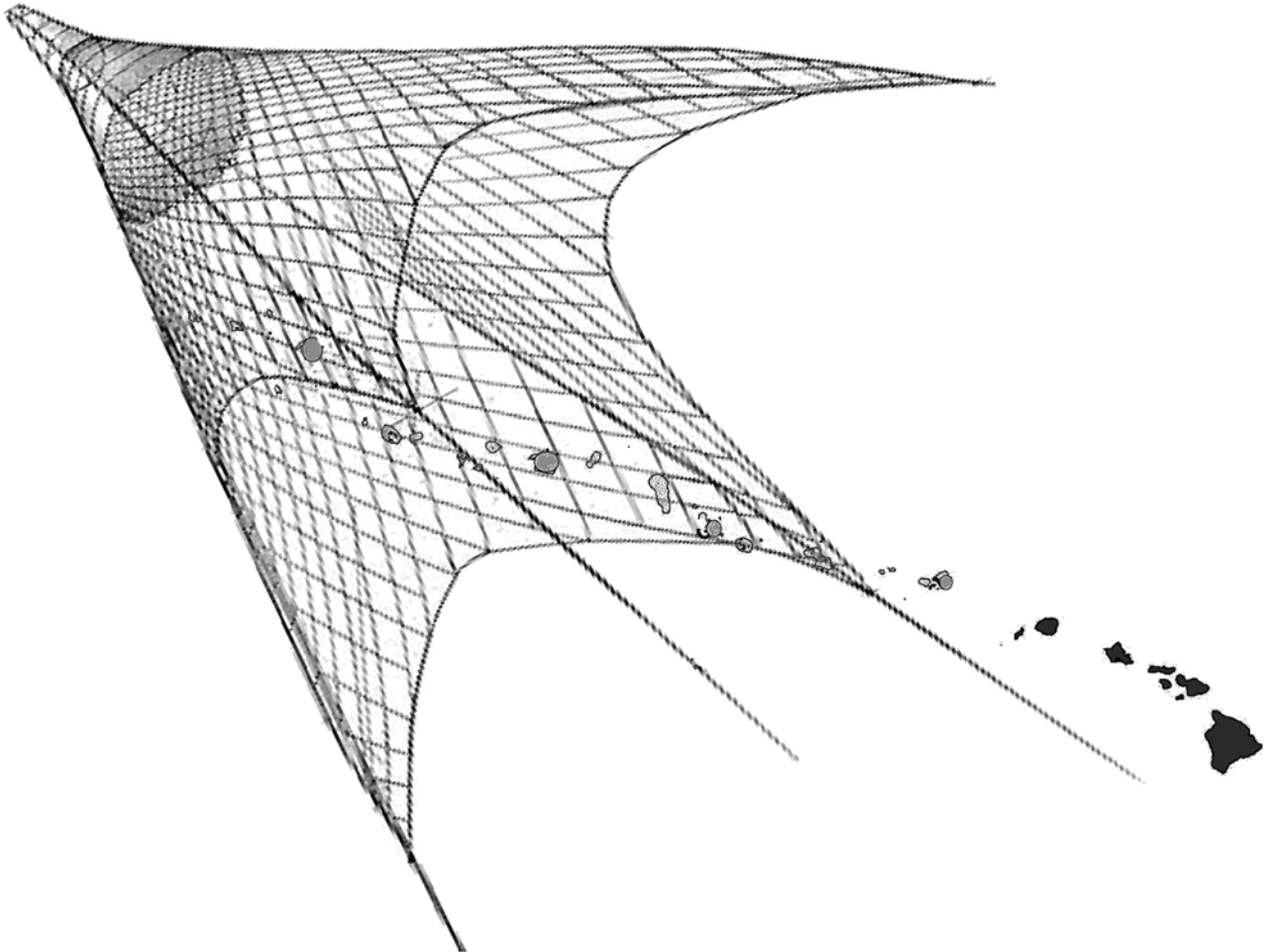


Marine Debris of the Northwestern Hawaiian Islands:



Ghost Net Identification

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Prologue

A successful and novel multi-agency marine debris removal program, focusing on the underwater removal of derelict fishing gear, has been conducted in the Northwestern Hawaiian Islands (NWHI) from 1998-2004 (Donohue 2003). The NWHI are the islands, atolls, and associated reefs of the Hawaiian Archipelago that extend for 1200 miles beyond the better-known eight main Hawaiian Islands. The NWHI are tremendously rich in natural resources and arguably represent the most pristine coral reef ecosystem on Earth today. This publication summarizes debris removal sites, the mechanisms for net accumulation in the NWHI, the impacts of derelict fishing gear on these pristine coral reef ecosystems, the multi-agency debris removal program, the analyses conducted on recovered nets, and information on the source of 250 net samples removed from NWHI coral reefs.

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Site: The Northwestern Hawaiian Islands

Extending northwest for 1200 miles (mi; 2200 kilometers [km]) beyond the inhabited main Hawaiian Islands is a chain of small islands, atolls, submerged banks, and reefs referred to as the Northwestern Hawaiian Islands (NWHI; Figure 1). The islands, atolls, banks, and reefs that comprise the NWHI include from east to west: Nihoa Island, Necker Island, Gardner Pinnacles, French Frigate Shoals, Maro Reef, Laysan Island, Lisianski Island, Pearl and Hermes Atoll, Midway Atoll, and Kure Atoll. The NWHI were geologically formed by the same volcanic hot spot that created the better-known eight main Hawaiian Islands but the NWHI are millions of years older.



NOAA Fisheries: Kelly Curtis

Seal-Kittery Islet, Pearl and Hermes Atoll.

Over time these islands submerged as the oceanic crust beneath them cooled. Today, only small islands, sand islets, or pinnacles remain above sea level with associated submerged coral reefs and banks covering nearly 3500 square mi (9124 square km).

Their sheer remoteness, 2500 mi (4000 km) from North America and 4500 mi (7200 km) from Asia, has sheltered the NWHI from many of the anthropogenic influences that affect coral reefs worldwide. Although not currently suffering from significant non-point source pollution, coastal development or sewage outflows, the NWHI are widely impacted by a different type of marine pollution: derelict fishing gear or ghost nets. Due to the oceanographic conditions in the Pacific Ocean and the persistent synthetic properties of fishing nets, derelict fishing gear and other ocean going trash accumulates in the remote NWHI.

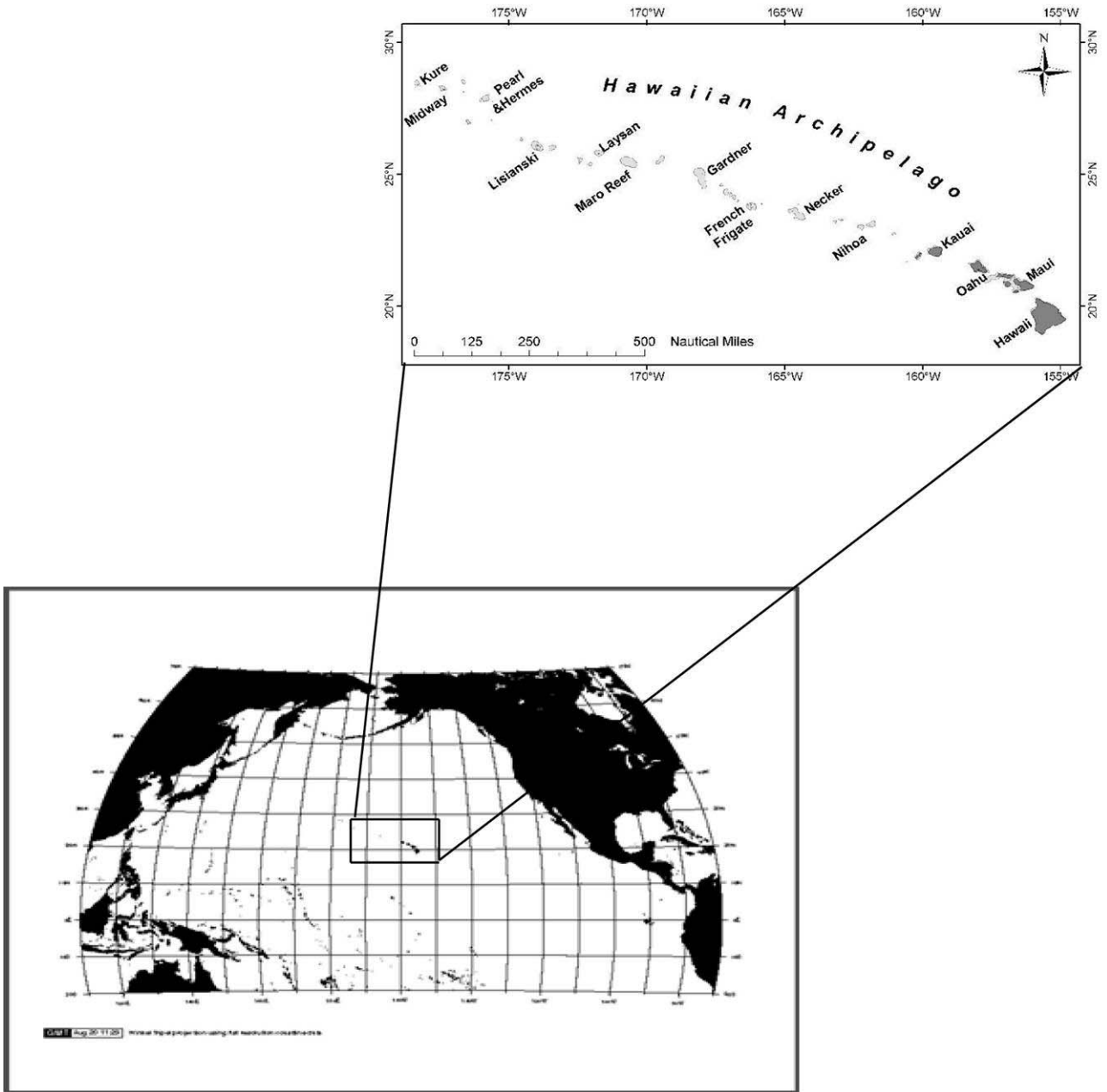
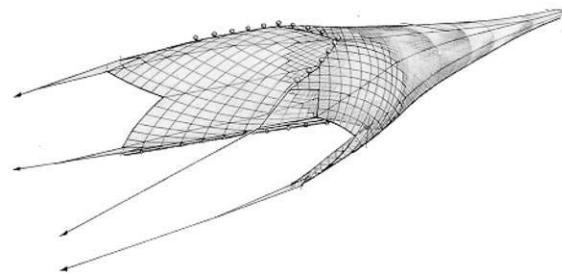


Figure 1. The location of the Hawaiian Archipelago in the North Pacific Ocean. The Northwestern Hawaiian Islands span approximately 1200 miles from Nihoa Island to Kure Atoll. Marine debris removal sites include Kure, Midway, and Pearl and Hermes Atolls, Lisianski and Laysan Island, Maro Reef, and French Frigate Shoals.

Mechanisms for Ghost Net Accumulation in the Northwestern Hawaiian Islands

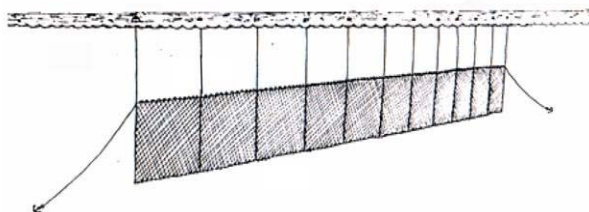
Fishing Gear Production

The onset of the manufacturing of synthetic materials, such as polypropylene, polyethylene, and nylon 40 years ago heralded the modern pollution problem of plastics in the marine environment, including ghost nets in the Northwestern Hawaiian Islands. Prior to modern synthetic webbing, fishing nets were constructed from natural fibers such as cotton, flax, and hemp. Natural fibers have several drawbacks which motivated the fishing industry's transition toward the fabrication of plastic net webbing.



Trawl Net

Natural fibers have a tendency to snag, tear, decay, and absorb water, causing them to sink. Synthetic materials add strength and endurance to fishing nets and increase their resistance to both decay and water absorption. Many synthetic fibers are positively buoyant and therefore float on the ocean's surface. Synthetic fibers that are neutral or



Gill net

negatively buoyant, such as nylon, are fashioned into nets with multiple plastic floats attached which prevent them from sinking. One disadvantage of modern synthetic fishing gear is that their

material composition essentially renders the nets impervious to photo-, mechanical- and biodegradation; whereas, natural fibers degrade over time. As a result, fishing gear intentionally discarded or unintentionally lost at sea during storms or active fishing operations becomes a type of persistent marine pollution.

Ocean Circulation

Debris accumulation throughout the Hawaiian archipelago is influenced by oceanic and atmospheric circulation in the North Pacific Ocean. The large-scale North Pacific oceanic currents (North Equatorial, Kuroshio, North Pacific, and California), and atmospheric winds (Northeast Trade Winds and Westerlies), generate a clockwise circulation pattern that forms the

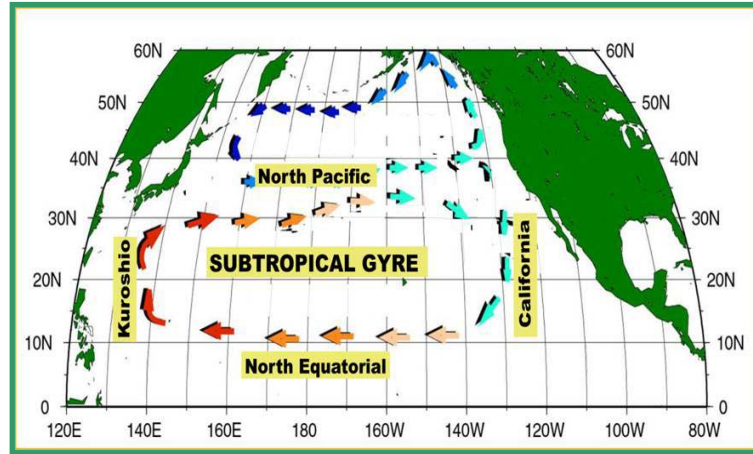


Figure 2. Currents of the North Pacific Ocean that form the North Pacific Subtropical Gyre.

North Pacific Subtropical Gyre (Figure 2). Fishing gear discarded anywhere in

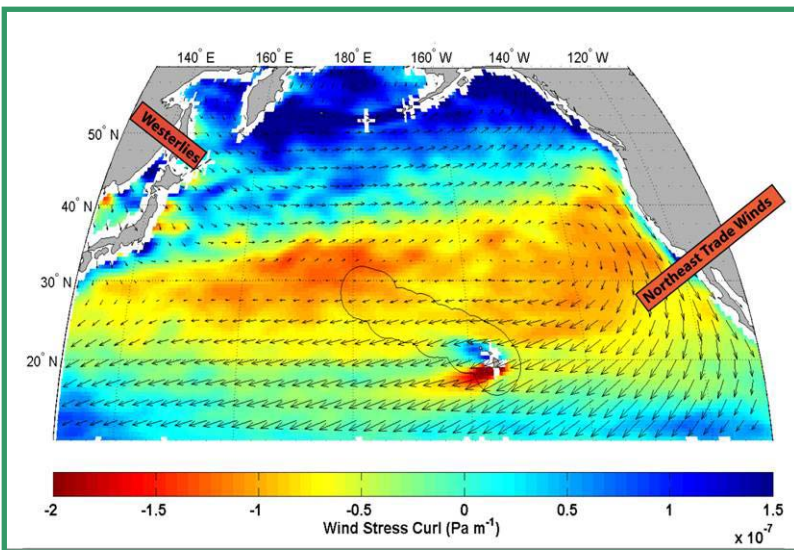


Figure 3. North Pacific Ocean mean winds from 1999-present measured by the NASA QuikSCAT satellite. Areas of sea surface movement are indicated by wind stress curl. Converging sea surface waters are indicated by negative wind stress curl (illustrated by the red, orange and yellow colors). The Hawaiian Archipelago is circled by a black line.

the North Pacific Ocean may circulate for years in this gyre (Dotson *et al.* 1977; Ingraham and Ebbesmeyer 2001). Oceanic and atmospheric forcing mechanisms tend to force surface waters to the right and towards the center of the North Pacific Subtropical Gyre thereby

generating the North Pacific Subtropical Convergence Zone (STCZ; Figure 3). The seasonal sea surface convergence along the mean position of the STCZ, located just north of the Hawaiian Archipelago, is the probable vector for marine debris accumulation in the Northwestern Hawaiian Islands (Figure 4; Kubota 1994; Bograd *et al.* 2004). Once in the Subtropical Gyre, buoyant synthetic nets

likely enter the Subtropical Convergence Zone where they aggregate and eventually encounter the Northwestern Hawaiian Islands (Kubota 1994; Brainard 2000; Donohue *et al.* 2001; Bograd *et al.* 2004).

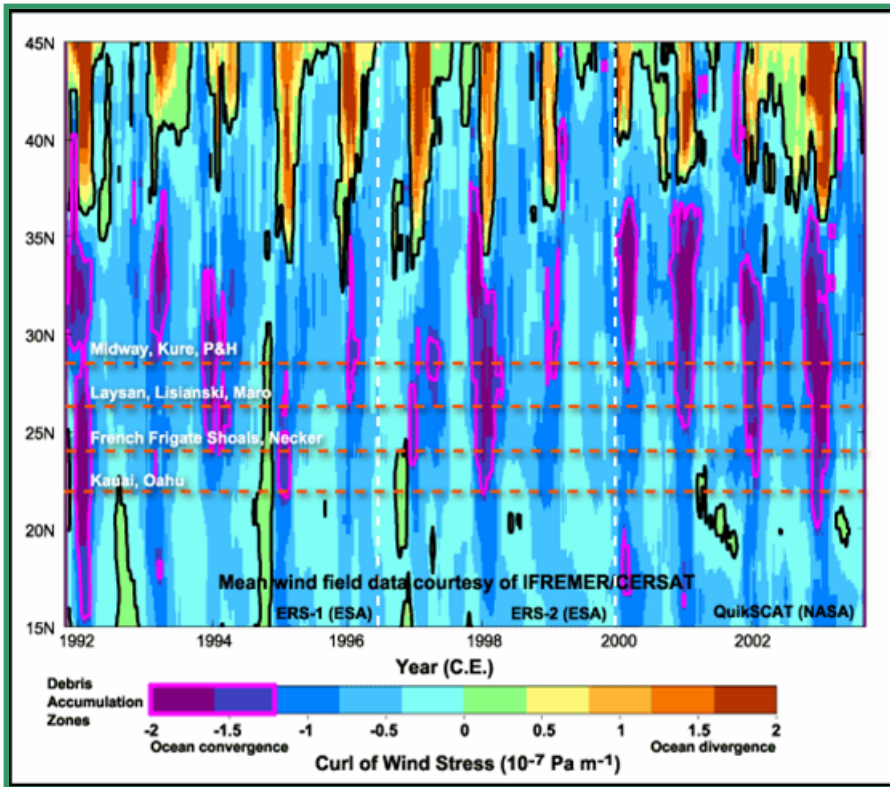


Figure 4. The location and duration of the Subtropical Convergence Zone (STCZ), formed in part by wind stress curl, over the Hawaiian Archipelago from 1992 through 2002. Locations of marine debris accumulation based upon the movement and location of the STCZ are represented in purple. The red dashes represent the approximate latitudes of some of the islands within the Hawaiian Archipelago (adapted from Bograd *et al.* 2004).

Impacts of Ghost Nets in the Northwestern Hawaiian Islands

Ghost nets threaten the ecological balance in the Northwestern Hawaiian Islands (Donohue *et al.* 2001). When large tangled conglomerations of floating derelict fishing gear reach the surf zones of the atolls and islands, the coral reefs function like sieves. Wave energy forces the derelict fishing gear across the reef causing it to tumble and snag on rocks and coral heads. The net webbing abrades, scours, and entangles and breaks coral heads

NOAA Fisheries: Megan Moews



NOAA Fisheries: Carla Navarro



Godwin

Left to right: ghost nets tangled in coral reefs of the Northwestern Hawaiian Islands (NWHI); a known invasive sea anemone (*Diadumene lineata*), native to Japan, discovered on a net recovered in the NWHI (Zabin *et al.* 2004).

from the substrate. Eventually nets may be deposited on islet shorelines and beaches, where they become a threat to the critically endangered Hawaiian monk seal as well as nesting seabirds. If not removed from the beaches and shorelines, the nets are likely to refloat and return to the nearshore reefs during large and intense winter surf; thereby extending the nets' ability to damage the marine environment. Ghost nets in the Northwestern Hawaiian Islands not only damage the living coral reefs, they

entangle and kill organisms that live within coral reefs as well as serve as a vector for the introduction of exotic and potentially invasive species into these relatively pristine ecosystems.

Entanglements

Sharks and other fish, marine mammals, sea turtles, seabirds, and crustaceans inhabiting the Northwestern Hawaiian Islands are all at risk from entanglement in ghost nets. Documented entanglement records exist for all marine turtle species that occur in Hawaiian waters including the endangered olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricata*), and leatherback (*Dermochelys coriacea*) as well as the threatened green sea turtle (*Chelonia mydas*) (Balazs 1980, 1985).

Perhaps the most notable species severely impacted by ghost net entanglement is the critically endangered Hawaiian monk seal



NOAA Fisheries: Jake Asher

Green sea turtle entangled at Pearl and Hermes Atoll. This turtle was released alive by NOAA personnel.



NOAA Fisheries: John Henderson

Hawaiian monk seal entangled at Lisianski Island (Henderson 1984). This seal was released alive by NOAA personnel.

(*Monachus schauinslandi*). This seal is the only living tropical seal, occurring wholly within the jurisdiction of the U.S. in the Hawaiian Islands. The monk seals' principle breeding subpopulations are located in the NWHI. Hawaiian monk seals have suffered one of the greatest entanglement rates of

any seal or sea lion to date (Henderson 1985, 1988, 1990, 2001; Boland and Donohue 2003). True mortality as a result of entanglement is difficult to quantify

because some seals become entangled and die at sea or underwater where they are not observed. Pups and juvenile monk seals, curious by nature, are particularly susceptible and have higher entanglement rates than adults (Henderson 1990). With a total Hawaiian monk seal population estimated to be less than 1400 individuals (Johanos and Baker 2004), the contribution of derelict fishing gear removal in mitigating monk seal mortality and injury is likely significant.



U.S. Fish and Wildlife Service

Dead seabird entangled in a fragment of fishing net.



NOAA Fisheries: Oliver Dameron

Dead lobster entangled at Pearl and Hermes Atoll.



NOAA Fisheries: Joe Chojnacki

Whale vertebrae found in a recovered ghost net at Pearl and Hermes Atoll.



State of Hawaii: Cynthia Vanderlip

Entangled shark beached at Kure Atoll.

Marine Debris Removal Program

Marine debris removal efforts were initiated in response to increasing entanglements of the critically endangered Hawaiian monk seal in fishing gear (Henderson 2001). Removal of derelict fishing gear on NWHI beaches has been ongoing since 1982 (Henderson 2001). Removal of derelict fishing gear from NWHI coral reefs began in earnest in 1998.

To mitigate the impacts of ghost nets in the NWHI, the United States National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service, Pacific Islands Fisheries Science Center partnered with other stakeholders to conduct the first large-scale multi-agency underwater marine debris removal effort in the world. The primary goals of the program are to:



NOAA Fisheries: Raymond Boland

The NOAA ship Townsend Cromwell.



NOAA Fisheries: Raymond Boland

Marine debris divers disentangle a Hawaiian monk seal caught in a ghost fishing net at French Frigate Shoals. This seal was released alive by NOAA personnel.

- Assess and monitor the amount of derelict fishing gear present on NWHI nearshore coral reefs
- Remove and safely dispose of derelict fishing gear on NWHI nearshore coral reefs

- Identify fishing fleets responsible for derelict fishing gear present in the NWHI
- Evaluate impacts of derelict fishing gear on NWHI nearshore coral reefs and associated endangered, threatened and protected species
- Increase public awareness of marine debris issues worldwide

Several ship platforms have supported these efforts by housing and deploying divers to remove debris and by storing and transporting recovered debris back to port in Honolulu, Hawaii where it is disposed of through recycling. The NOAA ship *Townsend*

Cromwell dedicated approximately one month of ship time per field season from 1998 through 2001. The United States Coast Guard Cutters *Kukui* and *Walnut* served as diver platforms for approximately one month during the 1999 and 2000 field seasons,

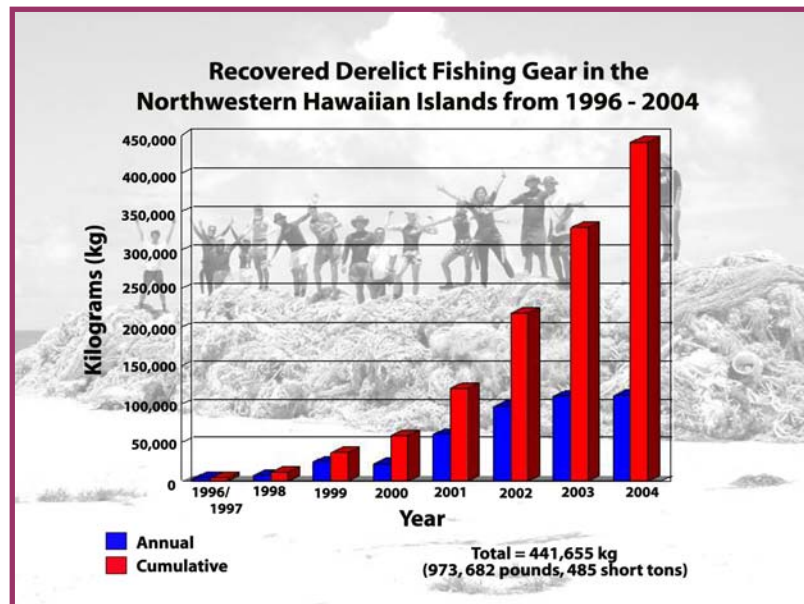


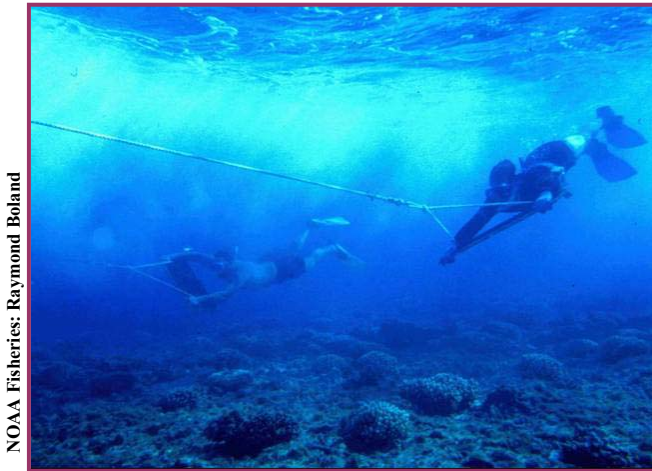
Figure 5. Total amount of derelict fishing gear removed by weight each year, as well as the accumulative project total, in the Northwestern Hawaiian Islands by the NOAA Fisheries-led multi-agency marine debris removal effort.

respectively. From 2001 through 2004, NOAA increased the removal effort by chartering privately owned research and fishing vessels to remain at selected NWHI islands and atolls for up to four months to serve as support platforms for debris divers. Areas surveyed for ghost nets to date include Pearl and Hermes, Midway, and Kure Atolls, Lisianski and Laysan Islands, Maro Reef, and French Frigate Shoals (Figure 1). This highly successful multi-agency effort has removed

and recycled over 485 short tons of derelict fishing gear (Figure 5 and see Donohue 2003 for a review of this novel partnership).

Survey and Removal Methods

In-water ghost net surveys were conducted using two methods: manta tow and free swim surveys (for a detailed description of methods used, please see



NOAA Fisheries: Raymond Boland

The Ocean Conservancy and US Fish and Wildlife personnel search for marine debris at Pearl and Hermes Atoll using manta boards.

Donohue *et al.* 2001). Manta tow surveys involve towing two snorkel divers behind a small boat at a constant speed. Each diver maneuvers a plywood board that is connected to the boat by a rope bridle and a 10 meter towline. Divers use these “manta” boards to steer themselves in an oscillating pattern from surface to depth while they concurrently

serpentine laterally. This creates a swath patterned transect. The towpath is recorded in real-time by a Global Positioning System (GPS) receiver onboard the small boat (Figure 6). This enables the removal team to document surveyed areas and increase efficiency.

Free swim surveys are performed in areas where towing is not feasible such as patchy reefs too shallow or exposed for safe small

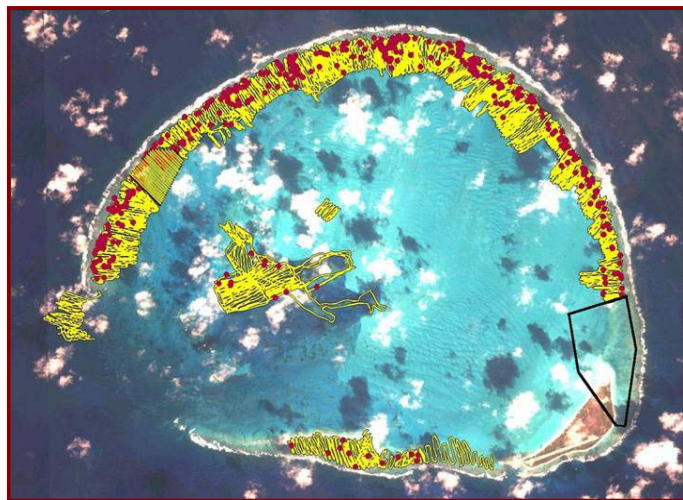


Figure 6. Ikonos satellite image of Kure Atoll with towboard tracks in yellow and locations of removed ghost nets or derelict fishing gear fragments indicated by the red dots.

boat operations. In these areas pairs of snorkel divers swim through and around the reefs searching for debris.

All debris encountered during manta tow and free swim surveys are documented by a GPS location and then meticulously removed using handheld knives or scissors to prevent additional damage to the reef. After freeing nets from the coral, nets are hauled aboard attendant small boats and subsequently transported back to the larger support vessel where net analysis is conducted.



NOAA Fisheries: Kate Jordan

Ghost net removal from a sand flat and reef.



NOAA Fisheries: Jen Homcy

Hauling recovered nets into attendant small boats for transport back to the larger support ship.



NOAA Fisheries: Megan Moevs

Transporting debris to the support ship.



NOAA Fisheries: Molly Timmers

Loading debris into the hold on the support ship.

Disposal Methods

Recovered nets are transported to Honolulu, off-loaded from the support ships, and transported to Hawaii Metal Recycling Co. At Hawaii Metal Recycling Co. debris is chopped into small, manageable pieces. This processed debris is distributed to H-Power Hawaii, and incinerated for the production of electrical power. In 2003 alone, 111 metric tons of derelict fishing gear was collected and incinerated, providing power

to 42 Oahu Hawaii homes for one year; the energy equivalent of 120 barrels of oil.



NOAA Fisheries: Mark Defley

Transporting debris in Honolulu.



NOAA Fisheries: Jen Stephenson

Off-loading debris from the ship.



NOAA Fisheries: Mark Defley

Chopped debris from Hawaii Metal Recycling Co.

Net Analysis

Over 5000 samples of ghost nets removed from NWHI coral reefs from 1998-2004 have been analyzed; 250 of which are included in this document. During the 1998 and 1999 removal efforts, all recovered nets were analyzed. Beginning in 2000, due to increased amounts of net removed, 25 percent of recovered debris was



NOAA Fisheries: Phil White

Net Analysis being conducted on a U.S. Coast Guard support ship.



NOAA Fisheries: Christina Kistner

A ghost net sample analyzed and archived during net analysis.



NOAA Fisheries:

A recovered net for analysis.

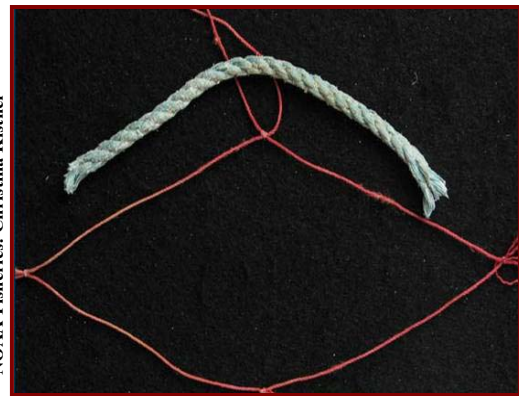
analyzed using a systematic sampling scheme to reduce sampling bias. As a result of increased removal efforts during the 2003 field season, 10 percent of recovered net was analyzed. A representative 40 X 40 cm section from each unique net sample analyzed was physically archived in all years. The following parameters were recorded for all analyzed net samples: net type, net construction, net stretch mesh size (mm), net twine diameter (mm), net color, net twist direction, and the number of strands composing the net webbing material.

Net Type:

Recovered net fragments were classified into the following net type categories: trawl/seine, monofilament gillnet, multifilament gillnet, cargo net, hawser, long-line, miscellaneous line, trawl (multi-panel/cod ends only), and other. We defined a multi-panel as a net that consisted of one or more panels of net physically connected together. Each panel of a multi-panel sample may have varying net parameters, which are recorded independently. The archived samples of multi-panel nets include a section of the connection point(s).



Monofilament gillnet



Multifilament gillnet



Miscellaneous net



Trawl/Seine net

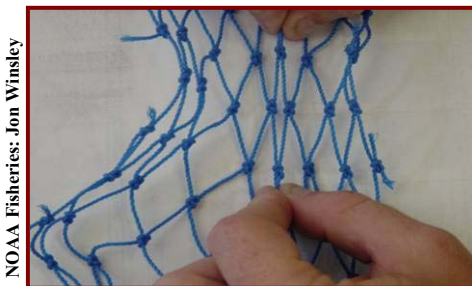


NOAA Fisheries: Christina Kistner

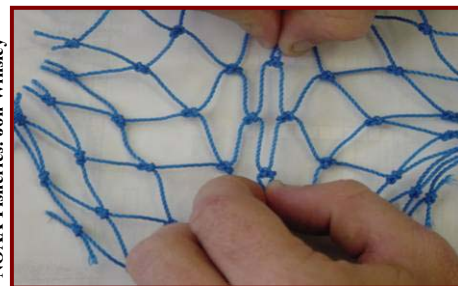
Multi-panel trawl net

Net Stretch Mesh:

Stretch mesh distance is the diagonal distance between two corners of a net cell (or “eye”) as it is pulled taught. It is measured in millimeters from the middle of one knot or cross point (for knotless webbing) to the middle of the opposite knot or webbing cross point. This measurement is obtained correctly on the cell when it is stretched in the orientation that produces a flattening of the webbing as shown below.



NOAA Fisheries: Jon Winsley

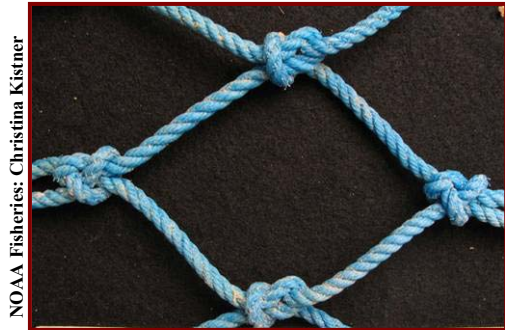


NOAA Fisheries: Jon Winsley

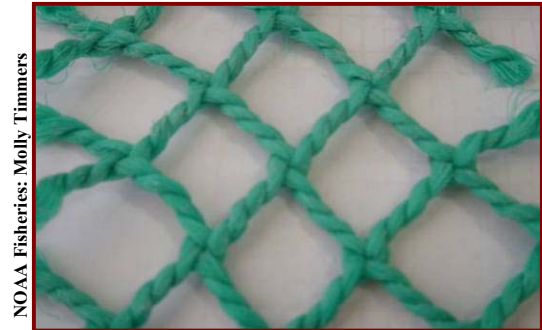
Net cell stretched correctly to measure stretch mesh, left and incorrectly, right.

Net Construction:

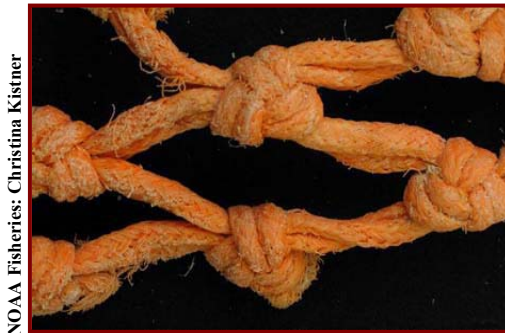
Net fragments were classified into one of the following net construction types: twisted-knotted, twisted-knotless, braided-knotted, braided-knotless, double-stranded, and other.



Twisted-knotted



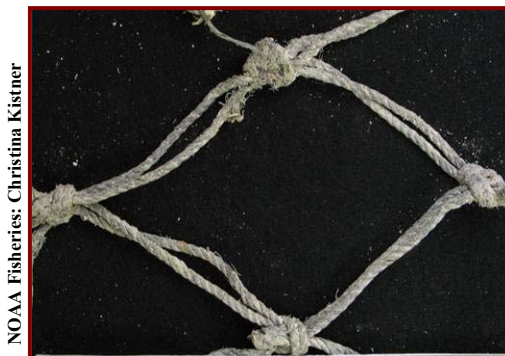
Twisted-knotless



Braided-knotted



Braided-knotless



Double-stranded

Net Twine Diameter:

The net twine diameter is the thickness of the line (rope) from which the net webbing is constructed. It is measured in millimeters.



Twine diameter measured in millimeters.

Net Color:

Nets were classified into one of the following color categories: green, black, blue, orange, yellow, red, white, grey, clear, or other.

Net Twist Direction:

The net twist direction describes the twist configuration of the webbing line (rope). Nets were assigned one of three twist directions: Z, S, or O-other. The Z twist direction results in a right-handed lay and the S twist direction a left-handed lay.



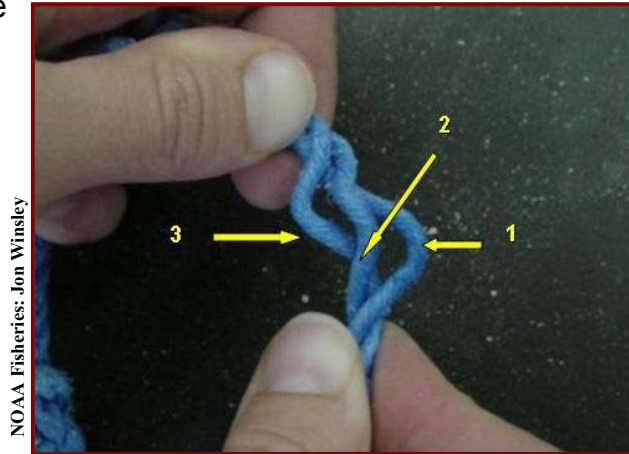
Z twist configuration of the webbing.



S twist configuration of the webbing.

Number of Strands:

The number of strands value is based upon how many strands are used to construct the net webbing line (rope). To determine this parameter, the line is unwound by hand, exposing the number of strands.



Number of strands is determined by unwinding of the net webbing.

Ghost Net Identification Process

Photo Documentation

The 250 ghost net samples represented in this document were selected to illustrate the multitude of unique net types recovered in the NWHI. These samples were photographed using a Canon Power Shot G5 beneath a photo mount. Images were then imported to a Microsoft Access database and linked with corresponding metadata.

NOAA Fisheries: Christina Kistner



Net Identification

Photo mount used to capture the webbing images represented in the Ghost Net Identification Database.

A panel of experts that included fishing vessel owners, fishermen, and net manufacturing industry representatives as well as a fishing net specialist from the

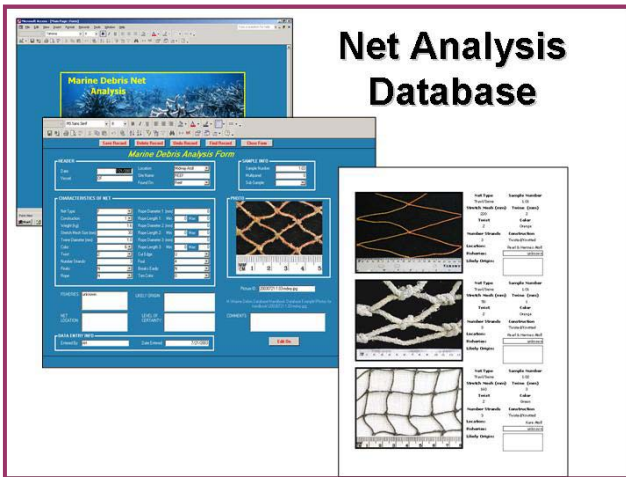


Image of the database used by marine debris divers for entering net analysis data.

NOAA Alaska Fisheries Science Center reviewed the 250 net samples presented in this document to aid in the source identification of ghost nets recovered in the NWHI. These net experts examined the physical samples of the nets represented in this handbook and discussed their synthetic material compositions, countries of webbing manufacture, and potential target fisheries.

A level of certainty index was created for the country of webbing manufacture and target fishery categories. The index scale is

based on a 1 through 5 level of certainty; 1 being low certainty and 5 being high certainty.

Net Sample Database

By clicking on the link below you will enter the net sample database. Refer to the Net Analysis and Net Identification sections of this document for an explanation of the parameters presented alongside the photographs. To view a higher resolution image of any photograph, double-click on the image. A separate window will appear. You **must** minimize the document to view both the database and the high resolution image simultaneously.

Marine Debris of the Northwestern Hawaiian Islands: Ghost Net Identification Database

Conclusions

Removal of ghost nets and other marine debris in the NWHI is a valuable tool to reduce wildlife entanglement and permit natural re-growth and restoration of damaged coral reefs.

However, it is a short-term solution to a potentially long-term problem. Reduction of fishing gear loss or discard is crucial. This work endeavors to increase the awareness of the NWHI marine debris problem on a national and international scale. We hope

to engender the significant social and political will necessary to reduce the source of derelict fishing gear and marine debris from both the NWHI as well as the remainder of the World's oceans.



NOAA Fisheries: Ashley Greenley

A Hawaiian monk seal swimming past nets later removed at Pearl and Hermes Atoll.

References

- Balazs, G.H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. U.S. Dep. Commer., NOAA-TM-NMFS-SWFC-7, 141 p.
- Balazs, G.H. 1985. Impact of ocean debris on marine turtles: entanglement and ingestion. *In* Proceedings of the Workshop on the Fate and Impact of Marine Debris, 1984, eds. R.S. Shomura and H.O. Yoshida, pp. 387-429. U.S. Dep. Commer., NOAA-TM-NMFS-SWFC-54.
- Bograd, S. J., D. G. Foley, F. B. Schwing, C. Wilson, R. M. Laurs, J. J. Polovina, E. A. Howell, and R. E. Brainard (2004). On the seasonal and interannual migrations of the transition zone chlorophyll front. *Geophys. Res. Lett.*, 31,L17204, doi:10.10129/2004GL020637.
- Boland, R.C. and Donohue, M. 2003. Marine debris accumulation in the nearshore marine habitat of the endangered Hawaiian monk seal, *Monachus schauinslandi* 1999-2001. *Mar. Poll. Bull.* 46:1385-1394.
- Brainard, R., Foley, D., Donohue, M. and Boland, R. 2000. Accumulation of derelict fishing gear by ocean currents threatens coral reefs of Hawaii. *In* presentation abstracts, International marine debris conference on derelict fishing gear and the ocean environment. August 7-11, Hawaii, Honolulu.
- Donohue, M.J., Boland, R.C., Sramek, C.M., Antonelis, G.A., 2001. Derelict fishing gear in the Northwestern Hawaiian Islands: diving surveys and debris removal confirms threat to coral reef ecosystems. *Mar. Poll. Bull.* 42(12), 1301-1312.
- Donohue, MJ. 2003. How multiagency partnerships can successfully address large-scale pollution problems: a Hawaii case study. *Mar. Poll. Bull.* 46:700-702.
- Dotson, A. Magaard, L. Niemeeyer, G. and Wyrski, K. 1977. A simulation of the movements of fields of drifting buoys in the North Pacific Ocean. Rep. HIG-77-3, Hawaii Institute of Geophysics, Honolulu, 59 p.
- Henderson, J.R. 1984. Encounters of Hawaiian monk seal with fishing gear at Lisianski Island, 1982. *Mar. Fish. Rev.* 46(3):59-61.
- Henderson, J.R. 1985. A review of Hawaiian monk seal entanglements in marine debris. *In* R.S. Shomura and H.O. Yoshida (editors), Proceedings of the workshop on the fate and impact of marine debris, 27-29 November 1984, Honolulu, Hawaii, p.326-335. U.S. Dep. Commer., NOAA-TM-NMFA-SWFC-54.

- Henderson, J.R. 1988. Marine debris in Hawaii. *In* D.L. Alverson and J.A. June (editors), Proceedings of the North Pacific Rim Fisherman's Conference on Marine Debris, 13-16 October 1987, Kailua-Kona, Hawaii pp.189-206. Natural Resource Consultants.
- Henderson, J.R. 1990. Recent entanglements of Hawaiian monk seals in marine debris. *In* R.S. Shomura and M.L. Godfrey (editors), Proceedings of the second international conference on marine debris, 2-7 April 1989, Honolulu, Hawaii, p. 540-553. U.S. Dep. Commer., NOAA-TM-NMFS-SWFSC-154.
- Henderson, J.R. 2001. A pre- and post- MARPOL Annex V summary of Hawaiian monk seal entanglements and marine debris accumulation in the Northwestern Hawaiian islands, 1982-1998. *Mar. Poll. Bull.* 42(7):584-589.
- Ingraham Jr., W.J., Ebbesmeyer, C.C., 2001 Surface current concentration of floating marine debris in the North Pacific Ocean: 12-year OSCURS model experiments. *In* Proceeding of the International conference on derelict fishing gear and the ocean environment, 2001, Hawaiian Islands Humpback Whale National Marine Sanctuary Publication.
- Johanos, T.C. and J.D. Baker (Eds) 2004. The Hawaiian monk seal in the Northwestern Hawaiian Island, 2001. U.S. Dep. Commer., NOAA-TM-NMFS-PIFSC-1.
- Kubota, M. 1994. A mechanism for the accumulation of floating marine debris north of Hawaii. *Journal of Physical Oceanography* 24:1059-1064.
- Zabin, C.J., Carlton, J.T., and Godwin, S. 2004. First report of the Asian sea anemone *Diadumene lineata* from the Hawaiian Islands. *Bishop Mus. Occas. Pap.* 79:54-58.

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