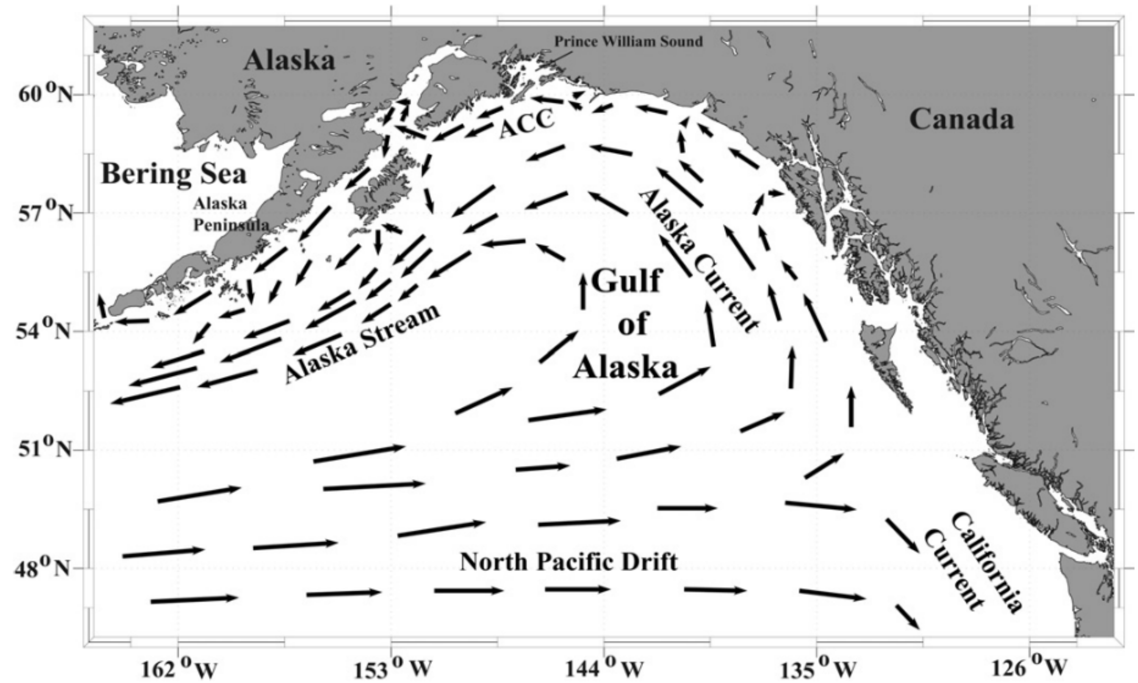
North Pacific (Alaska) Region

In addition to influences of the North Pacific Current (part of the North Pacific Gyre), which brings foreign ALDFG to the shores of the Aleutian Islands, the Alaska Current also operates to distribute domestic marine debris, including ALDFG, onto remote islands throughout the Gulf of Alaska, creating challenging cleanup operations (Figure III.3).

In the Aleutian Islands, large amounts of marine debris, including ALDFG, have been documented for decades. Fishing debris from Japan, Russia, Norway, Korea, China, and Taiwan has been documented in the islands (Manville, 1990; Merrell, 1980), with trawl net being the majority of debris found by weight (Johnson, 1990; Manville, 1990). This debris is likely transported along the North Pacific Current and the Alaska Current.

In the Gulf of Alaska, surveys have found "hotspots" of large debris accumulation, though much of it seems to be from regional fishing activity (Pichel et al., 2012). Hotspots include areas that protrude into the Alaska Current or the Alaska Coastal Current, the windward sides of islands, and capes such as points off the Kenai Peninsula, Kodiak Island, and the Shumagin Islands. But lee sides also collect debris (Pichel et al., 2012). Marine debris retrieval and survey projects in five coastal Alaskan National Parks (Kenai Fjords National Park, Wrangell-St. Elias National Park and Preserve, Katmai National Park and Preserve, Bering Land Bridge National Preserve, and Cape Krusenstern National Monument) found the greatest debris density at beaches in the Kenai Fjords National Park, with ALDFG (rope and netting) comprising the bulk of the debris by weight (Polasek et al., 2017).

Figure III.3. Currents affecting deposition of ALDFG in Alaska.



Source: Pichel et al., 2012.

Pacific (West Coast) Region

In the Pacific region, the transport of ALDFG is more localized, with ALDFG from the region being transported by storms and sometimes transported out to the North Pacific Gyre. Ribic et al. (2012b) conducted a thorough analysis of marine debris loading in Hawaiʻi and the U.S. West Coast, considering oceanic currents and the effects of the El Niño Southern Oscillation and the La Niña Southern Oscillation as well as upwelling along the west coast. They looked at both land-based and sea-based sources and related ALDFG to fishing effort as well. They found sea-based sources of debris decreased during upwelling events along the U.S. West Coast and found a correlation between areas of ALDFG accumulations and local fishing activity. This supports the assumption that ALDFG found on shorelines on the west coast in the Pacific region tends to be from local sources.

ALDFG generated on the west coast of the Pacific region can be a source of ALDFG farther west in the Western Pacific region. Two crab pot tags and floats from the Oregon Dungeness crab fishery were found in 2010 on Lisianski Island and the Kure Atoll (about 1,000 miles west of Hawaiʻi) 4 years after they were lost (Ebbesmeyer et al., 2012).

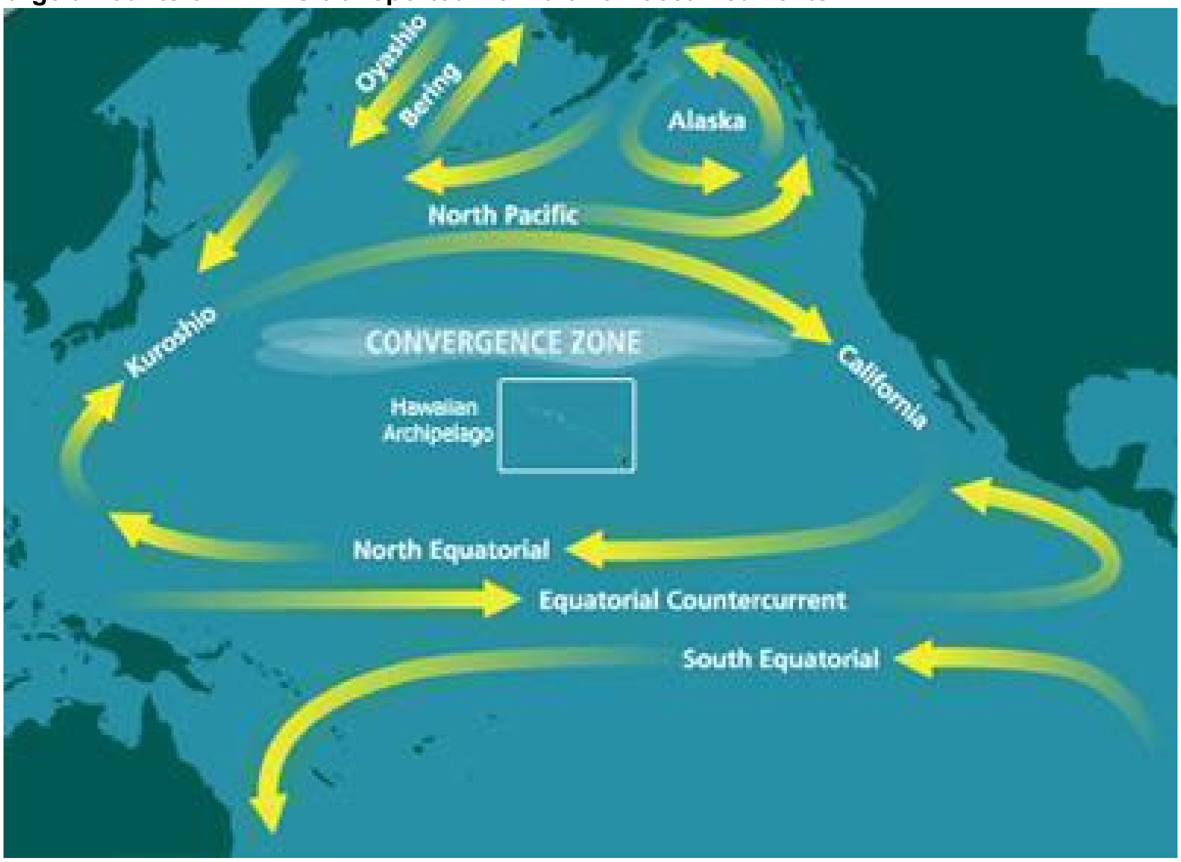
Western Pacific Region

Ribic et al. (2012b) found that shorelines of Hawaiʻi accumulated 10 times the sea-based debris load than either the Pacific Coast or Southern California Bight. These high accumulations are brought to Hawaiʻi and Pacific Island territories by ocean currents, with Hawaiʻi in a convergence zone in the North Pacific Gyre (Figure III.4). ALDFG transport in the Pacific Ocean is affected by El Niño Southern Oscillation and the La Niña Southern Oscillation, with debris loading increasing during El Niño events (Lebreton et al., 2018; Morishige et al., 2007; Ribic et al., 2012b).

The most prevalent ALDFG encountered in surveys and retrieval operations (nearshore waters and shoreline) in the Papahānaumokuākea Marine National Monument is trawl netting (86%–91%), followed by gillnets (4%-7%; Donohue et al., 2001). A baseline survey of shoreline marine debris on the Midway Atoll was conducted in 2010. Of 32,696 total objects collected (Ribic et al., 2012a), 46.2% were potentially ALDFG, including rope (30.4%), buoys/floats (18.5%), eel trap cones (3.9%), and nets (1.5%). Uhrin et al. (2020) reported 13,265 marine debris items intercepted by longlines in the Hawaiʻi-based pelagic longline fishery from 2008 through 2016, most of which was ALDFG. Nets comprised 51.8% of ALDFG and ropes and lines comprised 26.7% by count respectively (Uhrin et al., 2020).

A 2008 survey of shorelines on the main Hawaiian Islands identified 711 sites with ALDFG consisting of multiple gear types including trawl/seine netting, monofilament gillnet, multifilament gillnet, longline, and FADs (NOAA MDP, 2022c: Grant 081N008; https://clearinghouse.marinedebris.noaa.gov/project?mode=View&projectId=79). Aerial surveys of debris conducted by Moy et al. (2018) in 2015 confirmed that the majority of debris on shorelines is ALDFG, including nets and line, buoys, and floats. Debris tends to collect on the windward side of islands. Ni'ihau, the smallest of the main Hawaiian Islands, was documented to have the greatest quantity of macro-debris (objects larger than 0.5 ft^2) surveyed in 2015 (Moy et al., 2018).

Figure III.4. Hawai‘i sits on the edge of a convergence zone in the North Pacific Gyre, subjecting it to large amounts of ALDFG transported from afar on ocean currents.



Source: NOAA MDP, 2013.

Considering that regional fisheries active in and around Hawai‘i use only longline gear, it is likely that trawl gear and FAD debris are predominantly from foreign fisheries. Identifying the source fisheries of ALDFG from foreign sources is challenging. Researchers at the Hawai‘i Pacific University Center for Marine Debris Research have compiled an extensive database of samples of ALDFG collected from Hawai‘i shorelines and longline fisheries. They are analyzing the materials and gear type to identify source fisheries (Royer et al., 2023; Corniuk et al., 2023, McWhirter et al., 2022).

Drifting FAD buoys from tropical tuna purse seine fisheries in the both the Eastern Pacific Ocean and Western Central Pacific Ocean have been found regularly in Hawai‘i and on the Palmyra Atoll (Lynch et al., 2019) and are known to beach in nearshore areas of U.S. Pacific territories and Hawai‘i (Escalle et al., 2020a). The Palmyra FAD Watch program, managed by The Nature Conservancy and the USFWS keeps a record of all FADs encountered on Palmyra Atoll. Serial numbers and identifying markings on some of the FADs and FAD satellite buoys have pointed to Japanese, Korean, and Ecuadoran buoy manufacturers or fishing companies. This confirms likely foreign sources of ALDFG, but it does not provide information on the original FAD deployment location or the transport pathway to the U.S. shorelines.

D. Causes of Gear Loss [§ 135 (1)(C)]

To implement effective ALDFG management, including both prevention of fishing gear loss and mitigation of negative impacts of ALDFG after loss, it is critical to understand the causes of fishing gear loss, abandonment, and discard (Gilman et al., 2022; Richardson et al., 2018). The causes of ALDFG in the United States and its territories are not unique and, as in other countries and regions, vary across fisheries. Causes of fishing gear loss, abandonment, and discard have been documented in many fisheries in the United States and its territories (Bilkovic et al., 2016; Bowers, 1979; Butler and Matthews, 2015; CFMC and NOAA Fisheries, 2019a; Drinkwin and Shipley, 2021; Renchen et al., 2021; Uhrin et al., 2005; Uhrin, 2016). Causes vary by fishery but fall into the general categories of environmental, operational, behavioral, and management pressures.

Environmental causes include strong winds, hurricanes, tropical cyclones, and strong currents which can move gear around. Major weather events such as hurricanes, cyclones, and typhoons can cause massive influxes of marine debris, including ALDFG, in the Caribbean, Gulf of Mexico, and South Atlantic. Estimates of trap losses from hurricanes Katrina, Rita, and Wilma suggest that well over 50 percent of all pots were lost during the storms (Macfadyen et al., 2009; NOAA, 2015). Gear loss and other debris resulting from extreme weather events can further interfere with fishing operations, causing more gear loss from snagging on obstructions. Other environmental causes include bottom obstructions such as reefs, rock outcrops, kelp, or log aggregations that can snag gear; and animal interactions such as large animals damaging gear or repositioning it after becoming entangled. Accumulations of floating kelp, which can form large masses during winter months on the U.S. West Coast, have also been identified as causing fishing gear loss (Drinkwin and Antonelis, 2022).

Operational causes generally relate to controllable fishing practices such as the depth of gear, contact with the seabed during deployment/retrieval, amount of gear and soak time, type of gear marking, and location and timing of fishing (which can lead to gear and vessel conflicts) (Jedziniak, 2017). Operational causes also include mechanical or equipment failure.

Behavioral causes include degree of compliance with fisheries regulations; intentional discard; improper stowage; faulty, old, or badly maintained gear; any type of operator error; vandalism or theft; vessel conflicts; and lack of communication between vessels.

Management causes include management actions that can drive other causes of gear loss, such as lack of enforcement of fisheries rules that can create opportunities for gear theft, rules prohibiting fishing activity in specific areas that lead to fishers being unable to retrieve gear that has drifted out of their assigned fishing areas, or lack of separation between fisheries that result in gear conflicts.

While primary causes of ALDFG can be relatively easy to identify, there are secondary drivers that can influence fishing gear loss (Richardson et al., 2018). For example, foul weather is a major cause of gear loss in the Dungeness crab fishery on the U.S. West Coast and the spiny lobster fishery in south Florida; however, the fisheries operate in seasons prone to foul weather due to market forces that dictate timing of harvest. In other fisheries, the biology of the target species influences when and where they are harvested. Illegal, unreported and unregulated fishing can also be a secondary driver of ALDFG. Persons engaged in illegal, unreported and unregulated fishing are more prone to discard fishing gear to evade enforcement action or avoid being denied entry to port (FAO, 2016).

FAO has developed a global ALDFG survey that identifies 16 causes for fishing gear loss (Table III.22) which have become standardized causes for documenting gear loss in fisheries of the United States and its territories (FAO, 2022c). These causes include categories of environment, operational, behavioral, and management pressure as described previously and secondary drivers where appropriate (Table III.22).

Table III.22. Common causes of loss, abandonment, and discard of fishing gear. Modified from FAO (2022c).

Cause	Cause category				Resultant ALDFG
	Environmental	Operational	Behavioral	Management	
Gear snagged on an obstruction	X	X			Lost, abandoned
Poor weather conditions	X				Lost, abandoned
Damaged or towed away by animals	X				Lost, abandoned
Drifted out of vessel-accessible area		X		X	Abandoned
Faulty, old, or damaged gear			X		Lost, abandoned
Operator error			X		Lost
Strong currents	X				Lost
Deep water (e.g., line or buoy too short)			X		Lost
Gear not properly stowed on-board			X		Lost
Conflict with other gear		X	X	X	Lost
Vandalism (stolen or destroyed)			X		Lost
Surface marking lost, sunk or malfunctioned		X			Lost
Gear intentionally discarded overboard			X		Discarded
Vessel conflict		X	X	X	Lost
Equipment failure (i.e., hauler or location equipment)		X			Lost, abandoned
Lack of communication between fishing vessels			X		Lost

Direct interviews with fishers are an important tool to better understand how to prevent adverse effects of ALDFG. Fisher interviews or surveys identifying causes of ALDFG have been conducted in several states and regions, including in Alaska, Washington, California, Maine, Louisiana, Virginia, and the Caribbean. Interviews often seek to identify the primary cause of ALDFG as well as gather insights into effective preventive practices. Several researchers have surveyed fishers on the subject of ALDFG, generally using modified versions of the FAO survey.

Richardson et al. (2021) reported on fisher surveys conducted with 73 U.S. fishers using gillnets (n = 12), purse seine nets (n = 15), trawl nets (n = 15), longlines (n = 16), and pots and traps (n = 16). Fishers were interviewed at ports in Alaska (Dutch Harbor, with fishery range including Bering Sea, Bristol Bay, and Gulf of Alaska), California (Monterey, with fishery range including west coast of North America from California to British Columbia), Maine (Gulf of Maine, with fishery range including the Gulf of Maine to New Jersey), Louisiana (Abbeville and Vermilion Bay, with fishery range including Gulf of Mexico), and Virginia (Chesapeake Bay and Reedville, with fishery range including North Carolina to New York). The results are summarized by region in the following sections.

Other regional examples of specific causes of gear loss identified for specific U.S. fisheries where information is available are summarized below. Causes were identified through literature review; review of unpublished reports (including reports of fisher surveys); and conversations with state and federal fisheries managers, NGO representatives, and researchers active in ALDFG prevention and management.

New England Region

In the Gulf of Maine lobster fishery, conflicts with net fishers accidentally damaging trap gear, buoy cutoffs from vessel propellers, and storms are major causes of loss. There is also some intentional discard of pots. Secondary drivers include the lack of licensing of recreational boaters (e.g., leading to boaters' not recognizing trap gear markings) and lack of low-cost, convenient disposal options for pots that have reached the end of their useful life (leading to discards) (Erin Pelletier, Gulf of Maine Lobster Foundation, personal communication). In Massachusetts, if a trawler, dragger, or seiner fishing in federal waters accidentally pulls up or encounters active or derelict fishing pots (e.g., Hagfish pots), rather than bringing them back to port for proper disposal, they may intentionally dump those pots overboard before they reach port because legally, they are not allowed to have other fishers' gear on their boats. Often, they transport the pots into state waters where they will no longer interfere with their fishing (Laura Ludwig, Center for Coastal Studies, personal communication). Table III.23 provides examples of primary and secondary gear loss drivers in the New England lobster fishery.

Table III.23. Primary and secondary drivers of gear loss in the New England region, identified by fishery and gear type. NGOs include the Gulf of Maine Lobsterman Foundation and the Center for Coastal Studies.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
Gulf of Maine lobster	Pots	1, 2, 10, 11, 13	Lack of recreational boating licensing; lack of adequate port reception facilities for end-of-life gear	NGO	Personal communication
Massachusetts lobster	Pots	10, 13, 14	Prohibition on mobile fisheries to land pots encountered during active fishing; Hagfish fishery unregulated; recreational fishery unregulated	NGO	Personal communication

a. Primary causes of gear loss:
1 – Gear snagged on an obstruction
2 – Poor weather conditions
3 – Damaged or towed away by animals
4 – Drifted out of vessel-accessible area
5 – Faulty, old, or damaged gear
6 – Operator error
7 – Strong currents
8 – Deep water (e.g., line or buoy too short)
9 – Gear not properly stowed on-board
10 – Conflict with other gear
11 – Vandalism (stolen or destroyed)
12 – Surface marking lost, sunk or malfunctioned
13 – Gear intentionally discarded overboard/abandoned
14 – Vessel conflict
15 – Equipment failure (i.e., hauler or location equipment)
16 – Lack of communication between fishing vessels
17 – Other (e.g., kelp interference; steep slopes)

Mid-Atlantic Region

Blue crab pots are the most abundant ALDFG in this region with high numbers documented in Chesapeake Bay (Bilkovic et al., 2014). Responses from 416 commercial blue crab fishers surveyed in 2019 identified vessel traffic conflicts and storms as the prevalent causes of pot loss (DelBene et al., 2021). In the smaller blue crab trap fishery of the New Jersey Mullica River-Great Bay Estuary, crab pots are lost mainly from vessel traffic, with recreational boats accidentally cutting buoy lines in an area where commercial crabbing and high vessel traffic overlap (Sullivan et al., 2019). Table III.24 provides examples of primary and secondary gear loss drivers in Mid-Atlantic crab fisheries.

Table III.24. Primary and secondary drivers of gear loss in the Mid-Atlantic region, identified by fishery and gear type.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
New Jersey blue crab	Pots	14	None identified	Researcher	Sullivan et al., 2019
Virginia blue crab	Pots	2, 5, 13, 14	None identified	Researcher, fisher survey	Bilkovic et al., 2014; Delbene et al., 2021

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
a. Primary causes of gear loss: 1 – Gear snagged on an obstruction 2 – Poor weather conditions 3 – Damaged or towed away by animals 4 – Drifted out of vessel-accessible area 5 – Faulty, old, or damaged gear 6 – Operator error 7 – Strong currents 8 – Deep water (e.g., line or buoy too short)			9 – Gear not properly stowed on-board 10 – Conflict with other gear 11 – Vandalism (stolen or destroyed) 12 – Surface marking lost, sunk or malfunctioned 13 – Gear intentionally discarded overboard/abandoned 14 – Vessel conflict 15 – Equipment failure (i.e., hauler or location equipment) 16 – Lack of communication between fishing vessels 17 – Other (e.g., kelp interference; steep slopes)		

South Atlantic and Gulf of Mexico Regions

In the South Atlantic and Gulf of Mexico, extreme weather patterns associated with tropical storms and hurricanes are the major cause of loss in the regions (Arthur et al., 2020). In Louisiana, boats accidentally cutting buoy lines are also noted as causes of loss (Peyton Cagle and Christopher Schieble, Louisiana Department of Wildlife and Fisheries, personal communication). In 2020, Louisiana Department of Wildlife and Fisheries distributed a survey to 1,490 commercial crab fishers and received 326 responses (21%). Reporting on reasons for trap loss in 2019, the fishers noted vessel conflicts from commercial and recreational boats and theft as major causes of loss (Isaacs, 2020).

In Florida, storms are a major cause of loss in the lobster and stone crab fisheries. According to unpublished data from the Florida Fish and Wildlife Conservation Commission reported by Butler and Matthews (2015), lobster trap losses reached 65% during years with hurricanes. However, abandonment of pots is also very common, as there are no adequate disposal facilities and pots are very heavy, with up to 70 pounds of concrete used to weight the trap (Pamela Gruven, Florida Fish and Wildlife Conservation Commission, personal communication).

Gear conflicts between fishing gear types can also cause gear loss. In South Carolina, crab pots were being set in shrimp trawling areas, causing loss of crab gear and damage to shrimp trawls. As a result, the South Carolina Department of Natural Resources has proposed a new law in 2022 prohibiting the setting of pots in the shrimp trawl zone during trawl season (Mel Bell, SCDNR, personal communication). In North Carolina inshore gillnet fisheries, gear may become lost in poor weather conditions, and conflicts occur between gillnets and recreational fishing activity (Lee Paramore, North Carolina Department of Environmental Quality, personal communication).

Table III.25 summarizes the primary and secondary gear loss drivers in the South Atlantic and Gulf of Mexico regions.

Table III.25. Primary and secondary drivers of gear loss in the South Atlantic and Gulf of Mexico regions, identified by fishery and gear type.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
North Carolina blue crab	Pots	7	None identified	Researcher	Voss et al., 2015
North Carolina multispecies inshore	Gillnets	2, 10, 14	None identified	Fishery manager	Personal communication
South Carolina blue crab	Pots	10	None identified	Fishery manager	Personal communication
Florida lobster and stone crab	Pots	2, 13	No adequate disposal facilities available; increasing storm severity (climate change)	Fishery manager	Personal communication
Louisiana	Pots	2, 11, 14	None identified	Fishery manager	Personal communication
Louisiana crab	Pots	11, 14	None identified	Fishery manager	Isaacs, 2020

a. Primary causes of gear loss:
1 – Gear snagged on an obstruction
2 – Poor weather conditions
3 – Damaged or towed away by animals
4 – Drifted out of vessel-accessible area
5 – Faulty, old, or damaged gear
6 – Operator error
7 – Strong currents
8 – Deep water (e.g., line or buoy too short)
9 – Gear not properly stowed on-board
10 – Conflict with other gear
11 – Vandalism (stolen or destroyed)
12 – Surface marking lost, sunk or malfunctioned
13 – Gear intentionally discarded overboard/abandoned
14 – Vessel conflict
15 – Equipment failure (i.e., hauler or location equipment)
16 – Lack of communication between fishing vessels
17 – Other (e.g., kelp interference; steep slopes)

Caribbean Region

In the Caribbean region, hurricanes and foul weather are also major causes of gear loss. Macfadyen et al. (2009) reported large losses associated with reef nets and lobster pots during hurricanes, with losses typically running to around 50 percent of a string of 20 pots once in every 3 years.

Matthews and Glazer (2009) conducted surveys with fishers, managers, and researchers including participants from Florida, USVI, and Puerto Rico to gain a better understanding about causes, scale, and management measures of ALDFG in the Caribbean. Respondents acknowledged that a significant amount of gear is lost, abandoned, or discarded. Major causes of loss included damaged gear and bad weather. Respondents said that gear is discarded when it is too much effort to dispose of it properly and that there are no good disposal options.

Fishers in the USVI reported theft and vessel conflicts as major causes of lost fish and lobster pots (CFMC and NOAA Fisheries, 2019b; Clark et al., 2012). Trap fishers in Puerto Rico reported during surveys that theft, vessel conflicts, strong currents, and storms are major causes of gear loss. Most fishers try to retrieve any pots they lose by diving or grappling (Schärer et al., 2004). Hurricane Felix was also responsible for the loss of two of Puerto Rico's nine moored FADs (Wilson et al., 2020).

Table III.26 summarizes the primary and secondary gear loss drivers in the Caribbean region.

Table III.26. Primary and secondary drivers of gear loss in the Caribbean region, identified by fishery and gear type.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
USVI fish and lobster	Pots and traps	5, 12, 13	Buoys inadequate	Fisher survey; fishery manager	Clark et al., 2012; CFMC and NOAA Fisheries, 2019b
USVI net	Net	1, 2, 13	Low-cost gear (gillnets)	Researcher	Clark et al., 2012
Puerto Rico multispecies fish	Pots and traps	2, 7, 11, 14	Lack of enforcement	Fisher survey; researcher	Schärer et al., 2004
Puerto Rico multi species	Moored FAD	2	Design	Researcher	Wilson et al., 2020
Caribbean fisheries, including FL, USVI, and PR artisanal, trap, and reef fisheries	Multiple	1, 2, 5, 13	No adequate disposal facilities available; lack of awareness of ALDFG impacts	Researchers	Matthews and Glazer, 2009

a. Primary causes of gear loss:
1 – Gear snagged on an obstruction
2 – Poor weather conditions
3 – Damaged or towed away by animals
4 – Drifted out of vessel-accessible area
5 – Faulty, old, or damaged gear
6 – Operator error
7 – Strong currents
8 – Deep water (e.g., line or buoy too short)
9 – Gear not properly stowed on-board
10 – Conflict with other gear
11 – Vandalism (stolen or destroyed)
12 – Surface marking lost, sunk or malfunctioned
13 – Gear intentionally discarded overboard/abandoned
14 – Vessel conflict
15 – Equipment failure (i.e., hauler or location equipment)
16 – Lack of communication between fishing vessels
17 – Other (e.g., kelp interference; steep slopes)

<u>*Great Lakes Region*</u>

In the Great Lakes, foul weather and ice can cause fishing gear loss during winter months both by damaging gear and by moving it from its deployment location (Wisconsin DNR, 2022). Recreational boaters are also known to accidently cut lines in the net fisheries in Lake Superior and tributaries of Lake Erie (ODNR, 2016; Wisconsin Sea Grant, 2015). Wachter and Wachter (2021) documented the presence of lost nets snagged on 69 wrecks in Lake Erie, seven of which were in U.S. waters. This indicates that snagging on obstructions such as shipwrecks are likely a cause of gillnet loss. Many of the nets were very old, suggesting that new loss is occurring less than in past years.

Interviews with fishers and agency personnel identified the following causes of lost fishing gear in the Lake Erie Canadian gillnet fisheries, in order of importance: bad weather, ice, snagging on bottom obstructions, vessel conflicts (both commercial and recreational), conflicts with recreational fishing gear, and intentional discard (Antonelis and Drinkwin, 2021).

Table III.27 summarizes the primary and secondary gear loss drivers in the Great Lakes region.

Table III.27. Primary and secondary drivers of gear loss in the Great Lakes region, identified by fishery and gear type.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
Lake Erie multispecies – Canadian	Gillnets	1, 2, 14, 13	None identified	Fisher survey; researcher	Antonelis and Drinkwin, 2021
Lake Superior multi species	Gillnets	2	None identified	Researchers	Wisconsin DNR, 2022

a. Primary causes of gear loss:
1 – Gear snagged on an obstruction
2 – Poor weather conditions
3 – Damaged or towed away by animals
4 – Drifted out of vessel-accessible area
5 – Faulty, old, or damaged gear
6 – Operator error
7 – Strong currents
8 – Deep water (e.g., line or buoy too short)
9 – Gear not properly stowed on-board
10 – Conflict with other gear
11 – Vandalism (stolen or destroyed)
12 – Surface marking lost, sunk or malfunctioned
13 – Gear intentionally discarded overboard/abandoned
14 – Vessel conflict
15 – Equipment failure (i.e., hauler or location equipment)
16 – Lack of communication between fishing vessels
17 – Other (e.g., kelp interference; steep slopes)

North Pacific (Alaska) Region

In Alaska, ice plays a major role in gear loss, as does foul weather, winds, and storms (Long et al., 2014). Ice floes can move more than 40 nautical miles in 1 day in the Bering Sea (Kruse and Kimker, 1993). A large ice event in Cook Inlet in 1988 caused massive loss of Tanner crab pots, resulting in an estimated 15,000 crabs killed in lost pots (Kimker, 1990).

Conflicts between fishers, currents moving gear into deeper habitats, and vessel conflicts have also been identified as causes of gear losses in Alaskan fisheries (Kruse and Kimker, 1993). In Aleutian Island crab fisheries, steep slopes, depth, and strong currents also play a role in gear loss (Barnard, 2008). Maselko et al. (2013) suggested that causes of loss in the Dungeness crab fishery in Southeast Alaska include gear conflicts as well as weather. The relatively small fragments of trawl netting documented entangling fur seals in the Pribilof Islands in the 1980s (Fowler, 1982) suggest they may be net cutoffs discarded by fishers, rather than 'lost' fishing gear. Causes reported for gillnets lost in Taku Inlet in Southeast Alaska were excess weight of salmon in the nets, causing the nets to sink (Drinkwin, 2017a).

Table III.28 summarizes the primary and secondary gear loss drivers in the North Pacific region.

Table III.28. Primary and secondary drivers of gear loss in the North Pacific region, identified by fishery and gear type.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
Southeast Alaska Dungeness crab	Pots	2, 10	Crowded fishing grounds, long soak time	Researcher	Maselko et al., 2013
Kodiak Island crab fisheries	Pots	2	None identified	Researchers	Stevens et al., 2000; Long et al., 2014
Aleutian Island crab fisheries	Pots	2, 7, 8, 17	None identified	Researcher	Barnard, 2008

a. Primary causes of gear loss:
1 – Gear snagged on an obstruction
2 – Poor weather conditions
3 – Damaged or towed away by animals
4 – Drifted out of vessel-accessible area
5 – Faulty, old, or damaged gear
6 – Operator error
7 – Strong currents
8 – Deep water (e.g., line or buoy too short)
9 – Gear not properly stowed on-board
10 – Conflict with other gear
11 – Vandalism (stolen or destroyed)
12 – Surface marking lost, sunk or malfunctioned
13 – Gear intentionally discarded overboard/abandoned
14 – Vessel conflict
15 – Equipment failure (i.e., hauler or location equipment)
16 – Lack of communication between fishing vessels
17 – Other (e.g., kelp interference; steep slopes)

Pacific (West Coast) Region

Along the West Coast Dungeness crab fisheries in Washington, Oregon, and California, foul weather is the major cause of gear loss as fisheries occur in the winter months. Lost crab pots are moved by currents, waves, winds, and masses of floating kelp (Ayres, 2018; Kelly Corbett, Oregon Entanglement Working Group, personal communication). Lost crab pots can aggregate and tangle together in large assemblages known as "flower pots." These aggregations sometimes have visible buoys on the surface. They in turn can cause gear loss from entanglement with lines. On rare occasions, large losses of crab pots can occur when fishing grounds ice over during particularly severe winters.

In Puget Sound, Washington, predominant causes of loss identified in surveys of 21 commercial Dungeness crab fishers were gear snagged on an obstruction and vandalism or theft. These were followed by operator error and vessel traffic conflicts (Drinkwin and Antonelis, 2022).

These causes for commercial crab fishers are strikingly different for the recreational Dungeness crab fishery operating in the same area. Two separate projects involving interviews with 67 recreational crabbers indicated that recreational crabbers identified theft as a major cause of their own crab pot loss but attributed other fishers' losses to operator error (such as using too short ropes for water depth) (C+C, 2016). However, other evidence related to when and where enforcement personnel retrieved some of the fishers' lost pots indicated that their pots had actually moved off their deployment location due to operator error such as improper deployment or gear rigging (NWSF, 2015). These conflicting results illustrate that causes of loss between commercial and recreational fishers can be markedly different, and sometimes fishers assume their pots were stolen instead of recognizing their own error.

Surveys of salmon gillnet fishers in Puget Sound indicated that the major cause of loss is operator error and vandalism or theft. Some fishers noted that less experienced fishers set their gear in the wrong places and don't maintain their gear (Antonelis, 2013). Fishers also noted that fishing very deep is risky because it is hard to handle a deep net if it snags on a reef (Gibson, 2013). Data from removal operations show that most of the derelict nets removed from the salmon fishery in this area are removed from boulders or reefs, indicating that snagging could have been the cause of loss (Drinkwin et al., 2022).

Table III.29 summarizes the primary and secondary gear loss drivers in the North Pacific region.

Table III.29. Primary and secondary drivers of gear loss in the Pacific region, identified by fishery and gear type.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
Puget Sound Dungeness crab – commercial	Pots	1, 6, 11, 14	Lack of communication between fishery and vessel traffic	Fisher survey	Drinkwin and Antonelis, 2022
Puget Sound Dungeness crab – recreational	Pots	6, 11	Inexperience; no training required in licensing; gear on sale is too light for environment	Fisher survey	NWSF, 2015; C+C, 2016
Puget Sound salmon fishery	Gillnets	1, 6, 15	Inexperience; unfamiliar with fishing area; undercapitalized vessels and gear; lack of net depth restrictions	Fisher survey; retrieval data	Antonelis, 2013; Gibson, 2013; Drinkwin et al., 2022
Oregon Dungeness crab	Pots	2, 3, 10, 14, 17	Tug traffic deviates from established traffic lanes.	Fishery manager	Personal communication

a. Primary causes of gear loss:
1 – Gear snagged on an obstruction
2 – Poor weather conditions
3 – Damaged or towed away by animals
4 – Drifted out of vessel-accessible area
5 – Faulty, old, or damaged gear
6 – Operator error
7 – Strong currents
8 – Deep water (e.g., line or buoy too short)
9 – Gear not properly stowed on-board
10 – Conflict with other gear
11 – Vandalism (stolen or destroyed)
12 – Surface marking lost, sunk or malfunctioned
13 – Gear intentionally discarded overboard/abandoned
14 – Vessel conflict
15 – Equipment failure (i.e., hauler or location equipment)
16 – Lack of communication between fishing vessels
17 – Other (e.g., kelp interference; steep slopes)

Western Pacific Region

Gear loss in the Western Pacific region also is caused by foul weather, including cyclones and typhoons. FADs are amongst the gear used widely in this region and FAD losses can be large and have dramatic impacts. Hawai'i is the only state with a program deploying moored FADs. The lifespan of these FADs depends on where and at what depth they are deployed. They are lost generally when the connection between the FAD platform and the mooring line fails. Confirmed causes of these losses generally involve failure of the swivel-shackle assembly. Sometimes the lines are accidentally severed by vessel traffic (Holland and Jaffe, 2000).

The Pacific tuna fishery utilizes drifting FADs in conjunction with purse seine gear. FADs are regularly abandoned when they drift out of areas accessible for fishing vessels or out of the area where vessels are permitted to fish. They are also lost when the satellite buoy attached to them malfunctions and vessels can no longer find them (Gilman et al., 2018; MRAG Asia Pacific, 2016). Much of ALDFG encountered in this region is of foreign origin.

Table III.30 summarizes the primary and secondary gear loss drivers in the North Pacific region.

Table III.30. Primary and secondary drivers of gear loss in the Western Pacific region, identified by fishery and gear type.

Fishery	Gear type	Primary causes[a]	Secondary drivers	Source	Reference
Hawaiʻi multi species (pelagic)	Moored FAD	14, 15	None identified	Researchers	Holland and Jaffe, 2000
Pacific tuna	Drifting FAD	4, 12, 15	No requirements to retrieve deployed FAD	Researchers	Gilman et al., 2018; MRAG Asia Pacific, 2016

a. Primary causes of gear loss:
1 – Gear snagged on an obstruction
2 – Poor weather conditions
3 – Damaged or towed away by animals
4 – Drifted out of vessel-accessible area
5 – Faulty, old, or damaged gear
6 – Operator error
7 – Strong currents
8 – Deep water (e.g., line or buoy too short)
9 – Gear not properly stowed on-board
10 – Conflict with other gear
11 – Vandalism (stolen or destroyed)
12 – Surface marking lost, sunk or malfunctioned
13 – Gear intentionally discarded overboard/abandoned
14 – Vessel conflict
15 – Equipment failure (i.e., hauler or location equipment)
16 – Lack of communication between fishing vessels
17 – Other (e.g., kelp interference; steep slopes)

IV. IMPACTS OF ALDFG [§ 135 (2)]

This section summarizes the ecological, economic, human health, and maritime safety impacts of ALDFG. Each of these factors are summarized as they relate to fishing gear and methods [§ 135 (2)(A)]; construction materials [§ 135 (2)(B)]; and geographic locations [§ 135 (2)(C)].

The adverse effects of fishing gear when it is lost, abandoned, or discarded is often different from adverse effects associated with the gear during active fishing. Bycatch is "discarded catch of any living marine resource plus unobserved mortality due to a direct encounter with fishing gear" (Benaka et al., 2019). Unobserved mortality includes encounters with ALDFG (Benaka et al., 2019; NOAA Fisheries, 2004a). Bycatch management is a significant component of U.S. fisheries management. But the types of species that are caught as bycatch of active fishing gear can differ from the species affected by that same type of fishing gear when it becomes ALDFG (Lively and Good, 2018; NOAA, 2015).

For example, salmon gillnets in the U.S. portion of the Salish Sea (Puget Sound) can catch benthic invertebrates when the nets are lost and sink to the seafloor (Gilardi et al., 2010; Drinkwin et al., 2022). Habitat impacts from drifting FADs may be minimal when they are actively used in fishing, but when they are abandoned or lost and drift into nearshore habitats, their adverse effects can be significant (Balderson and Martin, 2015; Consoli et al., 2020).

A. Ecological Impacts

Adverse ecological effects from ALDFG include direct harm to marine animal species and direct harm to biotic habitats (e.g., kelp, coral reefs), as well as habitat degradation, which indirectly harms marine species. Entanglement in pots and traps, ropes, lines, and netting is a top threat to marine wildlife (Wilcox et al., 2016). When fishing gear is lost, abandoned, or discarded in the marine environment, it can continue to ghost fish both target and non-target species. Several review articles have captured the breadth and depth of effects from ghost fishing (de Carvalho-Souza et al., 2018; GESAMP, 2021; Gilman et al., 2021; IEEP, 2005; Lively and Good, 2018; Macfadyen et al., 2009; Matsuoka, 2005; NOAA, 2015; Scheld et al., 2016; Smolowitz, 1978) at the global and national level. Ghost fishing is considered bycatch in U.S. fisheries management (Benaka et al., 2019; NOAA Fisheries, 2004a). This section includes a summary of specific species and habitat effects within fisheries of the United States and its territories.

Ghost fishing and entanglement of animals, as well as damage to habitats, can continue for many years after fishing gear is lost, but the degree of damage caused often decreases over time (GESAMP, 2021; Gilardi et al., 2010; NOAA, 2015). For example, lost Dungeness crab pots in the U.S. portion of the Salish Sea (Puget Sound) were found to continue ghost fishing for about 2 years, after which they had degraded to the point where they no longer captured animals (Antonelis et al., 2011).

Adverse Effects on Biota

When entangled in ALDFG, mammals and birds may drown, and fish and invertebrates may die from injuries, starvation, predation, and smothering (Butterworth, 2016; Gall and Thompson, 2015; Parton et al., 2019). Some studies have looked at more specific mechanisms of animal entanglement related to animal behavior, such as a seal's behavioral response to marine litter or the foraging behavior of some fish (Butterworth, 2016; Dau et al., 2009; Fowler, 1987; Parton et al., 2019; Wallace, 1985). The kinds of animals affected by ALDFG change as ALDFG ages, changes shapes, and sinks or drifts (Drinkwin et al., 2022; Erzini et al., 1997; Renchen et al., 2014). Shoreline ALDFG also affects species through entanglement and sometimes ingestion (Dau et al., 2009).

Most studies documenting animal entanglement or ingestion of fishing gear do not differentiate between active fishing gear or ALDFG (Dau et al., 2009; Donnelly-Greenan et al., 2019; Marks et al., 2020; NOAA Fisheries, 2022; Raum-Suryan et al., 2009). However, Jacobsen et al. (2010) report on the death of two sperm whales (*Physeter macrocephalus*) stranded along the northern California coast that were likely killed by ingesting discarded fishing nets and other plastics over several years. The whales were found with more than 130 types of nets (mostly made of floating polyethylene) in their digestive tract. Nets included bait nets, gillnets, and trawl nets mostly made from floating polyethylene. This diversity of fishing gear indicates that the ingestion was not the result of a single encounter with active fishing gear, but perhaps of multiple encounters with floating ALDFG, possibly remnants discarded after onboard net repairs. This study highlights the adverse effects of discarded fishing gear.

Endangered, Threatened, and Protected Species

ALDFG affects multiple species in fisheries throughout the United States and its territories. Resource managers and researchers have identified several species that may experience population-level effects from ALDFG.

Along the eastern seaboard, populations of the diamondback terrapin (*Malaclemys terrapin*) are threatened by blue crab pot bycatch, and terrapin mortality has been documented in lost pots (Anderson and Alford, 2014). Terrapin bycatch reduction devices are required in some states but compliance in some recreational fisheries has been found to be very low (Radzio et al., 2013).

The effects of derelict gillnets in the U.S. portion of the Salish Sea in Washington are recognized as stressors to taxa listed under the Endangered Species Act, including rockfish species (NOAA Fisheries, 2017a, 2013; NOAA Fisheries, 2021a; WDFW, 2011) and marbled murrelets (*Brachyramphus marmoratus*) (USFWS, 2017). In 2015, 125 marine species at risk were identified in the Salish Sea by the Province of British Columbia, the State of Washington, Canada, and the United States (Zier and Gaydos, 2016). Of these species, 22 have been documented entangled and killed in derelict gillnets in the U.S. portion of the Salish Sea. Species included one mammal species, seven bird species, 12 fish species, and one invertebrate species.

In the Florida Keys, derelict lobster pots have been documented to damage hard corals including species listed as threatened under the Endangered Species Act (Renchen et al., 2021).

In the Western Pacific, entanglement in plastics, primarily ALDFG and operational/active fishing gear, was identified as a primary threat to the endangered Hawaiian monk seal (*Neomonachus schauinslandi*) in Hawaiʻi (Boland and Donohue, 2003; Donohue et al., 2001; Henderson, 2001).

Whale Entanglements

Whale entanglements in fishing gear are causes for concern, but attributing entanglements to ALDFG can be problematic. In the waters of the United States and its territories, interactions between large whales and fishing gear have been documented for many years (NOAA Fisheries, 2017). In some regions, such as the U.S. West Coast, whale entanglements in fishing gear appear to be on the rise (Lebon and Kelly, 2019; NOAA Fisheries, 2017). On the U.S. East Coast, the plight of the North Atlantic right whale is well known. The population has approximately 70 reproductively active females and is plagued by ship strikes and sometimes fatal entanglement in fishing gear (Moore, 2019; Reed et al., 2022). However, most cases of whale entanglements involve whales becoming entangled in active fishing gear, rather than in ALDFG (Asmutis-Silvia et al., 2017).

In 2017, large whale entanglements were reported along all U.S. coastal areas except the Gulf of Mexico, with 70% confirmed entangled in fishing gear. Most entanglements occurred in California and Massachusetts and the majority of entanglement involved humpback whales (NOAA Fisheries, 2017). Studies of specific cases of whales entangled in fishing gear often do not distinguish between active fishing gear or ALDFG as the source because it is not possible to do so (Citta et al., 2014; Moore et al., 2009). However, in many cases, fishers were interviewed and confirmed that the whales were entangled in active fishing gear (Asmutis-Silvia et al., 2017).

On the U.S. West Coast, Oregon fisheries managers report at least one instance of a whale entanglement in lost Dungeness crab gear. Crab gear removed from an entangled whale contained a tag several years old, indicating that at least some of the gear involved in the entanglement was not from the current active fishing season (Kelly Corbett, Oregon Entanglement Working Group, personal communication, 2022).

The distinction between entanglement in ALDFG or active fishing gear is important because it informs the management actions needed to prevent and reduce entanglement events (Asmutis-Silvia et al., 2017). Where active fishing gear is the major source of fishing gear-related whale entanglements, the management focus should be on mitigation measures aimed at active fishing gear.

Habitat Adverse Effects

Negative effects from ALDFG to marine habitats, such as kelp and seagrass beds, coral reefs, and rocky reefs have been reported. Habitat effects from ALDFG include breakage, dislodgement, tissue damage, sedimentation, and smothering (Beneli et al., 2020; de Carvalho-Souza et al., 2018; Figueroa-Pico et al., 2020; GESAMP, 2021; Macfadyen et al., 2009; NOAA MDP, 2016; NRC, 2009; Suka et al., 2020).

Regional examples of adverse ecological effects are highlighted below with tables listing the available information on ecological effects of ALDFG in U.S. fisheries.

New England Region

Adverse ecological effects from ALDFG in the New England region include ghost fishing by abandoned, lost, and discarded lobster pots. The Center for Coastal Studies (unpublished data) has retrieved more than 72 tons of ALDFG, including approximately 1,500 lobster pots as well as rope, trawl nets, cables, and buoys from Cape Cod Bay since 2013. Hundreds of lobster and crab have been caught in ghost-fishing pots, as well as many fish species (Laura Ludwig, Center for Coastal Studies, personal communication).

Derelict lobster pots often are washed onto shorelines by waves and winds where they can continue to harm animals; birds and small mammals have been documented caught in the pots and unable to escape (Erin Pelletier, Gulf of Maine Lobster Foundation, personal communication; Andranovich et al., 2022). Podolsky and Kress (1989) reported 37% of examined cormorant nests (188 of 497) in the Gulf of Maine contained plastic materials including lobster pot lines, and fishing net fragments. Table IV.1 summarizes documented examples of ALDFG ecological impacts in the New England region.

Table IV.1. Ecological impacts of ALDFG in the New England region.

Fishery	Gear type	Species interactions and impacts	Reference
Massachusetts lobster	Pots	726 lobster; 1,550 crab found (in 1598 retrieved pots from 2013 through 2021); 15 fish species found	Center for Coastal Studies
Massachusetts lobster	Pots	Birds	Erin Pelletier, Gulf of Maine Lobster Foundation, personal communication

Mid-Atlantic Region

In the Chesapeake Bay, an estimated 3.3 million blue crab, 3.5 million white perch, and 3.6 million Atlantic croaker are killed annually in accumulated derelict blue crab pots (Bilkovic et al., 2016; Scheld et al., 2016). Lost blue crab pots also capture and kill other finfish and turtles (Bilkovic et al., 2016). In the New Jersey blue crab fishery, derelict blue crab pots also were documented to ghost fish blue crab, other crabs, whelks, and diamondback terrapins (Sullivan et al., 2019). Table IV.2 summarizes documented examples of ALDFG ecological impacts in the Mid-Atlantic region.

Table IV.2. Ecological impacts of ALDFG in the Mid-Atlantic region.

Fishery	Gear type	Species interactions and impacts	Habitat impacts	Reference
Chesapeake Bay blue crab	Pots	40 species observed captured (including spider crab, black sea bass, sheepshead); 3.3 million blue crab/yr; 3.5 million white perch/yr; 3.6 million Atlantic croaker/yr	Minimal impacts on oyster beds and submerged aquatic vegetation	Bilkovic et al., 2014; Bilkovic et al., 2016; DelBene et al., 2019
New Jersey blue crab; others	Pots	Documented 2.9 animals/ALDFG retrieved: Jonah crab, blue crab, whelk, diamondback terrapin; other animals using ALDFG as habitat		Sullivan et al., 2019

South Atlantic and Gulf of Mexico Regions

Adverse ecological effects of ALDFG in the South Atlantic and Gulf of Mexico regions include ghost fishing by commercial blue crab pots and spiny lobster pots as well as impacts to non-target species effects from recreational fishing gear, nets, and pots. Derelict blue crab pots continue to capture blue crab as well as diamondback terrapin (Voss et al., 2015). Caribbean spiny lobster pots are known to damage seagrasses and coral reefs during active fishing and when they are moved by wind and waves (Lewis et al., 2009; Uhrin et al., 2005). The large numbers of lobster pots lost to storms and other causes (Uhrin, 2016; Uhrin et al., 2014) in this region have similar effects on nearshore and subtidal habitats.

A survey of marine debris in the Florida Keys in 2014 estimated an average of 85,548 derelict lobster pots still ghost fishing and more than a million pots that were no longer ghost fishing in the study area (Uhrin et al., 2014). A later survey of marine debris in Florida Keys marine protected areas found 61.8% of trap debris was affecting coral reef habitats (Renchen et al., 2021). Another survey of 63 sites in the Florida Keys found marine debris at 92% of sites (87% was mostly hook and monofilament line gear) damaging invertebrates (hydrocorals, stony corals, gorgonians) (Chiappone et al., 2005).

In a study of fishing gear interactions with dolphins, manatees, and sea turtles in Florida, researchers noted that manatee entanglements were likely from interactions with ALDFG, while dolphin entanglements were more likely from encounters with active fishing gear while foraging (Adimey et al., 2014; Marks et al., 2020). For sea turtles, both causes were likely. The propensity of angler line collecting on outcroppings where it is commonly snagged was identified as a source of ingestion of fishing line for manatees (Adimey et al., 2014).

In addition, there are significant coastal gillnet fisheries in North Carolina. Gillnets, both active and abandoned, have been documented to entangle threatened or endangered sea turtle species (Boyd, 2017). Abandoned gillnet entanglement with other species such as sharks and cobia have also been documented (Boyd, 2017; NCCF, 2020).

Table IV.3 summarizes documented examples of ALDFG ecological impacts in the South Atlantic and Gulf of Mexico regions.

Table IV.3. Ecological impacts of ALDFG to species/habitats in the South Atlantic and Gulf of Mexico regions.

Fishery	Gear type	Species interactions and impacts	Reference
Florida recreational and commercial	Multiple gear types	132 bottlenose dolphins, 380 Florida manatees, and 1070 sea turtles (418 loggerhead, 481 green, 69 Kemp's ridley, 30 hawksbills, 43 leatherbacks, 1 olive ridley, and 28 unidentified sea turtles) with fishing gear strandings from 1997 through 2009	Adimey et al., 2014*
Florida spiny lobster	Pots	637,622 lobster killed in Florida Keys/yr; 66 fish species reported in retrieved derelict pots	Butler and Matthews, 2015
Florida spiny lobster	Pots	Declines in shoot density and percent cover for seagrasses (*Thalassia testudinum* and *Syringodium filiforme*) resulting from presence of lobster pots	Uhrin et al., 2005

Fishery	Gear type	Species interactions and impacts	Reference
North Carolina blue crab	Pots	*Spartina alterniflora* damaged from derelict blue crab pots recovered within 10 months after ALDFG retrieval	Uhrin and Schellinger, 2011
North Carolina blue crab	Pots	Blue crab, stone crab, sheepshead, black sea bass, diamondback terrapin, clapper rail; 18 species identified	Voss et al., 2015
North Carolina multispecies	Gillnet	Green sea turtle dead in large mesh gillnet	Boyd, 2017
Florida recreational and commercial	Line; pots	Manatee entanglements in fishing gear represent 25% of all rescue reports; 50 deaths reported in 20 years	Reinert et al., 2017*
Florida recreational and commercial	Line; pots	Damage to 1 sessile invertebrate/100 m^2 affected by ALDFG (hook & line); less than 0.5% of density	Chiappone et al., 2005
Florida Spiny lobster and stone crab	Pots	61.8% trap debris in coral reef habitats in Florida Marine Protected Areas; interactions observed with Endangered Species Act listed hard corals	Renchen et al., 2021
Louisiana blue crab	Pots	2.5–3.5 blue crabs/trap and 19 species observed in derelict pots	Anderson and Alford, 2014
Gulf of Mexico blue crab	Pots	25.8 crabs/trap/yr; 8 fish per trap/yr	Arthur et al., 2020
Florida spiny lobster	Pots	Spiny lobster sublethal effects of confinement in derelict pots, with some observation of mortality	Butler et al., 2018

*Studies included interactions with active fishing gear as well as ALDFG.

Caribbean Region

In the Caribbean region, the effects of lost Caribbean spiny lobster pots and fish traps are a large concern. Mortality and injury of Caribbean spiny lobster confined in derelict lobster pots and mortality of fish trapped in fish traps have been documented (Butler et al., 2018; Clark et al., 2012; Renchen et al., 2014). From January 2018 to November 2019, Conservacion ConCiencia removed 57,237 lbs. (25,962 kg) of ALDFG. While the initial work focused on ALDFG lost due to Hurricane Irma, the retrieval program uncovered a pervasive problem of illegal lobster pot fishing as well (Drinkwin, 2019). In the USVI, loss of fish traps is significant but ghost fishing rates appear relatively low (Renchen et al., 2014). Table IV.4. summarizes documented examples of ALDFG ecological impacts in the Caribbean region.

Table IV.4. Ecological impacts of ALDFG to species/habitats in the Caribbean region.

Fishery	Gear type	Species interactions and impacts	Reference
Florida Spiny lobster	Pots	Spiny lobster sublethal effects of confinement in derelict pots, with some observation of mortality	Butler et al., 2018
USVI fish trap	Pots	2%–5% of trapped fish die in traps; 11 fish species mortally trapped	Renchen et al., 2014; Clark et al., 2012

Great Lakes Region

There is a paucity of data on the ecological effects of ALDFG in the Great Lakes region. Most information around ALDFG addresses negative effects in marine waters, but ALDFG has similar direct and indirect negative effects in freshwater environments (Cera et al., 2020; NRC, 1990; Nelms et al., 2021; Spirkovski et al., 2019). Earn et al. (2021) note that fishing and fishing gear are sources of macro-plastic debris in the Great Lakes but they do not report on ecological effects of ALDFG.

The Great Lakes Marine Debris Action Plan includes ALDFG as a source of marine debris but makes no mention of any actions around the issue nor documented ecological effects (NOAA MDP, 2020b). Driedger et al. (2015) noted that fishing gear comprised only a small amount (about 1%) of shoreline debris along the Great Lakes from beach cleanup data. The Marine Stewardship Council certification for Lake Erie yellow perch and walleye fisheries noted that the soft-bottom habitat results in limited risk to habitats from demersal gillnets. They acknowledge that the mortality from lost fishing gear is unknown.

North Pacific (Alaska) Region

In the Southeast Alaska Dungeness crab fishery, researchers found that derelict crab pots ghost fished for up to 7 years (Maselko et al., 2013). In Kodiak, Long et al. (2014) estimated that 16%-37% of the red king crab population in Women's Bay died in lost crab pots and gillnets from 1991 through 2008. They identify this as a "substantial" source of mortality for that population.

Marine debris, including ALDFG, has been identified as a major source of mortality for the Northern fur seal population on the Pribilof Islands. Modeling studies suggested that 50,000 fur seals may have been killed annually by entanglement in trawl web and other debris during the 1970s (Fowler, 1987). Marine debris is also a documented cause of mortality and injury in Steller sea lion population in Southeast Alaska, though nets, rope, and monofilament line are responsible for only 16% of entanglements compared to 84% from packing and rubber bands (Raum-Suryan et al., 2009).

Table IV.5 summarizes documented examples of ALDFG ecological impacts in the North Pacific region.

Table IV.5. Ecological impacts of ALDFG to species/habitats in the North Pacific region.

Fishery	Gear type	Species interactions and impacts	Reference
Foreign and domestic	Lines, ropes, nets	Steller sea lions entangled in ALDFG (Southeast Alaska); fur seals entangled in ALDFG (Pribilof Islands)	Raum-Suryan et al., 2009*; Fowler, 1987*
Cook Inlet Tanner crab	Pots	15,000 Tanner crab killed in 1988**	Kimker, 1990
Kodiak Island crab fisheries	Pots	4 Tanner crab /lost pot (n = 140); multiple fish found in retrieved pots	Vining, 1995
Southeast Alaska Dungeness crab	Pots	Dungeness crabs entrapped in 32.5% of derelict pots retrieved; pots ghost fished for 7 years	Maselko et al., 2013

*Studies included interactions with active fishing gear as well as ALDFG.
**This event occurred prior to the reduction in escape cord thread count (which was prompted by this event).

Pacific (West Coast) Region

In the Pacific region, ALDFG from nearshore Dungeness crab, spiny lobster, and salmon fisheries are the most studied. The California Lost Fishing Gear Recovery Project has retrieved approximately 380 derelict nets, 1,300 derelict Dungeness crab pots, and 1,900 derelict Spiny lobster pots from California marine waters since 2006. In the U.S. portion of the Salish Sea, 5,638 portions of fishing nets (94.5% gillnets) and more than 5,000 derelict Dungeness crab pots have been retrieved from marine waters since 2002. Animals observed mortally entangled in the retrieved gillnets included 126,308 individuals of 119 unique species, including mammals, fish, birds, and invertebrates (Drinkwin et al., 2022). These nets were affecting more than 874 acres of Essential Fish Habitat and Habitat Areas of Particular Concern for groundfish and salmon fish stocks (Drinkwin et al., 2023). Of the 5,638 nets retrieved from the Salish Sea, 4,665 (82.7%) were in essential Chinook salmon habitat, 393 (6.9%) were in essential Chum salmon habitat, 5,358 (95%) were in essential Bocaccio rockfish habitat, 132 (2.4%) were in essential yelloweye rockfish habitat, and 2,500 (44.3%) were in essential green sturgeon habitat (Drinkwin et al., 2023).

Data analysis of bird and mammal strandings in California shows consistent effects of fishing line and other gear entanglement and ingestion on multiple species, though it is not possible to determine whether the fishing gear was encountered by the animals while it was actively deployed or as ALDFG. Much of the documented entanglements were caused by recreational fishing line (Dau et al., 2009; Donnelly-Greenan et al., 2019). In a study of wildlife rehabilitation center data on injuries to gulls, pelicans, and pinnipeds over a 6-year period in California, fishing gear including recreational fishing lines and rope was responsible for injuries to these animals in 11.3% of the cases analyzed (Dau et al., 2009).

Table IV.6 summarizes documented examples of ALDFG ecological impacts in the Pacific region.

Table IV.6. Ecological impacts of ALDFG to species/habitats in the Pacific region.

Fishery	Gear type	Species interactions and impacts	Reference
California Dungeness crab; spiny lobster; net fishery	Pots, nets	750 spiny lobster, >500 crab, fish (including sharks), cormorants, dolphins, and pinnipeds observed live and dead in retrieved ALDFG	Kirsten Gilardi, California Lost Fishing Gear Recovery Project, personal communication, 2022
Puget Sound Dungeness crab – commercial & recreational	Pots	142,935 Dungeness crab killed/yr	NRC, 2021
Puget Sound salmon fishery	Gillnets	119 unique species observed mortally entangled: 4 mammal species, 21 bird species, 58 fish species, 36 invertebrate species; 22 of 125 marine species at risk identified in the Salish Sea were found mortally entangled in derelict gillnets	Drinkwin et al., 2022; Good et al., 2010
Puget Sound salmon fishery	Gillnets	Observed catch rates/net/day: seabirds = 0.196; fish = 0.275, invertebrates = 2.119	Gilardi et al., 2010
Recreational fisheries	Lines, ropes, pots	Gulls, pelicans, pinnipeds, 26 bird species: 11.3% of injuries at wildlife rehabilitation center caused by ALDFG	Dau et. al., 2009*; Donnelly-Greenan et al., 2019*

*Studies included interactions with active fishing gear as well as ALDFG.

Western Pacific Region

There are limited reports of ecological effects from domestic fisheries in Hawaiʻi. Cauliflower coral (*Pocillopora meandrina*) colonies are known to suffer damage, including mortality, from recreational monofilament line (Asoh et al., 2004). Mortality of green sea turtles has also been attributed to nearshore gillnet and hook-and-line fisheries in Hawai‘i (Chaloupka et al., 2008).

Table IV.7 summarizes documented examples of ALDFG ecological impacts in the Western Pacific region.

Much of the documented ecological effects from ALDFG in the Western Pacific region involve ALDFG from foreign source fisheries. Additional information on these effects are described in Section IV.E: Impacts Attributable to Foreign Countries.

Table IV.7. Ecological impacts of ALDFG to species/habitats in the Western Pacific region.

Fishery	Gear type	Species interactions and impacts	Reference
Hawai‘i multi species (nearshore)	Gillnets	Green sea turtle entanglement (cause of 5% of strandings); mortality was 69% per stranding	Chaloupka et al., 2008*; Suka et al., 2020; Royer et al., 2023
Hawai‘i multi species (nearshore) – recreational	Other hook & line	Green sea turtle entanglement (cause of 7% of strandings); mortality was 52% per stranding; damage to cauliflower coral	Chaloupka et al., 2008*; Asoh et al., 2004

*Studies included interactions with active fishing gear as well as ALDFG.

B. Economic Impacts

Fisheries Impacts

Many sources exist in the literature estimating economic costs of ALDFG. Economic loss assessments have focused on lost harvest or the cost of lost gear within the ALDFG source fishery (Antonelis et al., 2011; Donohue et al., 2002; Gilardi et al., 2010; Jeffrey et al., 2016; McIlgorm et al., 2011; Scheld et al., 2016; Stevens et al., 2000; Sullivan et al., 2019; Uhrin, 2016). For example, Bilkovic et al. (2016) estimated that the derelict blue crab pots in Chesapeake Bay can mortally entrap 3.3 million blue crabs annually, representing 4.5% of the blue crab harvest in 2014. Ghost fishing from ALDFG is recognized as a form of bycatch under the United States' approach to managing bycatch. The unobserved mortality of animal species caused by ALDFG, including habitat-forming species such as corals, is included in the National Bycatch Reduction Strategy (NOAA Fisheries, 2004a; NOAA Fisheries, 2016).

Ghost fishing also affects non-target commercial species. Derelict Dungeness crab pots in Womens Bay, Alaska have captured red king crab (Long et al., 2014), and salmon gillnets in the U.S. portion of the Salish Sea have captured Dungeness crab (Drinkwin et al., 2022; Good et al., 2010). Tanner crab pots left on the grounds for at least 60 days following closure were responsible for the loss of an estimated 15,000 Tanner crabs (Kimker, 1990). These impacts of ghost fishing increase the economic costs of ALDFG and illustrate the need to calculate ghost fishing losses in bycatch considerations in all affected fisheries (NOAA Fisheries, 2004a).

Studies focusing on the cost to benefit ratios for certain ALDFG management measures also illustrate the economic costs of ALDFG. Retrieval of derelict blue crab pots from Chesapeake Bay over the course of 7 years at a cost of $4.2 million resulted in a 27% increase in harvest worth $21.3 million (Scheld et al., 2016). Bilkovic et al. (2016) found that derelict blue crab pots were causing a 4.5% loss in harvest annually in the Chesapeake Bay blue crab fishery by killing 3.3 million crabs each year through ghost fishing.

There are also economic effects from the loss of the gear itself as gear can represent a significant investment for fishers and fishing companies. An estimated $100,000 worth of fish traps are lost annually in the USVI (Arthur et al., 2014). Similarly, in the Western Pacific region, the costs of lost gear are a substantial expense to fishers. In fisheries in the Mariana Archipelago, Pacific pelagic zone, and American Samoa, the fisher-reported cost of lost gear is factored into annual stock assessments and evaluation reports. In Guam, for the years 2011-2020, the cost of lost gear in the bottomfish fishery ranged from $0.90 to $20.80/trip, representing 2%-30% of total cost/trip (WPRFMC, 2021a). The cost of lost gear in the pelagic troll fishery ranged from $11.70 to $30.50/trip, representing 12%-34% of total trip costs (WPRFMC, 2021c). In American Samoa, the cost of lost gear in the bottomfish fishery during 2011-2020 ranged from $2.00 to $22.00/trip, representing 2%-15% of total trip costs (WPRFMC, 2021b). The cost of lost gear in the pelagic troll fishery ranged from $2.20 to $11.50/trip, representing 3%-10% of total trip costs (WPRFMC, 2021c).

Non-Fisheries Maritime Impacts

There are also significant economic costs associated with vessel traffic conflicts with ALDFG and fishing gear. In 2017 and 2019, interactions with crab pot lines grounded the passenger ferries four times in the U.S. portion of the Salish Sea, Washington, costing the Washington Department of Transportation over $100,000 in each incident. The crab pots were encountered in the ferry line, indicating they either drifted there or were improperly deployed (Pilling, 2019; Thompson, 2018). Also in the U.S. portion of the Salish Sea, tow and barge companies have reported hiring divers about twice a week during crabbing season to remove crab gear from their vessels' propellers, at a cost of up to $500/day. More severe propeller entanglements require vessels to be dry docked for repair. These entanglements are usually attributed to active fishing gear (Drinkwin, 2016), but it can be hard to distinguish between active and derelict gear.

Table IV.8 summarizes published reports of economic effects from ALDFG in U.S. fisheries and territories.

Table IV.8. Published economic impacts of ALDFG by gear type and fishery.

Region	Fishery	Gear type	Harvest impacts	Other impacts	Source / reference
New England	Gulf of Maine lobster	Pots		$16 million lost harvest revenue and gear replacement costs resulting from 175,000 lost pots annually	GOMLF, 2022
Mid-Atlantic	Chesapeake Bay blue crab	Pots	27% increase through retrieval of 34,408 derelict pots	$4.2 million/$21.3 million cost to benefit ratio	Scheld et al., 2016
Mid-Atlantic	Chesapeake Bay blue crab	Pots	4.5% of harvest lost		Bilkovic et al., 2016
Mid-Atlantic	Chesapeake Bay blue crab	Pots	30% harvest lost in summer		DelBene et al., 2019

Region	Fishery	Gear type	Harvest impacts	Other impacts	Source / reference
Gulf of Mexico	Louisiana blue crab	Pots		2.4–3.5 crab caught/trap	Anderson and Alford, 2014
Gulf of Mexico	Mississippi blue crab	Pots		93% shrimp trawlers report encountering derelict crab pots during active fishing; shrimpers reported reduced harvest and incurred repair costs of fishing gear damaged by ALDFG	Posadas et al., 2021
Caribbean	Puerto Rico multi species	Moored FAD		2 of 9 moored FADs lost in Hurricane Maria, costing $16,000 for construction and $8,000–$10,000 for deployment	Wilson et al., 2020
Caribbean	USVI fish trap	Traps	$52/trap/yr lost to ghost fishing		Renchen et al., 2014
Caribbean	USVI fish trap	Traps		$100,000 in gear costs lost annually	Arthur et al., 2014
North Pacific	Southeast Alaska Dungeness crab	Pots	0.37% of harvest lost		Maselko et al., 2013
Pacific	Puget Sound Dungeness crab – commercial and recreational	Pots		142,935 Dungeness crab killed/yr; $1.26 million ex vessel value; $100,000 cost to dry-dock ferries with tangled crab line/incident ($300,000 in 2017)	NRC, 2021
Pacific	Puget Sound salmon fishery	Gillnets		$19,656 lost Dungeness crab harvest from one lost gillnet	Gilardi et al., 2010
Western Pacific	American Samoa bottomfish	Longline		Lost gear cost 2%–15% of trip cost	WPRFMC, 2021b
Western Pacific	American Samoa pelagic	Troll		Lost gear cost 3%–10% of trip cost	WPRFMC, 2021c
Western Pacific	Guam bottomfish	Longline		Lost gear cost 2%–30% of trip cost	WPRFMC, 2021a
Western Pacific	Guam pelagic	Troll		Lost gear cost 12%–34% of trip cost	WPRFMC, 2021a

C. Human Health Impacts

The impacts of ALDFG on human health are a focus of current research but not yet well understood (Garrido Gamarro and Costanzo, 2022). ALDFG can directly affect human health through direct contact (e.g., divers getting entangled in netting, beachgoers stepping on sharp debris such as hooks). ALDFG can also indirectly affect human health via the degradation of plastic waste, bioaccumulation of plastic degradation products in aquatic and marine organisms, and subsequent consumption of the plastics by humans.

While human entanglement risks from ALDFG are not widely reported, they are of concern to divers in the vicinity of abandoned nets. William High, an experienced NOAA science diver and one of the first researchers to sound the alarm about the effects of ALDFG in U.S. fisheries, presents this account of a diver interacting with ALDFG (High, 1998, p.8):

Only once was a member of my dive team in serious trouble from entanglement. The occasion was a non-government-related underwater filming of octopuses for television. My diving partner and I inadvertently became entangled in a ghost salmon gill net lost on the shipwreck Dauntless. Safety divers hired by the film company failed to intervene. I depleted my air supply but managed to escape to the surface while my partner remained entangled. As I returned to her aid with additional air, she freed herself and safely ascended. That close call contributed much to formalize and amplify the safety practices used when diving near gill nets.

A recent focus of the potential adverse effects of ALDFG on human health is from the degradation and subsequent ingestion of plastics in seafood. Once fishing gear is lost at sea or washed onto shorelines, exposure to ultraviolet radiation, waves, and other forces can cause fragmentation and degradation, producing much smaller pieces defined as microplastics (1 µm to 5 mm) (Cera et al., 2020; Wright et al., 2021). Microplastics are of growing concern in marine and freshwater environments, but the harm caused by ALDFG in the context of its contribution to microplastic pollution in the ocean is not well understood (Lusher et al., 2017).

As plastic ALDFG degrades into microplastics, these smaller pieces can infiltrate the food web, from tiny planktonic organisms to larger marine mammals. Studies have shown that nylon and other plastics commonly used in fishing nets release microplastics under laboratory conditions (Montarsolo et al., 1990). Further, microplastic fragments have a higher surface area to volume ratio, thus increasing the potential of leaching contaminants that accumulate in biota (Thushari and Senevirathna, 2020).

The potential risks to humans from microplastic bioaccumulation include risks to individuals who ingest seafood that has elevated microplastic concentrations in tissues, and food security risks if quantity and adverse effects of microplastic ingestion is sufficient to cause population-level declines in important fish stocks (Carbery et al., 2018; Cera et al., 2020; Garrido Gamarro and Costanzo, 2022; GESAMP, 2016, 2015; Lusher et al., 2017). The risk to humans from microplastic ingestion is relatively low because microplastics tend to be lodged in the gastrointestinal (GI) track of higher trophic level organisms. Humans generally do not eat the GI track of those organisms. Lusher et al. (2017) analyzed the potential ingestion of microplastics and plastic additives through consumption of shellfish and small fish that are consumed whole, and they concluded that the risk of adverse effects in the human consumer was negligible. Thus far, no research has shown that the toxicity of microplastic is likely to cause population-level declines that would lead to a food security issue (GESAMP, 2016).

While the effects of ALDFG on human health is an active area of research, at this time, the data suggest that the impacts to human health are small relative to the impacts to other biota (Garrido Gamarro and Costanzo, 2022).

D. Maritime Safety Impacts

ALDFG is often identified as a hazard to navigation, but there are few documented reports of maritime accidents caused by ALDFG in the literature (GESAMP, 2021). Hong et al. (2017) reported on 2,386 instances of Korean navy ships' propellers becoming entangled with ALDFG over 6 years. These entanglements required an average of 136 diver hours to remove the entangling gear and required the ships to be moved to port, taking them out of commission for about 2 days for every incident. Another prominent incident in the news was the incapacitation of the Russian submarine *Alagez* in 2005, which was stuck on the bottom of the Pacific Ocean for 3 days ensnared by fishing net and cables until a British remotely operated vehicle cut the submarine free, facilitating the rescue of all sailors aboard the vessel (RadioFreeEurope, 2005). In the United States, tangled crab pot lines grounded passenger ferries several times from 2017 through 2019 in Washington (Pilling, 2019; Thompson, 2018).

The USCG Marine Casualty & Pollution Data for Researchers includes information from the year 2013 of 269 incidents resulting in casualties associated with fouling in fishing gear throughout the United States and its territories. These 269 fishing-gear-related incidents represent 0.2% of the 132,717 incidents reported involving vessels that year. Data from more recent years were unavailable. Vessels involved in the fishing gear-related incidents included 221 commercial fishing vessels, 26 passenger vessels, 7 recreational vessels, 9 towing vessels, 4 unspecified vessels, 2 freight ships or barges, and 1 tank barge (USCG and USDHS, 2022). Like information on some animal injuries and whale entanglements from fishing gear, these reports do not specify whether the gear was active or ALDFG.

Fishers and fisheries managers often note vessel conflicts as a cause of loss of active fishing gear rather than an effect of ALDFG. However, there are some exceptions where hazards to navigation from ALDFG are noted. In surveys with fishers, resources managers, and researchers in Florida, USVI, and Puerto Rico, navigation obstruction from ALDFG was identified as an effect by 7.9% of respondents, indicating personal experience with ALDFG as a hazard to navigation (Matthews and Glazer, 2009).

Fisheries managers in Michigan reported that in 2014 there were multiple recreational vessel entanglements with abandoned trap nets in Lake Michigan, with at least one incident causing significant injuries (Nick Torsky, Michigan Department of Natural Resources, personal communication). Similarly, in 2022 a recreational sportfishing vessel became entangled in an abandoned trap net, causing significant damage to the vessel (Seth Herbst, Michigan Department of Natural Resources, personal communication).

E. Impacts Attributable to Foreign Countries [§ 135 (5)]

As noted In Section III.B, oceanic processes can transport ALDFG long distances, resulting in ALDFG from foreign fisheries occurring in the waters and on the shorelines of the United States and its territories. While the majority of ALDFG in waters of the continental United States are from U.S. fisheries, there have been some documented adverse effects from foreign sources on the U.S. East Coast (Imzilen et al., 2021; Kimak et al., 2022). Outside of the continental United States, the adverse effects from ALDFG attributable to foreign fisheries is more of a concern, particularly in Hawai‘i, Alaska, and Pacific territories (Donohue et al., 2001; Henderson, 2001; PIFSC, 2010; Suka et al., 2020).

However, it is not always possible to determine the source fishery of ALDFG, especially if it lacks marking or has deteriorated into small pieces (Lebreton et al., 2022; McWhirter, 2022). Even when a piece of ALDFG can be identified as to gear type (e.g., trawl net or FAD), without identifying marking, it is often impossible to determine its fishery of origin (He and Suuronen, 2018; Lebreton et al., 2022; Stelfox et al., 2019). Understanding oceanic transport processes can assist in identifying likely sources of ALDFG from foreign sources that are affecting the United States and its territories (Chassignet et al., 2021; Hardesty et al., 2017).

Most of the documented adverse effects from ALDFG attributable to foreign fisheries are similar in nature to the adverse effects of all ALDFG which were described in Section IV.A. These effects include ecological effects to species and habitats, economic effects to fishers and non-fishing maritime users, and navigation and safety impacts (GESAMP, 2021). One adverse effect which may be unique to ALDFG that has been transported long distances is the potential to introduce aquatic invasive species, which can disrupt the ecology of aquatic habitats and outcompete native species (Barnes, 2002; Gilman et al., 2021; PIFSC, 2010). Though there is no documented case of aquatic invasive species being transported into U.S. waters on ALDFG, it is a potential area of further research.

South Atlantic, Gulf of Mexico, and Caribbean Regions

As described in Section III.B, foreign fishing gear has been reported in Florida and the Gulf of Mexico from as far away as Africa and possibly Spain and Portugal (Baske and Adam, 2019; Kimak et al., 2022; Erzini et al., 2008; Sobrino et al., 2011). Octopus pots, which are not used in U.S. East Coast fisheries, are lost in large numbers from fisheries along the west coast of Europe and Africa (Erzini et al., 2008) and are regularly found along shorelines in Florida, including in National Parks (Thomas Pitchford, Florida Fish and Wildlife Conservation Commission, personal communication). No data were available related to the adverse effects of these derelict octopus pots.

Drifting FADs from Atlantic tuna fisheries have also been documented beaching in the South Atlantic, Caribbean and Gulf of Mexico regions. Approximately 19%-20% of the estimated 12,000 FADs deployed since 2013 by the French fleet in the Atlantic Ocean were documented to have beached in nearshore areas, including locations in the Gulf of Mexico and Florida (Imzilen et al., 2021). The Caribbean FAD Tracking Project is a crowd-sourced research project identifying FADs beached in nearshore and shoreline areas in the Caribbean. From 1999 through 2021, 171 beached FADs were reported in locations throughout the Gulf of Mexico and along the east coast of Florida. Sixty-eight of the beached FADs were reported in national or state parks in the United States, marine protected areas (both domestic and foreign), and foreign conservation areas (Kimak et al., 2022). As noted above, drifting FADs that snag in nearshore habitats and wash up on beaches are known to damage important habitats (Balderson and Martin, 2015; Consoli et al., 2020).

North Pacific (Alaska) Region

As noted in Section III.B, the Aleutian Islands accumulate ALDFG from throughout the Pacific, likely transported along the North Pacific Current and the Alaska Current. Trawl webbing, ropes, and netting have been documented on remote Aleutian Islands in important habitats for pinnipeds (Fowler, 1987; Johnson, 1990; Manville, 1990; Merrell, 1980). Foreign fishing sources for this ALDFG include Japan, Russia, Norway, Korea, China, and Taiwan (Manville, 1990; Merrell, 1980).

Fowler (1987) identified marine debris, including ALDFG, as a major source of mortality for the Northern fur seal population on the Pribilof Islands. The origin of ALDFG was not always known, nor was it always clear whether the seals became entangled with active gear or ALDFG. Modeling studies suggested that 50,000 fur seals may have been killed annually by entanglement in trawl web and other debris during the 1970s (Fowler, 1987).

Western Pacific Region

The relatively large amount of ALDFG affecting Hawaiʻi and the Papahānaumokuākea Marine National Monument is an example of the accumulation of ALDFG from all over the Pacific Rim through the action of ocean currents (Lebreton et al., 2018; Lebreton et al., 2022; Morishige et al., 2007; Ribic et al., 2012b). The source of most of this accumulated ALDFG is unknown, but Lebreton et al. (2022) found that debris items (mostly ALDFG) with legible writing on them that were collected from the North Pacific subtropical gyre, suggested that the debris came from Japan, China, Korea, the United States, and Taiwan.

Researchers have documented the adverse effects of accumulated marine debris in the Papahānaumokuākea Marine National Monument, which is mostly ALDFG, on the Hawaiian monk seal, green sea turtles, and other species, as well as damage to coral reefs (Boland and Donohue, 2003; Donohue et al., 2001; Henderson, 2001). Donohue et al. (2001) reported that the nearshore coral reefs of the Papahānaumokuākea Marine National Monument were damaged by ALDFG moving across shallow reefs through wave action, breaking coral heads and damaging other biota. They noted that in some cases 20% of the weight of ALDFG was coral fragments tangled in ALDFG.

Drifting FADs are used extensively in conjunction with purse seine gear in commercial tuna fishing in the Pacific Ocean, including by U.S. tuna fishing companies (Gershman et al., 2015). As noted in Section III, it is estimated that over 42.1% of the nearly 40,000 drifting FADs deployed in the Western and Central Pacific Ocean from 2016 through 2020 were abandoned, with 7.4% beached and 21.1% deactivated and left drifting (Escalle et al., 2020a, 2020b). A portion of those FADs are known to have beached in U.S. territories and Hawaiʻi (Escalle et al., 2020a). Banks and Zaharia (2020) estimate that 9,254 to 13,436 abandoned FADs wash into nearshore habitats every year in the Western Central Pacific Ocean. Drifting FAD components have been documented in ALDFG retrieved from nearshore and shoreline areas of Hawaiʻi, the Papahānaumokuākea Marine National Monument, and in the Pacific Remote Islands Marine National Monument. In Palmyra Atoll, the land managers have recorded 27 FADs beached in nearshore and shoreline areas since 2016 (PANWR, 2022).

Drifting FADs that snag in nearshore habitats and wash up on beaches are known to damage important habitats including coral reefs (Balderson and Martin, 2015; Consoli et al., 2020). The adverse effects of beached FADs in Hawaiʻi and the U.S. Pacific territories on coral reefs and other nearshore habitats are similar (Donohue et al., 2001).

Drifting FADs also represented 0.3% of the type of marine debris snagged by Hawaiʻi pelagic longline fishers from 2008 through 2016, demonstrating some adverse economic effects to those fishers (Uhrin et al., 2020).

Table IV.9. Ecological impacts of ALDFG to species/habitats in the Western Pacific region attributable to foreign sources.

Fishery	Gear type	Impacts	Reference
Foreign	Nets, multiple gear types	173 entanglements of Hawaiian monk seal documented in NW Hawaiian Islands (Papahānaumokuākea Marine National Monument); green sea turtles	Henderson, 2001; PIFSC, 2010
Foreign	Nets, multiple gear types	Net-affected sites at Papahānaumokuākea Marine National Monument had significantly lower percent cover of coral and macroalgae than control sites	Suka et al., 2020
Foreign	Nets, multiple gear types	Damage to and breakage of corals in shallow reefs of the Papahānaumokuākea Marine National Monument	Donohue et al., 2001

V. EVALUATION OF ALDFG MANAGEMENT MEASURES [§ 135 (3)]

Prior to making recommendations for management measures, as requested by Save Our Seas 2.0 § 135 (3), it is necessary to review and evaluate those that have already been taken. This section includes in-depth case studies, an assessment of the risks of gear loss and adverse impacts for different fisheries, and a review of management gaps. Section VI provides the recommendations for management measures.

A. ALDFG Management Measures

Both voluntary and regulatory management measures have been taken to prevent fishing gear loss and reduce the harmful effects of ALDFG on species, habitats, economies, and safety. These measures can be categorized by three types: prevention, mitigation, and remediation (Gilman, 2016; Gilman et al., 2022; GGGI, 2021), specifically:

- Preventive measures reduce the amount of fishing gear that becomes ALDFG;
- Mitigation measures reduce the harmful effects of ALDFG in situ (e.g., by reducing ghost gear through fishing gear design); and
- Remediation measures reduce ALDFG in the environment by retrieving ALDFG from the water or shoreline.

Each type of measure is necessary in most fisheries with the general acceptance that prevention is more cost effective than mitigation or remediation. The measures that prevent ALDFG are first priority, followed by measures that reduce effects of ALDFG, such as biodegradable escape mechanisms for lost shellfish pots. And retrieval of ALDFG is critical in many fisheries, especially where gear loss is high and gear design precludes reduction in ghost fishing or habitat effects. Fishing gear will be lost even in the best managed fisheries, so having a systematic approach to mitigating the effects of ALDFG and retrieving a significant percentage of lost ALDFG are important components of an ALDFG management program.

Four other management measures do not fall neatly into the categories of prevention, mitigation, and remediation:

- Reporting;
- Research;
- Regulatory monitoring and enforcement; and
- Third-party seafood certification programs.

Reporting of lost fishing gear is an important component of any well-managed fishery. Reporting is a type of mitigation of ALDFG effects and documents gear loss, facilitates immediate retrieval of lost gear, and can help to prevent adverse effects on navigation. Research is important to document the adverse effects of ALDFG and is also critical for testing new gear designs or evaluating the effectiveness of management measures. Regulatory monitoring and enforcement ensure that management measures designed to prevent and mitigate ALDFG are followed. They ensure that fishers who follow the rules are rewarded while fishers who do not follow the rules are penalized. Third-party seafood certification programs can be powerful tools to drive better management of fishing gear (Winson et al., 2022). Consumers look to these programs to inform their seafood purchases.

While fishers and fisheries managers play a primary role in ALDFG management, the GGGI Best Practices Framework for Management of Fishing Gear identifies additional stakeholders with potential roles in ALDFG management, including fisheries organizations, ports, municipalities, researchers, fishing gear designers, ecolabel certification programs, seafood companies, NGOs, and international development and funding agencies (GGGI, 2021). All these parties have a role in one or more management actions described in this section.

Fisheries management goes hand-in-hand with ALDFG management. Many of the well-established methods for managing fisheries related to harvest and sustainability have application to gear loss as well. There are management measures (required and voluntary) where reduction in gear loss and/or harmful effects of ALDFG is a byproduct of other management goals. Input controls, for instance, which include limits on gear numbers or limits on fishing seasons, may also serve to reduce gear loss (e.g., by restricting the amount of gear being fished, thus preventing gear loss from gear conflicts). Output controls, such as catch shares, also have been shown to reduce gear loss (e.g., by reducing competition, thus preventing fishing in sub-optimal conditions which can result in more frequent gear loss) (Citta et al., 2013; IPHC, 2022a). Hence, ALDFG management is best approached through the lens of fisheries management so it can be fully integrated into the accepted processes where harvest, bycatch, and habitats are managed within the context of sustainable fisheries.

Described below are ALDFG management measures that are used to varying degrees throughout the fisheries of the United States and its territories and serve to prevent, mitigate, and remediate harmful effects of ALDFG. Included in the descriptions of management measures are some case studies of their implementation in different regions and the partners involved in the implementation. Limited examples from other nations are presented to highlight unique programs that have no parallel in the United States and its territories.

Management measures that serve to prevent the loss of fishing gear include the following:

- Input control (e.g., gear restrictions, fleet reductions, spatial/temporal closures);
- Output control (e.g., catch limits);
- Spatial/temporal separation of fisheries and gear types;
- Vessel traffic controls;
- Fishing gear marking and identification;
- Best fishing practices (e.g., crew training, gear and vessel maintenance, secure stowage);
- Education, awareness, and training; and
- Appropriate disposal options for recovered ALDFG and end-of-life fishing gear.

Management measures that serve to mitigate the harm caused by ALDFG include:

- Reporting processes for lost gear;
- Disabling mechanisms, which allow wildlife to escape from derelict pots; and
- Gear redesigns that reduce loss, reduce persistence of lost gear in the environment, and minimize ghost fishing.

Management measures that remediate the harm caused by ALDFG include:

- Mandated attempted recovery of gear at the time of loss (when safe to do so); and
- ALDFG retrieval (including recovery at time of loss as well as after loss and out of season).

Prevention Measures

Input Controls

Input controls, such as limiting the allowable number of vessels that can participate in a fishery and limiting the size and number of gear types that can be used in a fishery, are two of the simplest ways to reduce ALDFG, because less gear in the water means fewer opportunities for gear to be lost (GESAMP, 2021; Uhrin, 2016). These actions can include simple schemes like limited access (no new entry) permitting, permit buyback programs, and limits on size and amounts of gear allowed per vessel (Escalle et al., 2019; WDFW, 2018). Limits on the numbers of FADs allowed to be deployed in the Western Central Pacific Ocean is an example of an input control, as is the limit on the number pots that can be fished by recreational crabbers in the U.S. portion of the Salish Sea. These also include spatial and temporal restrictions further described below.

Input controls that reduce the amount of gear deployed can be incentivized by aggressive pot or license buyback programs. Though challenging and requiring careful balancing of economic and cultural considerations of a reduced fleet, similar measures have been accomplished in other fisheries, driven by factors such as limited resources and bycatch of protected species. The effectiveness of these types of programs has been evaluated with mixed results but are useful in achieving capacity reduction (Teh et al., 2017).

Output Controls

Output controls include harvest limits such as total allowable catch, individual transferable quota, and catch share programs (Selig et. al., 2017). These programs can translate to smaller fishing fleets with longer, more flexible fishing seasons. Output controls can reduce gear loss caused by gear and vessel conflicts, poor weather conditions, and setting of gear in risky or marginal locations (NPFMC, 1997; Macfadyen et al., 2009; Citta et al., 2013).

Catch share programs assign species-based shares of the fishery harvest (Selig et.al., 2017). These programs in the United States began with the Atlantic sea scallop fishery. In 2022, there were 17 catch share programs in the U.S. federally managed fisheries. Catch share programs can eliminate the need to "race for fish" and allow fishers to make harvest decisions based on market and weather conditions. This reduces the likelihood of gear loss, while also improving safety at sea, economic performance, and achievement of annual catch limit goals (NOAA Fisheries, 2017b).

Cooperation between vessels in catch share programs can provide flexibility to allow hauling others' fishing gear when warranted, remediating impacts of gear loss. Logbook data from the IPHC from 1991 through 2019 show a steep reduction in total halibut gear loss and loss ratio (loss per total haul) following the implementation of the Alaska Halibut and Sablefish Individual Fishing Quota catch share program in 1995 (IPHC, 2022a).

Case Study: Output Controls

Bering Sea Aleutian Islands Crab Rationalization Program
Region: North Pacific
Partners: fisheries managers, fishers

The Crab Rationalization Program of the Bering Sea and Aleutian Islands crab fisheries is an example of output control fisheries management that results in a substantial reduction in ALDFG. It includes issuance of quota shares to eligible fishers who receive an individual fishing quota, which is an exclusive harvest privilege for a portion of the total allowable catch for the specific fishery. Fishers can form cooperatives to pool individual fishing quotas.

Prior to rationalization, pot loss rates in the Bering Sea and Aleutian Islands fisheries were estimated at 10%-20%, equating to an annual loss of 5,000-10,000 crab pots in the nine fisheries covered by the rationalization program (Citta et al., 2013; NOAA Fisheries, 2004b). Since crab rationalization, the estimated loss rate was reduced to a 10-year annual average of 1.32%, based on data summaries provided by ADFG.

The previous drivers for gear loss (e.g., crowded grounds, fishing in adverse conditions) changed dramatically with rationalization (Citta et al., 2013). The nature of the pace and market forces of the fisheries were drastically altered as fishers no longer had to compete with each other on the fishing grounds to catch as much as possible as fast as possible. Fishing is now safer, more efficient, more controlled, and more regulated. The size of the fleet is more compressed as vessels pool their quotas and fishers avoid risky areas. Furthermore, gear transfer and sharing regulations provide flexibility for cooperative groups, as any vessel registered for a fishery operating under the individual fishing quota management plan may "collectively operate and transport crab pot gear of another registered and active vessel." This creates multiple efficiencies for the fleet, reduces total gear on the fishing grounds, and allows fishers to collect each other's wayward crab pots if they encounter them during fishing (ADFG, 2021).

Spatial/Temporal Separation

Spatial and/or temporal separation management actions generally include restricting the timing and location of fishing through designating specific fishing seasons and fishing areas. Major causes of loss in many fisheries include conflicts between types of fishing gear and conflicts between gear and vessels (Richardson et al., 2021; Maselko et al., 2013). When mobile and static gear operate in the same space at the same time, there are often conflicts. In the Pacific

Northwest there have been documented conflicts between salmon troll gear and Dungeness crab pots. In New England, there are conflicts between lobster pots and bottom trawl gear. Similarly, where blue crab pot and shrimp trawls co-occur, there are often issues with gear conflicts. Spatial restrictions that can reduce fishing gear loss include separation of different fishing gear types (e.g., pot gear and trawl gear); exclusion of fishing gear from navigation channels or other high-density vessel traffic areas; separation between commercial and recreational fishing activity; and exclusion from sensitive habitats and submerged features (Gilman et al., 2022; GGGI, 2021). Temporal restrictions that can reduce fishing gear loss include restricting fishing or reducing soak time during foul weather months and allowing only one gear type at a time in a specified fishing area, such as designated trawl areas where pots are prohibited during trawl season.

Case Study: Spatial/Temporal Separation

Spatiotemporal Separation of Fishing Sectors
Regions: South Atlantic and Gulf of Mexico
Partners: fishers, fisheries managers, lawmakers

In South Carolina, commercial blue crab trap fishers recently found they could increase their catch by setting their gear in the General Trawl Zone established for shrimp trawls. This caused gear entanglements and loss, as well as conflict between the two sectors. During the shrimp trawl season, the trawlers were unable to fish in their primary grounds when covered with crab pots without risking gear and vessel entanglement with the pots. The conflict eventually led to a 2022 law prohibiting commercial pots in the waters that are open to shrimp trawling (SCDNR, 2022; Mel Bell, SCDNR, personal communication). Similar regulations are in place throughout the South Atlantic and Gulf of Mexico where mobile gear fisheries such as trawls co-occur with fixed gear fisheries.

Vessel Traffic Controls

Vessel traffic controls are used to prevent conflicts between fishing and vessel traffic. They serve to reduce navigational hazards from floating ALDFG and also reduce loss of fishing gear due to vessels damaging or carrying away active fishing gear. Commercial fishing grounds often overlap with commercial shipping lanes, recreational fishing and boating activity, transport ferries, cruise liners, tug-and-tow routes, and anchorages. Fishing gear conflicts with these vessel transportation activities is a known cause of ALDFG, as buoy lines can be severed or bound in propellers, gear can become attached to vessels and travel outside the fishing area, and gear can become damaged so that recovery becomes challenging or impossible (Drinkwin, 2016; Sullivan et al., 2019; Bilkovic et al., 2014). Voluntary and regulatory separations between fishing activity and concentrated areas where other uses occur can reduce gear loss (University of Washington Sea Grant, 2022).

In the pot-and-trap fisheries of the Mid-Atlantic states, vessel traffic has been identified as a cause of gear loss in the Chesapeake Bay and New Jersey blue crab fisheries. Voluntary collaborative agreements between fishers and vessel traffic interests can help to solve this problem. On the U.S. West Coast, a Crabber/Towboat Lane Agreement was developed over 50 years ago in response to regular spatial conflicts between commercial crabbers and oceangoing tugs. Washington Sea Grant has led this collaboration since the 1990s, which holds negotiations between the user groups multiple times a year (University of Washington Sea Grant, 2022).

Case Study: Vessel Traffic Controls

Commercial Crabber Towboat Lane Agreement
Region: Pacific
Potential replication: areas with high commercial or recreational vessel transit traffic
Partners: Sea Grant programs, transportation agencies, USCG, maritime traffic industry, fisheries managers, fishers

Each year, Washington Sea Grant identifies tug-and-tow lanes on the U.S. West Coast to both reduce loss of fishing gear caused by vessel traffic and to improve navigation safety. Prior to the establishment of these lanes, an estimated $1.2 million of crab gear was lost to vessel conflicts, and tugs and freighters could pay $50,000 or more to dry-dock their vessels when crab pot lines fouled their propellers (Scigliano, 2014). Now, established vessel traffic lanes along 680 miles of coastline from San Francisco, California to Cape Flattery, Washington give fishers access to more fishing grounds and provide vessel operators predictable, safe passage. This voluntary program has been in place for over 40 years. Year-round, summer, and advisory tow lanes are agreed to by industry at two regularly scheduled meetings each year, and locations of the lanes are posted online with coordinates and maps.

Marking and Identification of Fishing Gear

FAO (2018) has identified fishing gear marking and identification as a critical management measure to address ALDFG. Adequate visible gear marking, especially for fixed gear such as sink or set gillnets, pots and traps, and longlines can increase visibility, reduce navigational risks, and avoid accidental loss of gear via vessel strikes or conflict with mobile fishing gear (e.g., trawl gear). Brightly colored floats, buoys, and vertical poles (high-flyers) are commonly used for marking gear, and augmentation with reflective material and constant or flashing beacon lights can greatly increase visibility of gear, especially in the dark. This helps fishers find their own gear and increases the ability for other users to avoid interacting with the fishing gear. Inadequate buoys can also be harder to relocate by fishers who deploy them.

In the USVI fish and lobster trap fishery, inadequate buoys were identified as a cause of gear loss. Investing in high quality, high visibility buoys can reduce this loss. Regulations specifying the kind of buoy and markings including the fisher’s identification are common in many fisheries.

In addition, gear marking rules that require owner identification can reduce intentional discarding of gear and increase fishers’ incentive to report gear loss (Bowling, 2016; Gilman, 2015; Macfadyen et al., 2009). Added technologies such as radio frequency identification (RFID) tags embedded in buoys can electronically link video and positional location with catch and effort data, and alert managers of theft, tampering, extended soak time, and possible gear loss or misplacement (He and Surronen, 2018; Northwest Treaty Tribes, 2015; Teemfish, n.d.). Furthermore, radio buoys configured with GPS systems provide fishers and regulators real-time knowledge of gear locations and movement and can provide alerts of abnormal movements or movements out of fishing areas (Blue Ocean Gear, n.d.; FAO, 2020).

Some marking schemes involve affixing plastic tags to shellfish pots. When separated from their pots, these tags can contribute to the problem of marine plastic pollution (Ebbesmeyer et al., 2012). This potential problem can be avoided by employing marking schemes with more durable attachment procedures.

Case Study: Marking and Identifying Fishing Gear

Marking Untended Shellfish Gear in North Carolina
Region: Mid-Atlantic
Partners: fisheries managers

There are no closed periods in the North Carolina blue crab fishery, but regulations require fishers to tend their gear at least every 5 days (NCMFC, 2020). To identify if a pot is lost or abandoned, North Carolina fisheries managers place a plastic tag on the door of blue crab pots that must be removed by the fisher to retrieve any catch. Fisheries managers return to check on the pot after 6-7 days. If the tag is in place, indicating that the pot has not been tended, they determine it is lost or abandoned and retrieve it, thereby eliminating any ghost fishing. The law further states that it is unlawful to have any fishing equipment in coastal waters that contains "…edible species of fish unfit for human consumption." (NCMFC, 2020). This was also enacted to incentivize tending of gear and reduction of gear abandonment.

Remote Detection and Location of Lost or Derelict Crab Traps
Region: Pacific
Partners: Commercial fishers, NFWF, NOAA MDP

Dungeness crab traps are at high risk of loss or entanglement, resulting in financial loss to the fisher and impacts to the environment. With initial funding from NOAA MDP through the NFWF Fishing for Energy partnership, Blue Ocean Gear developed a Smart Buoy prototype to detect and locate lost crab traps. The project demonstrated the ability of these devices to detect and locate lost fishing gear to allow fishers to know where their gear is located at all times. As part of this project, five Smart Buoy devices were assembled and successfully tested off a fishing boat in typical operations to demonstrate operational compatibility, robustness of design, and utility of data transmitted (NFWF, 2017).

Best Fishing Practices

Best fishing practices such as gear tending, gear and vessel maintenance, and secure stowage are basic measures to prevent ALDFG. Operator error, inexperience, gear and vessel malfunction, and other avoidable problems are known to be causes of gear loss (Antonelis, 2013; Bilkovic et al., 2016; Richardson et al., 2018). Many of these problems can be avoided by adopting general and/or fishery-specific best fishing practices. Fishers can practice continued maintenance of fishing gear to ensure it is operable under all possible conditions, without weak points such as abrasions on lines or excessive corrosion on hardware that could lead to breakage and loss. Similarly, regular maintenance and upkeep of fishing vessels and equipment used to set and retrieve gear (e.g., hydraulic systems) can reduce the possibility of failure during fishing operations that lead to gear loss. Regular or constant tending of static fishing gear also reduces the likelihood of gear loss. If fishers remain with or nearby their gear, they can monitor and address problems as they arise and reduce the occurrence of theft or vandalism, which are causes of loss in some fisheries.

Education, Awareness, and Training

Education, awareness, and training is an expansion of the best fishing practices management strategy, covering everything from fishing crew training to boater education. Fishing crew training for operation of the vessel, fishing gear, and equipment can help prevent loss of fishing gear from operator error. Training of newer fishers can include sharing knowledge and experience related to the fishery and fishing grounds, such as nuances of how tidal cycles and water depths affect fishing operations in certain locations, and the location of snags or other hazardous areas to avoid. Building awareness about the effects of ALDFG is also an important component of fisher education.

Education and outreach on best practices in recreational boating and fishing are also effective management strategies, because many recreational fishers engage in fishing sporadically and inexperienced fishers are more prone to lose their gear (Drinkwin, 2016). Educating boaters about how to recognize and avoid fishing gear is another important practical management measure that can help prevent ALDFG. In the Florida Spiny Lobster fishery, vessel conflicts are a prevalent cause of loss after hurricanes have moved pots to new locations. Targeted education campaigns to build awareness within the boating community on how to recognize and avoid commercial lobster pots could be an effective method to reduce loss from this cause.

In addition, recreational boaters are not required to have a license in Florida. In other states, recreational boaters must pass a boater licensing process that includes education on good seamanship, navigation, and boater safety. A model outreach program was developed by Wisconsin Sea Grant, local tribal governments, and fishing associations who worked together to educate boaters on how to identify and avoid active fishing gear (Wisconsin Sea Grant, 2015).

Case Studies: Education, Awareness, and Training

Preventing Debris and Crab Trap Loss in New Jersey
Region: Mid-Atlantic
Partners: academia, NOAA MDP, recreational fishers

Storm events, improper rigging, and damage to lines from power boats can all lead to pot or trap loss. Through a Marine Debris Prevention through Education and Outreach Grant, NOAA MDP (2017) funded Rutgers University in 2015 to work with recreational crabbers and recreational boaters on an education and outreach campaign to prevent recreational crab pot loss in New Jersey. Rutgers engaged recreational crabbers, teachers, students, and the coastal community to prevent recreational crab pot loss. Rutgers hosted crab pot workshops aimed to teach recreational crabbers about marine debris and how to properly rig their pots. These workshops also provided crabbers with "Rig It Right" kits that showed crabbers the correct type of rope and buoys to use, the required biodegradable panels, and other best practices. Similar outreach was provided to the boater community to provide guidance on best practices to avoid buoy lines and why ghost fishing is an issue (NOAA MDP, 2017).

Educating Recreation Boaters in Lake Superior
Region: Great Lakes
Partners: fishery managers, NGOs, Sea Grant, recreational fishers

In 2011, the Wisconsin Sea Grant Program partnered with the Apostle Islands Sport Fishermen's Association and the Great Lakes Indian Fish and Wildlife Commission Law Enforcement team to conduct an education project aimed at reducing gillnet loss in Lake Superior from causes including vessel conflicts with recreational boats. The program focused on two main target audiences: commercial gillnet fishers and recreational boaters/anglers. Workshops for new commercial and tribal fishers to discuss best practices to avoid gear loss. The program also developed education materials for recreational boaters focused on avoiding deployed gillnets, recognizing buoys and net configuration, removing nets from propellers, and protocols to follow if a derelict net is found. The program developed a video outlining this information for boaters/anglers (Conklin, 2014; NOAA MDP, 2022b; Wisconsin Sea Grant, 2015, 2022).

Louisiana Crab Fisher Training
Region: Gulf of Mexico
Partners: fisheries managers, fishers, Sea Grant, NGOs

The Louisiana blue crab fishery is an open access fishery with no limits to the numbers of fishers participating. This allows access to individuals with little or no fishing experience. Fisher inexperience is often cited as a driver of ALDFG (GGGI, 2021; Drinkwin, 2016; Macfadyen et. al., 2009). To ensure that fishers have the knowledge and technical expertise to safely engage in commercial crab fishing, Louisiana Department of Wildlife and Fisheries requires new entrants to complete the Louisiana Fisheries Forward Commercial Crab Gear Requirements Program. The program includes a boating safety course, four online courses on best fishing practices (including information on ALDFG), and field training through an apprenticeship or sponsorship with an experienced fisher (LDWF, n.d.). The Louisiana Department of Wildlife and Fisheries and Louisiana Sea Grant College Program also collaborate on the Louisiana Fisheries Forward voluntary education program for commercial fishers. The program hosts workshops and training days for seafood industry leaders and fishers. The program developed eight training videos and over 20 fact sheets covering information on impacts of lost crab pots and how to safely remove ALDFG (Louisiana Fisheries Forward, n.d.).

Provide Disposal Options for ALDFG and End-of-Life Fishing Gear

Appropriate disposal options for recovered ALDFG and end-of-life fishing gear help prevent the intentional discard of fishing gear. Derelict fishing gear is often encountered and hauled onto fishing vessels during regular fishing operations, especially in bottom trawl and longline fisheries (KIMO International, 2021). These encounters can damage fishing gear to various degrees, costing the recipients of the haul both time and money in net repairs and lost fishing time. Sometimes, there is no room on the vessel deck for storage of ALDFG, and therefore it is discarded from the vessel. Trawlers may have specific locations outside their fishing grounds where these encountered gear items are dumped (Laura Ludwig, Center for Coastal Studies, personal communication).

Deck space can also be limited onboard fishing vessels, making storage of encountered ALDFG inconvenient (Gilman et al., 2022). Some Korean municipalities have deployed floating barges for fishers to deposit debris, rather than having to store it (Hong et al., 2015). Even when there is deck space for ALDFG, it can be cost-prohibitive for the vessel encountering ALDFG to coordinate and pay for disposal. Also, in most fisheries, it is illegal for one fishing vessel to have another fishers' gear onboard, creating a disincentive to bringing encountered ALDFG into port for proper disposal (Bowling, 2016).

In addition, old and worn end-of-life fishing gear may be left at sea when there are no recycling/disposal options in port. Intentional discards such as this can be reduced by ensuring that port facilities have adequate disposal options for large fishing gear accessible to the fishing fleet. Fishing gear-specific recycling and disposal bins placed in easily accessible locations at port facilities can assist in reducing dumping at sea.

Creating markets for end-of-life fishing gear through circular economy models (Charter, 2018) have assisted in diverting end-of-life fishing gear away from discard in the ocean and from dry-storage in fisheries in other countries (Bureo, 2022; Ocean Conservancy et al., 2020). This approach can include extended producer responsibility components, which are being explored in the European Union and Canada (CCME, 2020; EC, 2020; MRAG Europe, 2020; OSPAR Commission, 2020). There are several programs, including the NFWF's Fishing for Energy Program, Bureo NetPlus, Net Your Problem in the United States, and Fishing for Litter in Europe that work collaboratively with fishers and ports to provide disposal and recycling options (see case studies below). Any of these options could reduce the illegal discard of end-of-life fishing gear at sea (Bureo, 2022; KIMO International, 2021; McCoy, 2010). Appropriate disposal of recreational fishing line is also a component of this management measure.

MARPOL Annex V covers regulations for a garbage management program and outlines disposal procedures for ships at sea (IMO, 1973). Every ship of 100 tonnes gross tonnage and above, every ship certified to carry 15 or more persons, and fixed and floating platforms are required to carry and implement a garbage management plan. Compliance is managed and enforced through Port State Control, garbage record books, garbage reception receipts, and audits and assessments conducted by Port State Control. In the United States and its territories, the USCG is the authority overseeing compliance with MARPOL Annex V. The USCG keeps a public list of MARPOL Annex V facilities at its Maritime Information Exchange website.

Governments are required to provide adequate port reception facilities to streamline disposal and make the disposal quick and affordable in order to encourage participation. The 50 U.S. ports with the top fisheries landings are MARPOL Annex V facilities and do supply disposal options for fishing vessels, but they do not all provide options for recycling of fishing gear as recommended by NOAA Fisheries (NOAA Fisheries, 2022). Furthermore, many fleets in the United States and its territories use smaller ports that are not MARPOL Annex V facilities.

Case Studies Provide Disposal Options for ALDFG and End-of-Life Fishing Gear

Net Your Problem
Regions: New England, North Pacific, Pacific
Waste management techniques: mechanical recycling
Gear type: end-of-life

Before Net Your Problem started working in Alaska, the most common ways of disposing of fishing gear at its end of life were indefinite commercial storage (Dutch Harbor, Kodiak), landfill (Kodiak, Naknek, Dutch Harbor for a subset of materials) and shipping to Asia for recycling (Cordova). Now that these communities and others in the Pacific and New England regions are working with Net Your Problem, the most common disposal method is mechanical recycling, and disposal decisions are based on material type, volume, and location. Local warehouses allow for the aggregation of smaller amounts of material (in Seattle, Washington and Freeport, Maine) collected from individual fishers or dedicated collection events; however, it is more efficient to load large volumes of material into dry 40 ft containers at the port of origin and ship directly to the recycling facility.

For certain types of gear, preparation and sorting is done by the fishers (gillnets, seines, pots). For others (longline, trawl), that work is done internally or by a third party. Homogeneous loads of materials are then arranged to be shipped to the most appropriate disposal facility given purity, type, quantity, and location.

Fishing for Energy
Regions: New England, Mid-Atlantic, Gulf of Mexico, Pacific, Western Pacific
Waste management techniques: waste to energy
Gear type: ALDFG and end-of-life

Fishing for Energy is a collaboration between NOAA, NFWF, Covanta, and Schnitzer Steel. The program provides a no-cost way to dispose of all types of derelict and retired fishing gear that needs minimal sorting and preparation. As of March 2020, the program had deployed bins at 56 ports in 13 states. Since its inception in 2008, the Fishing for Energy Program has collected 4.95 million pounds of derelict gear. Gear is first sorted at a metal recycling facility, where metals are removed using magnets. The rest of the non-mechanically recyclable materials are then shredded and incinerated to generate electricity at waste-to-energy facilities. Because the types of plastics don't need to be monitored and separated, this reduces the labor costs associated with this type of disposal, while the metals (which have economic value) can be efficiently recycled.

Berkley Respool and Recycle
Regions: All regions
Gear type: ALDFG and end-of-life

Berkley is a for-profit company that manufactures and sells recreational fishing gear. Their Respool and Recycle program to recycle monofilament fishing line launched in 1990 and has since facilitated the safe disposal of more than 9 million miles of fishing line (Berkley, 2022). The company accepts fishing line for recycling through partnerships with marinas, sporting goods stores and also accepts mailed-in line, providing an address on their website. The line is mechanically recycled and later used to make other products, such as spools, tackle boxes, and artificial habitats.

Fishing for Litter
Region: Europe
Potential replication: trawl fisheries
Partners: ports, fishery industry associations, IGOs, NGOs, fishers

As discussed previously, the Fishing for Litter program incentivizes fishers to retrieve marine litter encountered during active fishing by providing waste storage bags and port disposal at no cost to the fisher. The program also supports the fishing industry and participating fishers through promotional material and public communications, creating a positive public relations image for fishers. This helps to mitigate the millions of dollars each year that ALDFG can cause in vessel repairs and malfunctions, gear repairs, and lost harvest (Mouat et al., 2010; Tschernij and Larsson, 2003). It also benefits trawl and net fishers, who catch marine litter and ALDFG in their gear during active fishing, sometimes causing gear damage (KIMO International, 2021).

The Fishing for Litter program now operates 16 projects in 11 countries: Belgium, Croatia, England, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Scotland, and Spain. Slovenia and Montenegro also participated in a pilot project from 2013 through 2016. Programs are supported by Kommunernes International Miljøorganisation (KIMO), an IGO with over 30 member municipalities in eight countries in Europe run by individual organizations such as Bord Iascaigh Mhara (BIM) in Ireland. Each program operates in multiple ports and recruits and supports its own fishers and vessels participating in the program. Over 60 ports and 670 vessels are participating. Most programs involve trawlers as they are most likely to encounter marine litter in their trawls during active fishing. The Irish program supports 244 vessels, mostly trawlers but also some smaller fishing vessels fishing for shrimp with pots. In 2020 the program reported 600 tons of marine litter removed during fishing and properly disposed of through its various partners.

The program includes close collaborations with ports, waste haulers, fishers, and program managers. Ports agree to participate then set up Fishing for Litter disposal sites where fishers can deposit the marine litter collected. The program pays for the waste disposal. In most programs, fishers receive no compensation, but the program promotes their participation and publicizes it on social media, through earned media and in other ways, providing positive public relations for the fishers and the fishing industry.

Mitigation Measures

Reporting

Reporting processes, including no-fault reporting of gear loss, are an important ALDFG management tool. Accurate recording of fishing gear loss that includes the identification and type of gear, location, time of loss, and reasons for the loss aids fisheries management.

First, keeping a record of gear loss through a systematic reporting program and storing those records in an accessible registry will build a clearer picture of the extent and severity of ALDFG per fishery. This will help fisheries authorities to assess the risk of ALDFG to harvest, species and habitats, and navigation (FAO, 2018).

Second, gathering information on timing and location of gear loss, sea conditions, and reasons for loss can indicate the underlying causes of loss. This information can inform preventive fisheries management strategies, such as spatio-temporal separation of fisheries, seasonal closures, gear marking for visibility, and designated vessel traffic lanes (Gilman, 2015; Huntington, 2017; Richardson et al., 2018).

Third, reporting accurate locations of where gear is lost also aids in efficient and sometimes immediate retrieval (Drinkwin, 2017b; Gilman et al., 2021; Morgan, 2019). By keeping an accessible registry of locations and types of lost gear, fisheries authorities can determine areas where ALDFG retrieval operations will likely be most effective and cost-efficient.

Fields for recording lost gear typically exist within fishers' logbooks; however, they are not often required. Fishers may have greater incentive to report lost gear if the reporting requirements are coupled with comprehensive gear marking requirements that include owner identification and consequences if the unreported lost gear is discovered (GGGI, 2021; Gilman, 2015).

Disabling Mechanisms

Disabling mechanisms have been repeatedly shown to reduce the effects of ghost fishing in derelict pots (Antonelis et al., 2011; Bilkovic et al., 2012; Renchen et al., 2014). Disabling mechanisms in lobster and crab pots are often called "escape panels." Escape panels are doors fastened by biodegradable twine made of natural material, usually cotton or jute, to provide egress routes for entrapped animals once the twine has deteriorated. In addition to twine, metal products are used to disable pots, such as galvanic time releases (ADFG, 2021) and steel hog rings (Whitmore et al., 2019). Finally, escape panels made of biodegradable polymer material ("biopanels") cover a hole in the pot, which becomes the escape route once the material has degraded (Bilkovic et al., 2012). Equipping pots with biodegradable material that will degrade over time is a relatively low-cost endeavor for fishers where escape panels are required. Replacing degraded biopanels once or twice a year can be integrated into regular fishing operations.

Other types of disabling mechanisms include escape rings, escape vents, or cull rings, which are small openings in pots and pots that are often required to allow sublegal-sized target species and non-target species to escape actively fishing pots. Small escape rings are effective for reduction in bycatch in active fishing gear but are not designed to reduce ghost fishing of target species/cohorts in ALDFG. Even with escape rings, a lost pot can ghost fish for the length of its structural viability, which could last many years (Breen, 1987; Havens et al., 2008; Maselko et al., 2013; Butler and Matthews, 2015).

Disabling mechanisms are standard in most Dungeness and other crab fisheries in the North Pacific and Pacific regions, as well as in some crab and lobster fisheries in the New England and Mid-Atlantic regions. For the Chesapeake Bay blue crab pot fishery, which does not require disabling mechanisms, Bilkovic et al. (2016) modeled the reduction of ghost fishing of lost pots if pot designs included a viable escape mechanism to allow escapement of any animal trapped in the pots if lost. They predicted that if all pots were deployed with working escape mechanisms, the 3.3 million crabs killed each year through ghost fishing would be reduced to under 440,000 (0.6% instead of 4.5% of total harvest). In the Puget Sound Dungeness crab fishery, NRC (2021) estimated that modifying pot designs and reducing the thickness of the escape cord required in recreational pots would save nearly $500,000 worth of Dungeness crab from ghost fishing mortality annually.

The following factors may influence the effectiveness of disabling mechanisms:

- Biodegradable materials used for pot disablement degrade at different rates, based on several variables including water characteristics (e.g., temperature, depth, salinity), material composition, material thickness, and placement on pot (Araya-Schmidt and Queirolo, 2019; Kimker, 1990; Barnard, 2008; Redekopp et al., 2006; Scarsbrook et al., 1988; Winger et al., 2015). It is important to understand the projected timing of disablement related to durability for fishers balanced against survival time of species entrapped.
- Not all escape panel designs are equally as effective in allowing entrapped animals to escape. The size of the escape panel and the location of the panel on the pot both can determine whether trapped animals can escape (Antonelis et al., 2023).
- Escape panels with hinged doors or gates can remain closed due to biofouling and/or pressure; therefore, it is important for escape panels to have unobstructed openings large enough for entrapped animals to escape (Antonelis et al., 2011; Antonelis et al., 2023; Long et al., 2014; Maselko et al., 2013).

Case Study: Disabling Mechanisms

Pot/Trap disabling mechanisms: biodegradable materials and escape panels
Regions: Caribbean and North Pacific
Partners: fisher associations, researchers, fisheries managers

Fish and lobster pots are a common gear type used throughout the Caribbean. The reef-based, multispecies fishery in the USVI, including over 3,500 pots and traps, accounts for a majority of the landings on St. Thomas and St. John and provides critical subsistence for the community (Renchen et al., 2014). To reduce ghost fishing in lost traps, all traps are required to be equipped with an escape panel fastened by biodegradable twine. If a trap is lost, the twine will degrade over time and disable the trap by providing an egress route for entrapped animals. In 2012, researchers simulated lost fish traps, with both closed and open escape panels, to assess mortalities caused by ghost fishing in derelict reef traps in the USVI. The closed traps accounted for 98% of the total fish mortalities observed. Based on the economic value of the species that were captured and killed, and an expanded estimate of mortality over time, Renchen et al. (2014) estimated the mortality of harvestable fish species equated to approximately $52 per trap per year.

In the mid-1970s, ADFG began requiring all shellfish and bottomfish pots to include a disabling mechanism to allow entrapped animals to escape lost pots. The escape mechanism was to be secured by biodegradable cotton twine or other natural fiber no larger than 120-thread that would degrade before trapped animals would die. Similar regulations exist in all shellfish trap fisheries along the U.S. West Coast.

In 1988, in the Cook Inlet Tanner crab fishery, a large ice event caused some pots to become derelict on the fishing grounds for at least 60 days after the closure of the fishery. When those pots were recovered, none of the 120-thread biodegradable twine had degraded and 15,000 Tanner crabs were documented killed in those pots from ghost fishing (Kimker, 1990). This prompted ADFG to conduct research on degradation rates of different sizes of cotton twine, and in 1990 the regulations were adjusted so that biodegradable cotton twine could be no larger than 30-thread, reducing the amount of time that lost pots could ghost fish. This regulation was eventually adopted in the pot fisheries throughout Alaska.

Later, fishers reported twine failure during active fishing, after the rationalization of the Alaska Bering Sea crab fishery (i.e., implementation of a catch shares program) and resultant increases in soak times for crab pots (Barnard, 2008; Gauemann, 2011). The regulations were again amended, with maximum thread count ranging from 30 to 60, depending on the target species, gear configuration, and fishing practices (ADFG, 2021).

Design Gear to Reduce Loss

Several gear designs can reduce loss and minimize ghost fishing. These include disabling mechanisms in pots as mentioned previously, but also include other strategies. When targeting demersal fish, gear can be designed to fish just above the seafloor, reducing potential snag hazards. Trawl nets can be designed with weak links on the chain that drags along the seabed in front of the net (tickler chain) or down the center of the net so that if the net becomes snagged, the gear will split and still be capable of hauling, rather than becoming completely snagged on the obstruction (NOAA Fisheries, 2022b). Similarly, breakaway lead lines on gillnets allow the gear to separate if it becomes snagged, rather than becoming fully ensnared on an obstruction (Gibson, 2013). In addition, the length and/or width of gillnets and other gear can be reduced to avoid gear loss due to obstructions and other reasons generally associated with excessive gear size (Antonelis, 2013; Morstad et al., 2010). FADs can be made with non-entangling and biodegradable materials, reducing their impact on marine fauna (Santana Ortega et al., 2014; ISSF, 2019).

Because some level of fishing gear loss is accepted as inevitable in fisheries throughout the world, there is a need to identify materials that can be used to construct fishing gear that will be less damaging than conventional plastics to species, habitats, and the ocean over the long-term. Biodegradable plastics in fishing gear are being explored as a viable alternative to more traditional plastics in fishing gear (Gilman, 2016; Wilcox and Hardesty, 2016). Research is being conducted on biodegradable fishing lines, gillnet mesh, and traps and pots (Araya-Schmidt and Queirolo, 2019; Deroiné et al., 2019; Grimaldo et al., 2020; Kim et al., 2016).

Research into biodegradable FADs is being advanced by involvement of the International Seafood Sustainability Foundation, which has supported several studies of different designs of

FADs with biodegradable components. Several regional fishery management organizations now encourage the use of biodegradable FADs (Franco et al., 2009; Herrera et al., 2019; ISSF, 2019; Lopez et al., 2019; NOAA Fisheries, 2021b).

Another option to mitigate ghost fishing effects in lost pots is a wholesale change to a fishing gear that does not ghost fish when lost. The hoop net, or crab ring, is a buoyed static gear similar to a pot, but instead of being a cage in which animals are trapped, it lays flat on the seafloor while baited, and when lifted the crabs on the crab ring are lifted to the surface inside the small portion of netting underneath the ring. Hoop nets are the only trap gear allowed in the California recreational spiny lobster fishery (CDFW, 2016).

In recreational fisheries, such as the Puget Sound recreational Dungeness crab fishery, crab rings are available, albeit rarely used. Recent estimates are that the nearly 9,300 lost traditional cage-type pots in this fishery ghost fish approximately 100,000 harvestable Dungeness crabs each year (NRC, 2021). If crab rings were used instead of pots, crabs would not be trapped in the rings and mortalities associated with ghost fishing ALDFG from that fishery would presumably drop to near zero. In addition, since successful fishing with crab rings requires hauling the gear before the crabs leave the baited area, tending occurs more frequently, reducing chances of loss from tides and currents or vandalism.

Remediation Measures

Mandated Recovery

Mandated attempted recovery of lost gear at the time of loss (when safe to do so) is an effective management tool because the best time to capture lost gear is immediately after it is lost and its location is known. Fishing gear can be expensive, and fishers regularly explain that they do not want to lose their gear and will make every attempt to recover it when they can (Antonelis, 2013; Goodman et al., 2021; Macfadyen et al., 2009, Matthews and Glazer, 2009). Fishing vessels often carry heavy creeper or grapnel hook equipment specifically to retrieve their gear if it becomes lost (Macfadyen et. al., 2009). Other tools are used by fishers to recover their lost gear, including “pot pumps” (systems that pump high pressure water into and around a lost pot to dislodge sediment) and SCUBA gear (CDFW, 2016; NRC, 2018). A fisher may return to the location to attempt retrieval, sometimes with extra assistance, if they know the specific location of the gear (Antonelis, 2013). Sometimes the weather and sea conditions (that possibly contributed to the gear loss) make it unsafe to attempt recovery. In other cases, fishers may not attempt recovery of lost gear even when it is feasible to do so. For example, it is common practice in the Pacific tuna purse seine fishery to abandon FADs in the water rather than recover them (Gilman et al., 2018).

Case Study: Mandated Recovery

Hydraulic Pot Pumps in West Coast Dungeness Crab Fisheries
Region: Pacific
Partners: fishers

Loss of crab pots in the West Coast Dungeness crab fishery is commonly associated with foul weather and strong currents. Pots can become inundated with sediment, making them difficult or impossible to retrieve with the standard crab pot haulers used by commercial vessels. To recover crab pots that become buried in the sand following storm events, fishers often carry onboard a hydraulic pot pump composed of a nozzle connected to a hose and high-pressure water pump that is used to jet seawater into sediment around a buried pot until it becomes free. This equipment is used both during the fishing season, and in post-season gear recovery. In addition, in situations where stuck gear cannot be freed by pressure from the vessel hydraulics or the pot pump, a line-cutter is sometimes used to send down the buoy line and sever the line where it meets the sea floor, leaving the buried pot in place but removing the buoy line and eliminating threats to navigation, gear conflicts, or whale entanglements (NRC, 2018).

ALDFG Retrieval

ALDFG retrieval is the only way to completely remediate the effects of ALDFG. Retrieval includes recovery at time of loss (described previously) and retrieval after loss has occurred. If recovery by fishers at the time of loss is not possible, in-season retrieval of lost gear by fishers conducted with grapples and other tools is the next most effective measure to remediate ALDFG. Marine enforcement officers can also be very effective at removing fishing gear immediately after a fishery closes via visual sweeps in heavily concentrated fishing grounds (NRC, 2021).

Legal restraints that prohibit fishers from carrying on their vessel the gear from another vessel are common in fisheries in the United States and its territories (Bowling, 2016). This can result in fishers identifying derelict gear during fishing but not retrieving it due to the potential legal consequences. Some fisheries, however, have adopted regulatory measures to address this and do allow fishers to responsibly carry other fishers' otherwise derelict gear back to port. For example, in Oregon, a law was developed specifically for the purpose of in-season retrieval of derelict gear. Oregon Dungeness crabbers can carry up to 25 pots in the early part of the season, 50 pots mid-season, and unlimited pots during the end of the season if those pots are clearly identified as derelict, and records are kept in logbooks [Or. Admin. R. 635-005-0490]. Fisheries managers indicate that this permitted activity is equally as important as the post-season retrieval program in reducing derelict crab pots on the fishing grounds (Kelly Corbett, Oregon Entanglement Working Group, personal communication). In some cases, cooperative fisheries agreements such as those of the Bering Sea and Aleutian Islands king and Tanner rationalized crab fisheries and the New England deep sea red crab fishery provide a framework for fishers to possess and in some cases fish the equipment of others.

Post-season retrieval is the only method available in some fisheries to remediate effects of ALDFG. Surveys of the fishing grounds following the closure of a fishery can result in large amounts of derelict fishing gear located and retrieved. These operations are often conducted through partnerships between a variety of groups including fisheries enforcement, management, fishing fleets, NGOs, researchers, and volunteer stakeholders. However, for post-season retrieval operations to occur, there needs to be a closure in the fishery to allow the derelict gear to be distinguished from the actively fishing gear. In fisheries that are open all year, without closures, such as the South Carolina blue crab fishery, there is no option for such retrievals to take place, and only marine enforcement is allowed to retrieve what they identify as derelict fishing gear (Mel Bell, SCDNR, personal communication).

Gear retrieval programs during fishing closures, even when brief, can be very effective in remediating the long-term effects of ALDFG, as seen in the crab pot “rodeos” that occur throughout the Gulf of Mexico states, the Cape Cod Bay lobster gear retrievals, and the West Coast Dungeness crab post-season retrievals. They can also be a great outreach and education opportunity for recreational fishers and boaters. Strategic planning or ALDFG hotspot mapping exercises will increase the benefit of ALDFG retrieval efforts (Martens and Huntington, 2012; NWSF, 2007). Maximizing the cost to benefit of retrieval over other management actions (such as preventive measures) is an important step when developing ALDFG management strategies (Domanski and Laverty, 2022; Gilardi et. al., 2010).

Studies focusing on the cost to benefit ratios for ALDFG remediation measures highlight the effectiveness of this type of management measure. Retrieval of derelict blue crab pots from Chesapeake Bay over the course of 7 years at a cost of $4.2 million resulted in a 27% increase in harvest worth $21.3 million (Scheld et al., 2016). In the Chesapeake Bay blue crab fishery, where derelict pots were causing a 4.5% loss in harvest annually, Bilkovic et al. (2016) estimated that potential harvest of blue crab could increase by 22 million pounds, or 14%, if 10% of derelict pots were removed from ten heavily fished areas.

Grapples and creeps are effective tools for gear recovery (Ocean Conservancy et al., 2020). Elsewhere, divers are commonly employed to remove ALDFG in places where grapples are either not allowed or would not be effective in ensuring complete removal of all gear present. This is common in places such as the U.S. portion of the Salish Sea, California, and Hawaiʻi (Drinkwin, 2022; Seadoc Society, 2009; Donohue et al., 2001; Henderson, 2001). In addition, remotely operated vehicles (ROV) have been used to recover ALDFG, primarily in deep water beyond maximum diver safety depth restrictions (NRC, 2019). Retrieval of ALDFG from shorelines also remediates species and habitat impacts along shorelines and prevents ALDFG from being washed back into the sea.

Case Studies: ALDFG Retrieval

NOAA MDP Removal Grants
Regions: all regions
Partners: any state, local, tribal, and territory governments, institution of higher education, nonprofit organization, or commercial (for-profit) organizations

To help reduce marine debris accumulation in U.S. coastal waters, NOAA MDP funds annual Marine Debris Removal Grants that prioritize large marine debris removal such as ALDFG. This funding supports locally driven, community-based marine debris removal projects that benefit coastal habitat, waterways, and wildlife, including migratory fish. With over 175 removal grants awarded since 2006, NOAA MDP has removed over 18,000 metric tons (40 million pounds) of marine debris, including ALDFG (MaryLee Haughwout, NOAA MDP, personal communication). For example, in 2019 the Pontchartrain Conservancy and its partners removed nearly 8,000 derelict crab traps from the Lake Pontchartrain Basin. This resulted in 119,030 lbs of marine debris being removed from coastal waters and marshes. The Pontchartrain Conservancy also collected bycatch data and worked with the Virginia Institute of Marine Sciences to analyze the economic impact of derelict crab traps on the Louisiana blue crab fishery (NOAA MDP, 2023a).

Dungeness Crab Commercial Fishery Retrieval Permit Process
Region: Pacific
Partners: fisheries managers, fishers

To help reduce ALDFG accumulation from the Dungeness crab fishery, the State of Washington approved legislation in 2009 for a crab pot removal permit to remove crab pots remaining on the fishing grounds after the close of the commercial Dungeness crab coastal harvest season. Coastal crab gear recovery permits may be obtained by individuals with a commercial Dungeness crab coastal license. Beginning 15 days after the close of the primary harvest season, recovery permit holders may remove Dungeness crab pots remaining in the coastal marine waters, regardless of the pot's ownership [WA RCW 77.70.500]. Since 2020, the program has allowed permitted fishers to retrieve pots lost in the winter during the summer crabbing season. These winter pots are identifiable from actively fished summer pots by a winter tag on their buoys. Fishers are allowed to keep any pots retrieved under this program. The program was developed collaboratively with the fisher advisors (WDFW, 2022).

The annual number of recovered pots has varied from a low of just 70 in 2011 to a high or 1,197 in 2016. In 2020, 47 participants removed 694 pots. In 2021, 36 fishers had already removed more than 700 pots by June (Daniel Ayers, WDFW, personal communication). The program development required several changes to legislation and regulations, including changes to the state's 'found property' laws, which generally require property to be returned to its original owner.

California has a similar program that was initiated by the Humboldt Fishermen's Marketing Association and has evolved into a permitted program. California commercial crabbers are also allowed to land up to six pots belonging to other fishers during part of the season. The California Lost or Abandoned Commercial Dungeness Crab Trap Gear Retrieval Program [Cal. Code Reg. 14 § 132.7] allows retrieval permits to be issued to organizations, rather than to individual fishers. Organizations can then hire multiple retrieval vessels (generally crab fishers). Retrieved pots are sold back to CDFG, which then pursues payment from the original owner, who must pay for the retrieved pots or lose their fishing license.

In Oregon, fishers are also allowed to bring from 25 to 50 pots belonging to other fishers into port during the fishing season, but they are not allowed to keep the pots. This facilitates the sweeping of stray pots by fishers during active fishing. Oregon also has a permitted post-season retrieval program that allows fishers and others to recover an unlimited number of pots left out after season closes. Under this program, the pots can be retained by whomever retrieves them.

Enforcement Sweeps in the Puget Sound Recreational Crab Fishery
Region: Pacific
Partners: fisheries managers, fishers

Fisheries enforcement actions can play an outsize role in mitigating harm of ALDFG. Enforcement sweeps of Dungeness crab pots left out during closed days in the recreational fishery in Puget Sound are an important tool to prevent harm from lost crab pots by limiting the amount of time they remain in the Sound. The recreational crabbing season in Puget Sound lasts throughout the summer months and includes two consecutive days each week when the fishery is closed. During these closed days, state fisheries managers conduct sweeps of crab pots left out. Research shows that the majority of recreational crab pots left out during the closed days are actually lost pots, rather than illegally set pots (NWSF, 2015). While managers do not have the capacity to sweep every pot left out in all areas, the sweeps are estimated to reduce ALDFG by 14% from the recreational fishery, saving an estimated 16,685 crabs from perishing in ghost fishing lost crab pots each year. These pot sweeps are more than six times as effective at reducing species impacts from ALDFG than post-season diver retrievals and cost significantly less to execute (NRC, 2021).

FAD Watch program in Palmyra
Region: Western Pacific
Potential replication: areas where FADs are affecting vulnerable nearshore habitats
Partners: fisher associations, satellite buoy companies, land and fisheries managers, fishers, NGOs, private industry

Drifting FADs have been documented to cause damage to sensitive nearshore habitats, such as seagrasses, coral reefs, and mangroves when they come ashore (Balderson and Martin, 2015; Baske and Adam, 2019; Consoli et al., 2020; Escalle et al., 2017; MRAG Asia Pacific, 2016). FADs have been found in the Palmyra Atoll National Wildlife Refuge, which is managed by the USFWS and The Nature Conservancy. To prevent damage to coral reefs, the refuge managers have adapted the FAD Watch program launched in the Seychelles. The innovative program involves coordinating with the U.S. Pacific Tuna Group and providers of the location data from satellite buoys attached to the FADs. When drifting FADs' positions come close to the island reef systems, the satellite buoy providers (with permission from the US Pacific Tuna Group) notify monument personnel so that the FADs can be intercepted before they land on the sensitive nearshore reef habitats. The Nature Conservancy pays the subscription fees for the satellite buoys and conducts the retrieval operations (Miller, 2022).

Norwegian Directorate of Fisheries
Region: Europe
Potential replication: federal fisheries
Partners: fishery industry associations, fisheries managers, fishers

The Norwegian Directorate of Fisheries has been implementing a lost gear location and recovery program for over 35 years and has so far retrieved over 22,000 gillnets and approximately 1,000 tons of other fishing gear types. The focus is on locating and retrieving gillnets due to the severe impact of lost gillnets on commercial catch rates, particularly of Greenland halibut (Humborstad et al., 2003; Large et al., 2009; Treble and Stewart, 2010). They plan the locations of their removal work using a combination of vessel monitoring system data and reported losses from fishers during the year.

For the removal operations, the government hires fishing vessels and undertakes a sweep and drag retrieval operation. Approximately 80% of reported losses are removed. In 2018 70% of the recovered pots and gillnets were delivered back to their owners. Remaining removed gear is recycled to the greatest extent possible through a partnership with Nofir. In 2019, removals were executed in the Svalbard archipelago, as far as 77 degrees north. These operations removed 1,200 snow crab pots, 800 gillnets, 57,000 m of rope, and 24,000 m of longlines and other gear (Ocean Conservancy et al., 2020). Fishers pay a special fee that covers 70% of the cost of these removal operations.

Norway Directorate of Fisheries also requires all fishers to recover lost fishing gear or to report any lost gear that cannot be removed. Regulations also require the fishers to report positions of fixed gear to avoid gear loss through vessel conflicts or conflicts with other fishing gear. These positions are displayed online and are available to download from BarentsWatch (www.barentswatch.no/en). This information allows all fishers using the area to see the locations of fixed gear so they can prevent loss of fishing gear resulting from vessel and fishing gear conflicts with set gear. Successful strategies such as these have been informed by years of work with fishers to understand causes of gear loss and to develop locally relevant and feasible solutions.

B. Regional Implementation Examples

Many of the management measures discussed above are in use to varying degrees throughout the United States and its territories. This section provides some examples of how fisheries are employing the measures. The examples are not exhaustive and do not reflect a comprehensive inventory of fisheries management measures employed throughout the United States and its territories.

New England Region

The New England region includes several management measures related to ALDFG mitigation. Input controls within the region's state and federal fisheries including trap limits, spatial and temporal area closures, and limited-access licensing. Output controls include catch share programs within the groundfish fishery and the sea scallop Individual Transferable Quota fishery. In these programs, pooled groups of fishers collectively determine the harvest plan, often pooling catch allocations to reduce the number of vessels on the fishing grounds. In addition, in the deep sea red crab fishery, which typically involves only a few vessels, fishers are allowed to haul other vessels' pots and work their gear cooperatively, which can reduce gear loss (NEFMC, 2020). The region enforces the gear marking requirements for fixed gear fisheries, with markers such as buoys, floats, high flyers, and radar detectors [50 CFR § 648.264]. Vessel monitoring systems and electronic vessel trip reports are required for several of the fisheries in the region (NOAA, 2022d).

Education, outreach, and training are also important preventive measures in New England. In Maine, new participants into the lobster fishery must pass an apprenticeship/student program prior to becoming a commercial license holder, and recreational lobster fishers must take a training course so they understand best fishing practices (MLCA, 2022). Outreach related to reduction of gear conflicts and whale entanglements on the fishing grounds is common.

To improve disposal and recycling of ALDFG and end-of-fishing gear, several ports in the New England region, including Provincetown and New Bedford, Massachusetts, have participated in the Fishing for Energy Program.

Mitigation measures in Maine include requirements for biodegradable escape panels in lobster and crab pots [12 MAC § 6433-A].

There are several derelict fishing gear retrieval programs throughout the New England region that include partnerships with fishers and fisher associations (GOMLF, 2022; MDMF, 2022). For example, the Center for Coastal Studies in Massachusetts is one of many organizations active in retrieval of ALDFG as well as in working with fisheries managers and policy makers to identify options for fisher-led retrieval actions. In addition, many other partners are actively working in the region collaboratively with fishers to retrieve ALDFG, with funding from the NOAA MDP and other sources.

Mid-Atlantic Region

Blue crab pots are the primary focus of ALDFG-related issues in the Mid-Atlantic region, and to a lesser degree, lobster pots in the northern states (i.e., New York and New Jersey). Input controls such as gear restrictions vary widely between the states; all states have pot limits per license, and Maryland and Virginia require escape (cull) rings in their pots. All pots are required to have buoys with owner identification for gear marking, and New Jersey requires reflective materials on the buoys for greater visibility. Sinking buoy lines to reduce cut lines associated with vessel strikes are required in New Jersey and North Carolina[2] (NCDMF, 2020).

Spatial restrictions to reduce conflict between different types of fishing gear (e.g., pots and trawls) and user groups (e.g., commercial and recreational) are in place in many areas of the Mid-Atlantic region. In Maryland, the “Float Free Channels” program requires fishers to avoid setting pot gear inside heavy vessel traffic areas. Many fishers have switched from single-buoyed pots to longlining their pots to avoid losing gear to vessel strikes. Fishers also use specialized grapple gear to recover their lost pots (Patrick, 2014; Genine McClair, Maryland Department of Natural Resources, personal communication).

At the federal management level, the MAFMC considers “fishery measures which avoid or reduce the potential for lost, or ‘ghost’ gear that has the potential for significant negative habitat impacts” (MAFMC, 2016, p.3). In addition, certain fishing areas have been closed or considered to be closed to commercial fishing due to excessive entanglement of recreational fishing gear in derelict pot and trap gear (MAFMC, 2017).

[2] North Carolina is represented in both the Mid-Atlantic and South Atlantic regions.

New Jersey requires blue crab pots to have escape panels either fastened by or made with biodegradable materials to remediate ghost fishing in derelict pots (NJDFW, 2021).

Derelict gear retrieval projects occur or have occurred in New York, New Jersey, Delaware, Maryland, and Virginia. The Cornell Cooperative Extension has been working with commercial fishers in the Long Island Sound to retrieve over 19,000 derelict lobster pots (CCE, 2022). Using multiple funding sources including NOAA MDP and NOAA funding through NFWF, the Virginia Institute of Marine Science and partners have conducted a series of derelict blue crab pot projects in the Chesapeake Bay, including employing fishers from closed fisheries to retrieve derelict pots, developing degradable biopanels, and conducting several research projects to increase the global state of knowledge about ALDFG (Havens et al., 2008; Havens et al., 2011; Bilkovic et al., 2012; Bilkovic et al., 2016; Jeffrey et al., 2016; DelBene et al., 2019; and others).

South Atlantic Region

In North Carolina, to avoid gear conflict between blue crab pots and shrimp trawl gear, the fishers and resource managers have collaborated on a compromise management strategy. In the cold months, all areas are open, and in the summer months, when there is more overlap between the two target species, blue crab pots must be in waters no more than 6 ft deep, while trawlers work the waters that are greater than 6 feet deep (Lee Paramore, NCDEQ, personal communication). As noted previously, in response to increased gear conflicts between blue crab pots and trawls in South Carolina, a new law prohibits the use of blue crab pots in the General Shrimp Trawl Zone during trawl season from late May to January (SCDNR, 2022; Mel Bell, SCDNR, personal communication).

In North Carolina, gear tending requirements are monitored by marine patrol officers, and pots are removed from fishing grounds if evidence shows they have not been tended within the regulated time period (NCMFC, 2020). This reduces the chances of the gear becoming derelict and harder to recover.

The number of pots allowed per license is an input control used in the Florida blue crab fishery, where the commercial inshore fleet is limited to 600 pots per license, and the offshore fleet is limited to 400 pots. In Georgia, all commercial blue crab licenses are limited to 200 pots (NCDMF, 2020). Sinking line is required in the Florida and North Carolina blue crab fisheries to reduce gear loss due to vessel strikes. The Florida Caribbean spiny lobster fishery has a 250-trap limit in the state and offshore waters off the southern counties where the bulk of the fishery occurs, and where derelict gear from the fishery has been a major concern (FFWCC, 2022c; Uhrin et al., 2014).

In Florida, plastic crab and lobster pots are required to include escape panels fastened with biodegradable twine to reduce ghost fishing in derelict gear (FFWCC, 2022d).

Several ALDFG survey, removal, and research projects have occurred to address the derelict lobster and crab pots, particularly in the Florida Keys (Butler and Matthews, 2015; FFWCC, 2022b; Uhrin et al., 2014; Uhrin, 2016). These projects include collaborations between state and federal researchers, resource managers, commercial fishers, and volunteers (FFWCC, 2022c). In North Carolina, derelict blue crab trap retrieval programs have been ongoing since 2003, retrieving anywhere from 654 to 8,343 pots per year. Funded in part by NOAA MDP, the North Carolina Coastal Federation led the retrievals, in collaboration with state agencies, North Carolina Marine Patrol, and other groups (NCCF, 2022).

Gulf of Mexico Region

Through the Gulf States Marine Fisheries Commission, state fisheries managers work together to address fisheries management issues that include ALDFG, primarily from the blue crab trap fisheries. In Florida, input controls that can reduce gear loss include a limit on the number of pots per license, and Texas has a 200-trap limit for commercial licenses (TPWD, 2021). In addition, in recent years Texas has implemented a commercial fishing license buyback program to reduce the amount of fishing effort from blue crab pots and other finfish and shrimp fisheries (Thomas, 2022). To reduce gear loss from vessel strikes, Alabama, Louisiana, and Florida require sinking buoy lines on all trap gear (NCDMF, 2020). Gear conflicts between shrimp trawls and blue crab pots are addressed within each state, with varying levels of spatial and temporal separation between the two user groups.

To build awareness about how to prevent gear loss, ALDFG retrieval projects usually include an educational component directed at crabbers (Cagle and Isaacs, 2022). In Louisiana, as discussed previously, new entrants into the blue crab fishery must complete a professional training program that includes training on best practices for reducing loss of gear (Cagle and Isaacs, 2022).

As a mitigation measure, Texas requires all crab pots to include degradable escape panels to reduce ghost fishing (TPWD, 2021).

For remediation measures, each of the Gulf States enacts periodic or scheduled closures for 10 to 30 days during which time derelict trap “rodeos” or “roundups” occur, including multiple stakeholder groups removing derelict blue crab pots from the fishing grounds (Louisiana Sea Grant, 2022; Saucier, 2019; Outdoor Alabama, 2019; TPWD, 2022; FFWCC, 2022e). These programs are funded by groups such as NFWF and NOAA MDP but also rely heavily on volunteers in some states. Other remediation measures throughout the states include provision of designated receptacles for recycling unwanted monofilament fishing lines, and proper disposal options for end-of-life pots.

Caribbean Region

ALDFG in the form of lobster pots and fish traps have been identified as a problem in the region for many years, as massive loss events occur during large storms and hurricanes. Derelict gillnets and monofilament lines from commercial and recreational fisheries have also been observed on reefs (Miguel Rolón, CFMC, personal communication).

Prevention measures in Puerto Rico have included education and outreach to local fishing communities, building awareness about ALDFG and how to prevent gear loss (Raimundo Espinoza, Conservacion ConCiencia, personal communication). There have also been several projects supported by NFWF and NOAA MDP to prevent the discard of recreational fishing line by providing recycling opportunities and education for fishers. In parts of the Caribbean, cargo vessels offloading supplies to the islands return to major mainland ports carrying waste including end-of-life fishing gear for recycling. These vessels utilize otherwise wasted space on the return journey, often called "backhauling." In St. Croix and St. John in the USVI, Leatherback Brewing, a private company, works with the captain of the *Norma H* to deliver bales of fishing gear to a recycling facility in Puerto Rico (Milam, 2021).

As a mitigation measure, pots are required to include escape panels that are fastened with biodegradable twine to reduce ghost fishing (see case study above).

Remediation measures include large scale retrieval projects over several years to retrieve derelict lobster and fish traps, including those lost in Hurricane Maria. A current project of Conservacion ConCiencia and the Ocean Foundation is aiming to continue this work. Under the same NOAA MDP grant, local fishing communities have also been engaged to retrieve derelict fishing gear.

Great Lakes Region

In the Great Lakes region, preventive management measures vary by state and management authority. They include input controls restricting the timing and soak times for fixed gear, and requirements to tend and haul gillnets within a certain timeframe. Some of these measures are designed to reduce fish spoilage but also serve to prevent ALDFG. Temporal closures restricting some fisheries during the winter prevents gear loss from foul weather and ice (Seth Herbst, Michigan Department of Natural Resources Fisheries Division, personal communication). Specific gear marking requirements are also in place, in part, to prevent gear from being misplaced and lost or abandoned (State Uniform Waterway Marking System R 281.1113). In Wisconsin, fishers are also required to report any gear loss (Yeo, 2018). As discussed previously, there is also active education and outreach in the region to inform recreational boaters about how to recognize and avoid conflicts with commercial fishing gear (ODNR, 2016; Wisconsin Sea Grant, 2015).

Remediation measures have included ALDFG retrieval from the waters of Lake Superior and Lake Erie, focusing on derelict nets. These projects have included partnerships with fisheries managers from state and tribal fisheries managers, fishing organizations, and Wisconsin Sea Grant. Included in their program was a reporting system for lost fishing gear (Seilheimer et al., 2018; GLIFWC, 2022). Shoreline cleanups such as the Great Lakes Plastic Cleanup also occur regularly in the region, and ALDFG has been found at most of the collection sites (Antonelis and Drinkwin, 2021).

North Pacific (Alaska) Region

Fisheries in the North Pacific region have implemented input controls that reduce ALDFG. For example, since implementation of catch shares, a reduction of ALDFG has occurred in Bering Sea and Aleutian Islands crab and Pacific halibut fisheries (see case study above) (Citta et al., 2013; IPHC, 2022a). Another input control in the region includes gear size and count limits in the Bristol Bay herring fishery, where substantial amounts of waste from lost and abandoned nets in the late 1980s was attributed to too much gear in the water (Morstad et al., 2010). As a result, authorities reduced the legal amount allowable to 100 fathoms (600 ft) per vessel, and later to 50 fathoms (Morstad et al., 2010). In the Kodiak and the Alaska Peninsula region, Dungeness crab fisheries are closed during winter months to keep gear out of the water during poor weather when it is most likely to be lost (Mark Stichert, ADFG, personal communication). In addition, the winter commercial king crab fishery in Norton Sound is open only January 15 through April 30, when shore fast ice is most stable, to reduce potential gear loss caused by mobile ice (ADFG, 2015). Each permit holder is limited to 20 pots, also to reduce potential for gear loss (Jen Bell, ADFG, personal communication).

In the Bristol Bay salmon gillnet fishery, the largest salmon fishery in the world, permit holders are required to report the loss of a gillnet, or portion of a gillnet, to the local ADFG office within 15 hours after the loss event, either in-person, by radio, or by telephone [5 AAC § 06.331]. All fixed gear and gillnet fisheries require highly visible marker buoys or floats, and in Bristol Bay, gillnets are required to include owner identification every 60 feet on the cork line (Tim Sands, ADFG, personal communication).

The Net Your Problem end-of-life fishing gear recycling program has worked extensively in the Port of Dutch Harbor and other Alaskan ports to recycle accumulated end-of-life fishing gear.

For mitigation of ghost fishing, Alaska regulations call for biodegradable release mechanisms on pot gear that are designed to disable lost pots within 30 days of loss [5 AAC § 39.145]. Biodegradable cotton twine ("biotwine") is required to be either 30 or 60 thread count, reduced from 120 count after a large ghost fishing event occurred in the late 1980s (Kimker, 1990).

Coastal communities and volunteers work to retrieve ALDFG and other marine debris from remote locations along the vast amounts of rugged shoreline in Alaska, and in-water derelict gear retrieval projects, funded by NOAA MDP, have occurred in Southeast Alaska targeting Dungeness crab pots (Maselko et al., 2013; NRC, 2017b).

Pacific (West Coast) Region

Fisheries along the Pacific Coast use input and output controls such as limited entry licensing, permit buyback programs, gear limits, trip limits on harvest, and catch share programs to manage the fisheries resources, which in turn reduces the amount of gear in the water. The California Spiny Lobster Fisheries Management Plan has trap limits to reduce an excess of lost gear and allows fishers to carry SCUBA gear during pot fishing operations to use in recovery of any lost pots (CDFW, 2016).

In the Puget Sound salmon fishery, state managed net fishers are required to report lost nets, or lost portions of nets, within 24 hours. Several of the Native American tribes have similar rules about reporting net and other gear loss (NRC, 2017a).

Many members of the Dungeness crab fleet on the U.S. West Coast carry a pot pump specifically designed for this fishery that can dislodge crab pots buried several feet in the sand. These are used both during active fishing and during post-season closures to retrieve lost pots (NRC, 2018).

Bureo recently began operating in Southern California, setting up a recycling hub in Oxford with custom machines designed to recycle fishing gear. They are working with six ports, fishing communities, and local organizations to buy end-of-life fishing gear from fishers to mechanically recycle into NetPlus®, a raw plastic material that can be used to make synthetic clothing or plastic products such as skateboards. The company started in California by providing a buyback and recycling option for drift gillnets, which were recently prohibited in the state. Approximately 40 tons of gillnets have been collected for recycling from local fishers, who are paid for their nets (Ben Kneppers, Bureo, personal communication).

To mitigate the impacts of ALDFG on target and non-target species, all fish and shellfish pot fisheries on the U.S. West Coast are required to have escape panels fastened by biodegradable twine ("escape cord") to reduce ghost fishing from lost gear (NOAA, 2011).

To remediate ALDFG from the Dungeness crab pot fisheries, California, Oregon, and Washington each has codified lost pot retrieval programs that primarily involve commercial crabbers retrieving stray pots from the fishing grounds immediately following the seasonal fishery closure and to a lesser degree during active fishing seasons (see case study above). In addition, several coastal and Puget Sound Native American tribes have conducted lost crab pot and debris retrievals in their fishing areas (NRC, 2018). California and Washington also have active third-party retrieval programs that address other fishing gear such as gillnets, other nets, and other pot gear (e.g., prawn, lobster) (Gilardi et al., 2010; Seadoc Society, 2009).

Western Pacific Region

Input controls that help to prevent gear loss in the Western Pacific region include strict tending requirements for gillnet fishing in Hawaiian state waters, such as mandatory inspection every 2 hours and a maximum soak time of 4 hours. Gear marking requirements include proper identification and surface buoys with registration numbers and reflective tape. It is unlawful to discard or dispose of any fishing gear in the waters of the state [Haw. Code R. § 13-75-4].

To prevent recreational fishing line from becoming ALDFG, several beaches around the islands have "net bins" placed at boat ramps and marinas where fishers can dispose of old fishing gear, including derelict fishing gear they find at sea (Broder Van Dyke, 2022). The Hawaiʻi Nets to Energy Program operates in the port of Honolulu, providing a no-cost disposal option for derelict nets that are retrieved by the Hawaiʻi longline fleet, as well as ALDFG collected during shoreline retrieval by local organizations (NOAA MDP, 2022a).

Hawaiʻi also manages an online public ALDFG reporting system (HDLNR, 2021).

Mitigation measures in the region include the Palmyra Atoll FAD Watch program, which intercepts drifting FADs from the Pacific tuna fleet before the FADs can affect sensitive coral reef habitats around the atoll (see case study above) (Miller, 2022). The longline fleet in Hawaiʻi has also helped to fuel the Hawaiʻi Nets to Energy program by bringing in ALDFG encountered during fishing. They have also provided some encountered ALDFG to researchers at the Hawaiʻi Pacific University.

Remediation is a large component of ALDFG management in this region. Multiple partners have worked to address the persistent accumulations of ALDFG from foreign and domestic fisheries that are transported onto nearshore and shoreline areas throughout the region (Lebreton, et.al., 2022). From 1996 through 2018, 923,000 metric tons of debris, most of it ALDFG, were retrieved from the coral reefs and shorelines of Papahānaumokuākea Marine National Monument (NOAA MDP, 2022d).

Retrieval projects in the main Hawaiian Islands have occurred over multiple years, undertaken by a variety of partnering organizations with funding support from NOAA MDP. Efforts by researchers from Hawaiʻi Pacific University and others to identify the specific source fisheries of this accumulated ALDFG are ongoing (McWhirter, 2022).

C. Data and Management Gaps

In this section, data and management gaps related to ALDFG in the United States and its territories are identified. Data gaps are identified related to the information provided in previous sections of this report about the scale of fishing gear loss and the adverse effects of ALDFG (Section II, III, and IV). It includes a broader discussion of general weaknesses of the current approach to ALDFG management. Section VII provides recommendations to fill the identified data gaps and to improve the management of ALDFG to prevent and reduce harm from ALDFG to species, habitats, economics, and safety throughout the United States and its territories.

Data Gaps

Rate of Gear Loss and Amount of ALDFG

Without a clear understanding of the scale and impacts of ALDFG, fisheries managers lack the necessary information to design effective prevention and reduction strategies or to evaluate the effectiveness of ALDFG management measures. There is still a significant lack of understanding of gear loss, its causes, and its effects in many fisheries. In the Chesapeake Bay area, for example, there is deep understanding of the rate of production and ecological and economic impacts of abandoned, lost, and discarded blue crab pots (DelBene et al., 2019; Jeffrey et al., 2016), but there remain clear gaps in understanding of the amount and effects of ALDFG in other fisheries such as recreational hook-and-line fisheries (GESAMP, 2021; Watson et al., 2022).

Gear loss rates and the amount of gear lost each year are both significant data gaps in many U.S. fisheries. The rate of loss of fishing gear can be calculated in three different ways:

- Percent of total amount of gear used during a season/year that is lost (i.e., annual loss rate);
- Percent of fishing trips with gear loss events (i.e., per trip loss rate); and
- Percent of sets (or hauls) with gear loss (i.e., loss rate per effort).

The first method is adequate for estimating the total amount of fishing gear being lost to the ocean and Great Lakes, but the latter two methods provide a better baseline from which to test and evaluate loss prevention methods.

In some fisheries, the total amount of gear lost per year is available or can be calculated using the gear loss rate. Of the U.S. fisheries described in Section III, gear loss rates were available from existing research and other data (e.g., logbooks, observer reports) for 61 fisheries. The amount of gear lost every year could be calculated for 59 fisheries. Many of the gear loss rates presented in Section III and the companion data on amounts of gear were developed specifically for this report and required significant effort to calculate based on observer reports and fishery catch records.

An inventory of all fishing gear used in a fishery versus the amount reported lost and the amount that is disposed of properly as end-of-life gear is required to fully understand the rate of accumulation of ALDFG into the ocean and Great Lakes. In no fishery, however, is there data quantifying the total amount of fishing gear used or the amount of gear that is disposed of as end-of-life.

Adverse Effects of ALDFG

There are also significant gaps in data on the causes and adverse effects of ALDFG on species, habitats, economics, and navigation/safety. Only 25 fisheries have documented causes of gear loss (Section III.C). Published data related to adverse effects on species were available for just 26 fisheries and data on adverse effects on habitats were available for just six fisheries (Section IV.A). Some of those published data do not differentiate between the effects of active fishing gear and ALDFG. Only 17 fisheries have published data on economic effects of ALDFG (Section IV.B). Very little information is available linking ALDFG directly to human safety or health effects. The information related to navigation safety is also sparse; USCG incident reports generally do not differentiate between active fishing gear and ALDFG if fishing gear is identified as a cause of an incident.

ALDFG Management Effectiveness

Finally, there are very few reports focusing on the direct effects of ALDFG management measures on the reduction of gear loss or reduction of adverse effects ALDFG. Most of the management measures described earlier in this section have been documented and, in some cases, projected to reduce gear loss and to reduce ghost fishing and other harmful effects of ALDFG (Arthur et al., 2020; Bilkovic et al., 2012; Gaeuman, 2011; IPHC, 2022a; Miller, 2022). However, few published reports document quantitatively the change in gear loss or the reduction in adverse effects of ALDFG in response to management actions.

Management Gaps

Inconsistent ALDFG Considerations in Fisheries Management

The lack of data on loss rates and adverse effects of ALDFG discussed above results in inconsistent approaches to ALDFG management. Although adverse effects of ALDFG are considered in many fisheries throughout the United States and its territories, there is not a set of overarching requirements or standards of practice to integrate ALDFG reporting, monitoring, or management into fisheries management schemes either at the federal or state and tribal levels.

At the federal level, disabling mechanisms are required in almost all pot fisheries to reduce the impacts of ghost fishing [50 CFR §§ 622.189; 622.510; 648.144; 660.230; 660.330; 679.2; 697.21]. NOAA Observer Programs often collect data on gear loss, but the data are not used regularly to inform harvest management. Managers regularly consider and monitor bycatch, which includes unobserved mortality caused by ALDFG, but only the IPHC uses logbook data on gear loss in halibut fishing to estimate bycatch from unobserved mortality caused by ALDFG (NOAA Fisheries, 2004a). In other fisheries, bycatch monitoring of unobserved mortalities has focused on protected species only where data are available (Benaka et al., 2019) and has not included monitoring of unobserved mortality caused by ALDFG.

State and tribal fisheries often include unobserved mortality and habitat effects from ALDFG in fisheries management decisions. For example, along the U.S. West Coast Dungeness crab fisheries, consideration of adverse effects of ALDFG in management decisions is common practice (California Ocean Protection Council, 2022; ODFW, 2021; WDFW, 2022). However, states are not consistent in how they monitor or track ALDFG data.

Inconsistent Consideration of ALDFG Management Effectiveness

There is no systematic practice to evaluate the effectiveness of existing ALDFG management. Despite the many examples of ALDFG management measures being implemented throughout the United States and its territories, there are still fisheries where existing approaches are not adequate to address the effects of ALDFG or the scale of gear loss.

Some fisheries with high gear loss rates lack input controls, and others with input controls continue to have high gear loss rates. Despite the input controls, such as gear limits in the Maine lobster fishery and FAD limits and closures in the Western Pacific tuna fishery, the amount of gear loss is still high compared to other fisheries. In the New England region, overcrowding of fishing grounds is a possible secondary driver for gear loss caused by vessel conflicts and conflicts between fishing sectors. This indicates that further input controls, vessel traffic controls, or other management measures that can reduce gear and vessel conflicts could be considered (Jedziniak, 2017). But there is no system in place in this fishery (or others) to regularly evaluate current ALDFG management measures in order to take adaptive management actions (Hare, 2020).

Uncoordinated Approach to Addressing ALDFG

There is a lack of effective communication between parties addressing different aspects of ALDFG management in some regions. Major stakeholders involved in ALDFG management in the United States and its territories include fishers, fishing companies, and fishing associations; fisheries managers; ports and waste management companies; researchers, and NGOs. In some fisheries, these stakeholders are coordinated and meet regularly to share information and evaluate the effectiveness of ALDFG management (University of Washington Sea Grant, 2021; Drinkwin, 2016). In other fisheries, there is limited communication between the stakeholders.

Lack of Requirements for Escape Mechanisms

Some trap and pot fisheries still do not require escape mechanisms designed to allow trapped animals to escape if the gear is lost. These components of trap and pot gear have been shown effective at mitigating adverse effects of ALDFG to multiple species in multiple fisheries throughout the world, including in the United States and its territories (Araya-Schmidt and

Queirolo, 2019; Barnard, 2008; Bilkovic et al., 2012; Broadhurst and Millar, 2018; Maselko et al., 2013; NRC, 2021; Renchen et al., 2014). Several of the blue crab fisheries in the Atlantic and Gulf of Mexico states do not require biodegradable escape panels in their pots (e.g., Virginia, Maryland, Louisiana, North Carolina). These fisheries have some of the highest amounts of gear loss in the United States, resulting in large amounts of ghost fishing on target and non-target species (Arthur et al., 2020; Bilkovic et al., 2016).

Inadequate Disposal Options for Retrieved ALDFG and End-of-Life Fishing Gear

Fisheries throughout the United States and its territories face a lack of infrastructure and prohibitive management structures for the convenient and affordable retrieval and proper disposal of retrieved ALDFG and end-of-life gear. These prohibitive management structures include regulatory prohibitions and inadequate disposal options for fishers who encounter ALDFG during active fishing to retrieve that ALDFG and bring it back to port for disposal (Bowling, 2016). Likewise, third parties such as NGOs that work to retrieve and dispose of ALDFG often face regulatory prohibitions, cumbersome permitting, and lack of disposal options (Bowling, 2016).

Inadequate Management of ALDFG from Foreign Fisheries

Foreign-sourced ALDFG adversely affects species, habitats, economics and safety in the United States and its territories in several regions. For example, ALDFG from fisheries operating in the Pacific is accumulating in ocean gyres and being transported to the North Pacific and Western Pacific regions of the United States and its territories (Lebreton et al., 2022). More progress is needed on gear loss prevention, mitigation, and remediation of this ALDFG by regional fishery management organizations and IGO forums.

In summary, gaps in the management of ALDFG in many fisheries in the United States and its territories include:

- Inconsistent consideration of adverse effects of ALDFG in fisheries management actions. There is no standard practice of reporting and monitoring of ALDFG and no coordinated registry to consolidate information on ALDFG.
- Inconsistent consideration of the effectiveness of ALDFG management.
- Uncoordinated approaches to addressing ALDFG between fisheries managers and other stakeholders, such as academics conducting research and NGOs conducting retrievals.
- Lack of standard requirements for disabling/escape mechanisms in some U.S. pot and trap fisheries.
- Inadequate disposal options for retrieved ALDFG and end-of-life fishing gear.
- Inadequate management of ALDFG from foreign fisheries affecting the United States and its territories.

VI. RECOMMENDATIONS FOR MANAGEMENT MEASURES [§ 135 (3)]

Presented here are recommendations for potential new or expanded actions to make further progress on the most pressing ALDFG management issues in the United States and its territories. The recommendations address the overarching management gaps and weaknesses of the current approach to ALDFG management described previously. For all the recommendations around ALDFG management, upfront and continual consultation and collaboration with fishers and fisher associations would serve to ensure that programs and systems put in place are feasible and supported by industry.

Recommendations are assigned sequential letters for reference but are not necessarily ranked by importance.

A. Federal-Level Recommendations

Establish a National Working Group on ALDFG to Develop a Standardized Approach to ALDFG Reporting, Assessment, and Management

A comprehensive approach to managing ALDFG is needed in the United States and its territories. Disparate data collection and disparate management activities remain inadequate to fully characterize and manage adverse effects of ALDFG on species, habitat, economics, and navigation safety. A National Working Group on ALDFG could be modeled after the National Working Group on Bycatch, which was convened to develop reporting and monitoring protocols for bycatch management after the first National Bycatch Strategy (Benaka and Dobrzynski, 2004; NOAA Fisheries, 2004a).

The work of the IMDCC is helping to ensure that federal efforts to address marine debris, including ALDFG, are aligned, but its mandate broadly includes both land and sea-based marine debris. Establishing a National Working Group on ALDFG will bring in other stakeholders, including state and tribal fisheries managers and the fishing industry to provide a more focused effort on addressing the unique challenges of ALDFG.

A National Working Group on ALDFG could address the following needed improvements in ALDFG management throughout the United States and its territories:

- Standardized reporting by fisheries of gear use, loss, and disposal;
- Assessment of ALDFG adverse effects;
- Frameworks of ALDFG management;
- Adaptive ALDFG management processes to include evaluating effectiveness of management measures; and
- Communication and collaboration with the fishing industry and other stakeholders active in ALDFG management.

To effectively address ALDFG management issues, the Working Group could include representatives from NOAA, the Fishery Management Councils, the Marine Fisheries Commissions, as well as tribal fisheries commissions (e.g., Great Lakes Indian Fish and Wildlife Commission).

Through the work of a National Working Group on ALDFG, this recommendation may also improve consideration of unobserved mortality from ALDFG in bycatch management and adverse effects on habitats in habitat protection processes. Effects from ALDFG could be considered by fisheries managers as they protect and restore these important habitats.

Establish Regional ALDFG Coordinating Committees

Regional ALDFG coordinating committees could improve the communication and collaboration around ALDFG management and inform the National Working Group on ALDFG.

The management of ALDFG involves practitioners and authorities from the fishing sector, the maritime transport sector, waste management sector, researchers, and many others. A good example of the breadth of stakeholders involved in this issue is the membership of the GGGI, which includes over 150 members including the United States and 19 other nations; IGOs such as the Pacific Islands Development Forum; academia such as the Hawaiʻi Pacific University; NGOs such as World Wildlife Fund; industry; and seafood suppliers such as Bumblebee Seafoods and Walmart. All of these voices have insights relating to points along the seafood supply chain that can affect ALDFG prevention, mitigation, remediation, and disposal.

Such integration could be facilitated through the regional ALDFG coordinating committees that would meet regularly to exchange new research findings, effective management strategies, and coordinate responses to regional ALDFG issues. Committees could include representatives from the NOAA MDP; federal, tribal, and state fisheries managers; maritime vessel interests (including the USCG); waste management interests; fisher representatives; researchers; and selected regional organizations active in ALDFG management. A model for these coordinating committees could be the various committees of the Atlantic Fisheries Management Commission (e.g., Habitat Committee, Fishing Gear Technology Committee, Aquaculture Committee).

Communication and collaboration within this kind of network builds creative and innovative solutions, and at the same time it builds industry support for effective fisheries management measures.

Promote Effective International Management of ALDFG and Reduce Adverse Effects Caused by ALDFG from Foreign Fisheries

As members of regional fishery management organizations and other IGOs, the United States can, as appropriate and consistent with relevant RFMO conventions, promote measures to reduce adverse effects caused by ALDFG from foreign fisheries. For example, the U.S. delegation to an RFMO could, consistent with the RFMO's establishing convention, advocate for resolutions or management measures to reduce adverse effects on species and habitats in the United States and its territories caused by ALDFG from foreign fisheries (NOAA Fisheries, 2021b; USEPA, 2020).

Because of the adverse effects of ALDFG in part originating from foreign fishing activities to the Papahānaumokuākea and Pacific Remote Islands marine national monuments, as well as to Pacific Island territories and Hawaiʻi, additional action at the regional fishery management organization level and within other IGO forums such as APEC is needed (Lebreton et al., 2022). APEC engaged on the subject of ALDFG as early as 2004, hosting an education seminar and recently created a Roadmap on Marine Debris. APEC also developed a best practice guide for managing lost and abandoned fishing and aquaculture gear (APEC, 2019; APEC Fisheries Working Group, 2004; Huntington and Drinkwin, 2022). A workshop held in May 2022 introducing concepts from the guide was attended by representatives from China, Taiwan, Indonesia, and South Korea. This indicates that there is opportunity for progress on the prevention of ALDFG from this region.

Consistent with its stated strategy for addressing sea-based sources of marine debris (USEPA, 2020), the United States could advocate, either bilaterally or within existing international organizations, for additional ALDFG reporting to include reporting of gear type, identification number, locations, flag state, sea conditions, reason for loss, recovery actions attempted, and current disposition of the gear. The United States could also advocate for improved detection and retrieval of ALDFG, including requiring recovery equipment on board and requiring at least an attempt to recover lost gear.

Documented negative impacts of lost and abandoned drifting FADs warrant special consideration for this gear type, especially because its current management is more complicated than other types of gear (Baske and Adam, 2019; Consoli et al., 2020; Gilman et al., 2018; Herrera et al., 2019; MRAG Asia Pacific, 2016). As a member of the International Commission for the Conservation of Atlantic Tunas, Western and Central Pacific Fisheries Commission, and Inter-American Tropical Tuna Commission, the U.S. delegations to these RFMOs have and could continue to advocate for progress on science-based management of FADs to reduce their loss and minimize their negative impacts on species and habitats. Delegations could consider management actions recommended by the International Seafood Sustainability Foundation, including reporting of FAD locations, loss, and abandonment; input controls limiting FAD numbers; promoting non-entangling and biodegradable FAD designs; and measures related to the recovery of FADs (ISSF, 2019; Restrepo et al., 2019).

Imzilen et al. (2022) identified measures that could be considered to reduce the numbers of drifting FADs from the Atlantic that are abandoned, focusing on recommended area closures during certain times of the year and development of local retrieval programs in selected areas where FADs drift close to ports. A comparison of environmental or operational causes of drifting FAD beachings in the Western Central Pacific Ocean also offers some practical basis for preventive management actions in that region, including restrictions on numbers of FADs deployed and continuing current closures (Escalle et al., 2019).

Continued support for the retrieval of ALDFG from the Papahānaumokuākea Marine National Monument will also remediate adverse effects of ALDFG from foreign fisheries. In 2017, Congress directed NFWF to establish a fund to help in the management of the monument. The purpose of the fund is to address challenges and the unique conservation needs of protecting and enhancing such a remote location. Guided by a Hawaiʻi-based Advisory Committee, the fund focuses on a variety of priorities including assessing and decreasing the effects of marine debris and ALDFG on species and habitats in the monument.

A corollary recommendation is to continue support for researching the source fisheries of ALDFG accumulating in the monument and in other Pacific territories. The results of this research will inform the management options and policy recommendations for the United States to consider addressing through multilateral organizations and bilateral engagements in the region.

B. Regional and Fishery-Level Recommendations

<u>Support Development of Fishery-Specific ALDFG Management Strategies</u>

To prevent loss of fishing gear and reduce harm from ALDFG, appropriate management strategies, both voluntary and regulatory, must be developed specific to each fishery (Gilman et al., 2022; Richardson et al., 2018). Some fisheries with the potential for severe adverse effects to protected species and habitats, economics, and navigation safety will require more aggressive management actions than other fisheries where adverse effects from ALDFG are not as great. Developing these fishery-specific strategies requires an evaluation of the causes and effects of ALDFG undertaken at the fishery level. In some fisheries, this has already occurred. In others, a first step will be to fill data gaps, after which managers can identify and execute management actions appropriate to the identified impacts of ALDFG by fishery.

Systematic approaches to identify management measures have been recommended in other ALDFG management processes, such as the Baltic Sea Blueprint developed through the MARELITT Baltic project (Tschernij et al., 2019). FAO recommends a simplified risk assessment model in its Voluntary Guidelines for the Marking of Fishing Gear focused on identifying the kinds of fishing gear markings that would reduce ALDFG (FAO, 2018). A systematic approach identifying ALDFG causes, drivers, and outcomes was used to develop the Puget Sound Crab Pot Loss Prevention Plan and prioritize geographic areas for derelict net retrieval work in the U.S. portion of the Salish Sea (Drinkwin, 2016; NWSF, 2007).

Jeffrey et al. (2016) presented a framework to identify appropriate management actions which included systematic steps to characterize the adverse effects of ALDFG by fishery and to evaluate, under various economic and ecological scenarios, the benefit of different management actions. Ocean Conservancy et al. (2020) presents a similar framework that also includes additional steps around management actions adoption, implementation, and evaluation. The steps outlined below follow a conceptual framework designed to identify management practices necessary to reduce adverse effects of ALDFG.

These general recommended steps could be adapted to identify appropriate management measures management at the fishery level adapted from Jeffrey et al. (2016) and Ocean Conservancy et al. (2020):

Step 1. Characterize the abundance and distributions of ALDFG in subject fisheries.

Step 2. Identify causes and drivers of ALDFG.

Step 3. Identify and quantify human health and safety effects of ALDFG and economic effects on fishery target and bycatch species.

Step 4. Determine ecological effects on living resources and critical or sensitive habitats.

Step 5. Evaluate management implications through scenario driven economic and ecological assessments.

Step 6. Identify appropriate management actions and strategies to reduce negative effects of ALDFG.

Step 7. Advance adoption of management actions and strategies through collaborative processes, market drivers, direct advocacy, and awareness-raising.

Step 8. Execute management actions.

Step 9. Evaluate effectiveness of management actions.

Step 10. Adjust management actions and strategies, as needed.

Promote and Support Establishment of Appropriate Disposal Options for Recovered ALDFG and End-of-Life Fishing Gear at Fishing Ports in the United States and its Territories

Feasible and affordable options for disposal of retrieved ALDFG and end-of-life fishing gear should be available to every fishery in every major fishing port in the United States and its territories. Programs collaborating directly with fishers to recycle end-of-life gear, such as the Net Your Problem program and Fishing for Energy are models that demonstrate creative end-of-life solutions with industry support.

Retrieving ALDFG encountered during active fishing is a widely accepted strategy to reduce harm from ALDFG and was advocated as early as 1988 (Drinkwin, 2022; Fjelstad, 1988; GGGI, 2021). Programs like Fishing for Litter and the Hawai‘i Nets to Energy Program rely on fishers (generally trawlers, but longliners in the case of the Hawai‘i program) to collect ALDFG encountered during fishing and return it to port for disposal (KIMO International, 2021; NOAA MDP, 2021b). Programs like Fishing for Litter seem to work best with larger vessels as some smaller vessels lack the deck space required to transport ALDFG. A pilot project in the Mediterranean showed that strong governmental support and consistent laws and regulations around marine litter help to streamline the program management (Drinkwin, 2022). The European Fishing for Litter model where multiple programs are supported by an IGO helps to ensure management consistency and support. Funding is naturally also a challenge (Ronchi et al., 2019).

Depending on the fishery, supporting the retrieval of marine debris and ALDFG encountered during active fishing might require changing regulations that prohibit fishers from carrying other fishers’ gear and ensuring adequate waste reception facilities for proper disposal. Several states have developed pathways for fishers to collect stray gear during and after fishing season. Oregon allows up to 50 stray pots per Dungeness crab fishing vessel to be retrieved during the season (Ayres, 2018; Seadoc Society, 2009). Such programs could serve as models to facilitate this recommendation.

Because space for storing retrieved ALDFG may be limited on vessels, another strategy could include a designated vessel (e.g., barge) or other location where encountered ALDFG could be deposited for subsequent retrieval and disposal (Hong et al., 2015).

Retrieval of ALDFG after the fishing season by fishers and other stakeholders is an effective solution in some fisheries; having reliable and affordable disposal options is necessary to support this work (Antonelis et al., 2011; Arthur et al., 2020; Bilkovic et al., 2016; Domanski and Laverty, 2022; Gilardi et al., 2010; Jeffrey et al., 2016). The Fishing for Energy program is a model of how NGOs, government agencies, and private businesses can work together to offer no-cost disposal options to the commercial fishing industry and others retrieving ALDFG across the United States and its territories. With appropriate support, this type of program could be replicated or adapted to many more locations in the United States and its territories.

Finally, having feasible disposal options for end-of-life fishing gear will assist in managing this waste from the fishing industry as it will remove a potential secondary driver of the discard of fishing gear (GGGI, 2021). The Berkley Respool and Recycle, Bureo, and Net Your Problem program models focus on providing fishers with feasible options to dispose and recycle their end-of-life fishing gear (Berkley, 2022; Bureo, 2022; Goodwin, 2016; NOAA MDP, 2021c). These programs and others like them can be supported through this recommendation.

Support the Establishment of Local ALDFG Reporting Systems and Registries Appropriate to Fisheries to Document Extent and Locations of Lost Fishing Gear

Reporting of lost gear is recommended as standard practice for all managed fisheries. Accurate recording of fishing gear loss that includes the identification and type and amount of gear, location and time of loss, and reasons for loss aids fisheries management in a number of ways.

For example, the reporting system in place in the Puget Sound salmon fishery is designed to mitigate effects from lost gillnets through mandatory reporting of loss (within 24 hours), response to every report, and mobilization of on-call dive teams to retrieve verified lost nets (Drinkwin et al., 2022; NWSF, 2015). Data on all reports of lost and retrieved gear are stored in an accessible and searchable statewide database. Other reporting systems, such as one in place in the Great Lakes Enforcement Unit are linked to a geospatial database and are used to guide response and ALDFG retrieval by marine enforcement personnel and has been used to link lost fishing gear to individual fishers in some cases (Nick Torsky, Michigan Department of Natural Resources, personal communications).

Effective reporting systems and registries could build off existing systems, such as emergency response systems or poaching hotlines, as well as data collection programs, logbooks, and observer reports. The Atlantic, Gulf of Mexico, and Pacific States Marine Fisheries Commissions already hold regionwide fisheries statistics data and might be good places to develop repositories of ALDFG reporting data and other information.

Support the Establishment of Disabling Mechanisms Requirements in All Pot Fisheries to Allow Escapement and Prevent Mortality of Any Animals Trapped in ALDFG

Minimizing the harm caused by ghost fishing of lost gear is the second most important step that can be taken when managing ALDFG. Unobserved mortality of target and non-target species is well documented in ALDFG from many pot fisheries (Antonelis et al., 2011; Butler et al., 2018; Clark et al., 2012; Havens et al., 2008).

Disabling mechanisms are an effective management measure to mitigate ecological effects of lost pots (Araya-Schmidt and Queirolo, 2019; Barnard, 2008; Bilkovic et al., 2012; Broadhurst and Millar, 2018; Maselko et al., 2013; NRC, 2021; Renchen et al., 2014). Bilkovic et al. (2016) estimated that if biodegradable escape panels were used on blue crab pots in Chesapeake Bay, the blue crab mortality as a result of ghost fishing would be reduced from 3.3 million crabs to under 440,000 crabs per year, and other non-target species, such as diamondback terrapin, would be saved as well. NRC (2021) estimated that changing the maximum size of cord required in the Dungeness pot fishery in the U.S. portion of the Salish Sea from 120 to 30 could reduce the amount of legal male equivalent Dungeness crab killed in derelict pots by at least 29% in recreational pots and 23% in commercial pots.

Many pot fisheries include regulations to require use of disabling mechanisms that can be used as models for fisheries where they are not yet required (Bowling, 2016; TPWD, 2022).

VII. COST OF MANAGEMENT RECOMMENDATIONS [§ 135 (4)]

Cost estimates for some of the management measures recommended in this report can be estimated based on the costs of similar programs. Others require more reliance on analogous estimation of the costs. In general, implementers include the United States Congress (for appropriations), NOAA Fisheries, NOAA MDP, and state and tribal fisheries managers collaborating with fishers and/or fishers associations, researchers, ports, private industry, and NGOs. Implementation of all recommendations is subject to appropriations as well as cooperation with implementers listed herein.

A. Federal-Level Recommendations

Establish a National Working Group on ALDFG to Develop a Standardized Approach to Reporting, Assessment, and Management

National working groups and task forces are established regularly to address fisheries management issues. The cost for this recommendation is estimated at less than $500,000, based on the Congressional Budget Office cost estimate for the Alaska Salmon Research Task Force Act. This law was enacted in 2022 and includes the establishment of a working group to study salmon migration. The working group's mandates are to review existing research on Pacific salmon, identify areas where additional research is necessary, and support sustainable management of salmon in Alaska (Congressional Budget Office, 2022).

Specific costs for establishing and supporting a National Working Group on ALDFG will depend on the specific mandates associated with the group.

Establish Regional ALDFG Coordinating Committees

The estimated cost to establish coordinating committees would include the cost of 25% of a full-time employee.

This cost estimation assumes that NOAA personnel will support ALDFG coordinating committees. However, the decisions on the working and support for the committees will likely be unique for each region. In particular, participation in the committees will likely be borne by participating organizations.

Promote Effective International Management of ALDFG and Reduce Adverse Effects Caused by ALDFG from Foreign Fisheries

The implementation of this management recommendation could be accomplished within the current workstream of NOAA Fisheries, NOAA MDP, and State Department personnel working on international efforts to address sustainable fisheries and ALDFG at international organizations, including RFMOs, IMO, and FAO (NOAA Fisheries, 2021b; USEPA, 2020). Because personnel are already actively engaged within these organizations, the estimated additional cost to address ALDFG issues at these meetings is minimal.

Continued support for remediation actions at the Papahānaumokuākea Marine National Monument is estimated at from $2 million to $3 million annually. This estimate is based on the 2022 grants funding amounts awarded through the Papahānaumokuākea Research and Conservation Fund to support management and conservation in the monument (NFWF, 2023).

B. Regional and Fishery-Level Recommendations

Regional and fishery-level recommendations could be supported through existing programs, such as the following:

- Bycatch Reduction and Engineering Program administered by NOAA;
- Marine Debris Prevention Grants Program administered by NOAA MDP;
- Saltonstall-Kennedy Competitive Grants Program administered by NOAA;
- Small Business Innovation Research Program administered by NOAA; and
- Fishing for Energy Program administered by the NFWF.

Fishery and marine debris funding program criteria could be adjusted to reflect the recommendations to support fishery specific ALDFG strategy development including the establishment of reporting systems and requirements for disabling mechanisms in pot fisheries. Fishery community and infrastructure support and waste management-focused funding programs criteria could be adjusted to include the establishment of appropriate disposal options for recovered ALDFG and end-of-life fishing gear at all fishing ports in the United States and its territories.

C. Local Implementation

The following cost discussion is designed to assist potential local and regional implementing agencies and organizations in estimating costs of regional and fishery-level recommendations.

Support Fishery-Specific ALDFG Management Strategies Development

The development of the Puget Sound Lost Crab Pot Prevention Plan is a pertinent example of employing the described steps of an ALDFG Fishing Gear Assessment Framework to identify appropriate management measures. Execution of the Puget Sound Lost Crab Pot Prevention Plan occurred in 2015 and 2016 and was developed through a collaborative process, bringing together an advisory committee of individuals from the fishing industry, recreational fishers, fisheries resource managers, vessel traffic authorities, maritime industry, Marine Resources Committees, NGOs, and government agencies, including NOAA MDP. The development included two workshops with over 40 participants. Participants identified goals, strategies, actions, budgets, and key partners necessary to prevent harmful effects from lost Dungeness crab pots.

The process identified necessary management measures needed to address causes of gear loss to achieve the overall goals of reduced crab mortality in ALDFG, increased crab harvest, and reduced effects on marine habitat. NRC has proposed a budget of $70,000 to revisit and update this plan, including professional facilitations, planning, travel, and stipends for participants. The

$70,000 cost is an estimate solely for the convening of a meeting of the stakeholders. It does not include the costs required to gather the necessary information related to fishery gear loss and ecological, economic, and safety effects.

Promote and Support Establishment of Appropriate Disposal Options for Recovered ALDFG and End-of-Life Fishing Gear at All Fishing Ports in the United States and Its Territories

While costs for implementing this recommendation will vary from port to port, Bureo has provided some estimates for startup and subsequent ongoing costs for developing and supporting disposal and recycling programs in fishing ports in California. Bureo estimates that start-up costs to develop a program in a new fishery would be approximately $50,000, including travel and facilitation, fisher community engagement, training, organization of a pre-processing facility, and subcontracting to local partners (Ben Kneppers, Bureo, personal communication). This does not include the cost of renting facilities. The Bureo model generally includes the acceptance of fishing gear directly from the fishers and does not include acceptance of ALDFG retrieved from the ocean.

Implementation of programs focusing on fisher-led retrieved ALDFG could take two directions. The first direction is developing programs similar to the Fishing for Litter program, where fishers such as trawlers and longliners are encouraged to bring in ALDFG and other marine debris they encounter during fishing. The second is allowing fishers to retrieve derelict gear (usually in the pot and trap fisheries) and bring it back to port.

Estimates of annual ongoing costs for the Fishing for Litter program vary from about $152,000 in Belgium to about $250,000 in the Netherlands. The Belgium program supports gear collection in 12 ports. The program in Ireland has estimated annual costs of $200,000 and supports 12 ports (Jan Joris Madavaine, KIMO, personal communication, 2022). Each port receives about $5,000 for waste disposal for the program (Catherine Barrett, BIM, personal communication, 2022).

The second direction for this recommendation is allowing fishers to retrieve derelict gear left behind during a seasonal closure. Estimates of costs associated with developing and managing this kind of program were obtained from Dungeness crab fisheries managers in California, Oregon, and Washington. The development of the California program cost roughly $20,000 and was absorbed by existing staff costs of CDFG. Subsequent ongoing management fees are recouped through permitting fees (Morgan Ivens-Duran, CDFG, personal communication). The Oregon program operates for just about 6 weeks and costs are relatively low. They include having staff at the dock to register retrieved pots and some program supervision and administration. The costs associated with the retrieval itself are absorbed by the fishers, who negotiate with the owners regarding the price of the pot(s) they retrieve (Kelly Corbett, Oregon Entanglement Working Group, personal communication). The costs of the Washington program are very similar to those of Oregon (Dan Ayres, WDFW, personal communication).

Support the Establishment of Local ALDFG Reporting Systems and Registries Appropriate to Fisheries to Document Extent and Locations of Lost Fishing Gear to Inform Prevention and Remediation Activities

The cost of implementation of this recommendation could vary depending on the reporting and data collection processes already in place. The cost to migrate the Washington State Derelict Gear Database to an online platform and integrate it with the online lost gear reporting system was approximately $75,000 in 2009 (NWSF, 2011), or about $100,000 in 2022 dollars. An initial cost could be in that range with subsequent maintenance absorbed into existing staffing support for fisheries data management.

Support the Establishment of Disabling Mechanisms Requirements in All Pot Fisheries to Allow Escapement and Prevent Mortality of Any Animals Trapped in ALDFG

To implement this recommendation, new fisheries regulations and potentially new legislation may be needed. These processes require many labor hours to develop appropriate language and engage the fishing industry in identifying feasible and supported approaches. This change would require a substantial level of effort for some agency staff members for a year or more.

Ongoing implementation costs could be minimal for fishers to integrate these mechanisms into current trap designs, but initial costs might be considered high. The initial costs for fishers to implement this recommendation was estimated at $1,500 per fisher. DelBene et al. (2021) found that Virginia blue crab fishers were “willing to accept” pot modifications as recommended with compensation ranging from $794 to $1,449. In a fishery with more than 133 fishers participating, the initial upfront costs to compensate fishers for gear modifications would exceed $200,000. (Teh et al., 2017).

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