NATURAL RESOURCES CONSULTANTS, INC.

4039 21st Ave West, Suite 404
SEATTLE, WASHINGTON 98199, U.S.A.
TELEPHONE: (206) 285-3480
TELEFAX: (206) 283-8263
E-Mail : kantonelis@nrccorp.com (corporate)
prudell@nrccorp.com

DEEPWATER DERELICT FISHING GEAR REMOVAL PROTOCOLS

Identifying and Assessing the Feasibility of Removal of Deepwater Derelict Fishing Nets from Puget Sound, Washington

PREPARED FOR:
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION AND NORTHWEST STRAITS MARINE CONSERVATION FOUNDATION

SUBMITTED BY:
NATURAL RESOURCES CONSULTANTS, INC.

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Abstract

Since 2002, derelict fishing gear removal in the Puget Sound has focused on operations in water depths between 0 and 105 feet. Several rockfish species have accounted for some of the many fish, mammals, birds and invertebrates that become mortally entangled in derelict nets. The federal ESA listing of the canary, yelloweye and bocaccio rockfish has prompted further interest in understanding rockfish mortality and derelict fishing gear, and reducing these impacts. Removal of derelict nets in rockfish habitat at depths beyond 105 feet, where they are commonly found, would reduce the threat that derelict nets pose on rockfish populations in the Puget Sound. Online research and interviews with industry professionals were conducted to identify various methods of deepwater derelict net removals used around the world. Reported here are five methods using: ROVs, deepwater divers, grapples and trawl nets. The methods were summarized and, when needed, modified to be applied in Puget Sound. They were ranked by safety, cost effectiveness and environmental impact to assess the feasibility of each application in Puget Sound. The use of ROVs was identified as the recommended method for deepwater net removal in the Puget Sound based primarily on high safety and environmental impact ranking. Additionally, three locations for potential pilot projects to test and adjust methods and protocols were identified where deepwater derelict nets are known to exist.

Introduction and Background

Commercial and recreational fishing in Puget Sound are part of a long history of social and economic development in the region. As a consequence of past and present fishing activities significant amounts of gear have been lost or abandoned and are defined as derelict fishing gear. Derelict fishing nets are a component of lost fishing gear that present unique challenges for removal operations. Often composed of synthetic materials that degrade slowly, these nets can have long-term negative impacts on the marine environment, threaten divers with entanglement and may pose navigational hazards. Removal of derelict fishing nets can result in significant habitat recovery and prevent the loss of protected bird, mammal and fish species as well as economically important commercial fish and shellfish populations. Research conducted by the Northwest Straits Initiative (NWSI) has shown that removal of derelict nets can restore service functions of effected seafloor habitat within one growing season (NRC, 2009). Derelict nets in the Puget Sound have accounted for the mortality of thousands of birds, fish, mammals and invertebrates (Good et al., 2010) and research focusing on catch and mortality rates have shown that derelict gear impacts on marine organisms continue through a continuous cycle of entanglement, mortality and decomposition (Gilardi et al., 2010) (Antonelis et al., 2011).

In 2002 the Washington State legislature passed senate bill 6313, establishing a derelict gear removal program administered by the NWSI. The legislation called for Washington Department of Fish and Wildlife (WDFW) to establish and adopt formal guidelines for the removal of nets and other lost gear items. WDFW, working with Washington Department of Natural Resources (WDNR), Northwest Straits Commission (NWSC) and numerous partners released Derelict Fishing Gear Removal Guidelines in November of 2002. This included specific protocols for the removal and disposal of derelict fishing nets found ranging from the surface to a depth of 105 feet.

Since 2002 these guidelines have been used by NWSI derelict gear removal program to successfully remove over 4,400 nets from the shallow, near shore marine waters of the Puget Sound, in depths from 0 to 105 feet. In general these nets are removed by divers using with surface supplied air and supported by a dive vessel with capacity for lifting nets to the surface and onboard.

Like in shallow water, derelict nets in deepwater can cause negative environmental impacts by entangling and trapping marine organisms and by covering and damaging benthic habitats. Removal of deepwater fishing nets creates unique technical and safety challenges for removal operations. Deepwater derelict nets in Puget Sound have been identified and reported by private citizens, state agencies, commercial and recreational divers, and sidescan sonar surveys. In addition, deepwater nets have been located during shallow water dive removals where nets extending below 105 feet were cut off to prevent divers from working beyond the maximum allowable safety depth for such work. The WA State derelict fishing gear database (DGDB) holds information on all documented derelict fishing gear in the Puget Sound, where there are currently records of 207 deepwater derelict nets (Figure 1). Sidescan sonar and drop camera survey techniques have been utilized to identify deepwater derelict fishing nets in the San Juan Islands (NRC, 2011), and discussions with fishermen, dive removal teams and state and federal agencies indicate that further deepwater surveys would reveal significantly more derelict fishing nets than the 207 presently inventoried. Information such as historical fishing effort, bathymetry, benthic terrain, bottom type and oceanographic processes can be used together to identify high priority areas exhibiting the greatest likelihood of deepwater derelict net occurrence. Similar to how surveys were conducted by NWSI in the Puget Sound for shallow water derelict nets, this information can be used to build a systematic survey plan to identify derelict net targets beyond 105 feet in depth. Presently, formal guidelines for deepwater derelict net removal operations inside the Puget Sound do not exist; however some protocols have been developed and applied in several US States and internationally.

Of special concern in Puget Sound are three rockfish species that have been listed under the federal Endangered Species Act, including canary (*Sebastes pinniger*) and yelloweye (*Sebastes ruberrimus*) as threatened and bocaccio (*Sebastes paucispinis*) as endangered. Locations of deepwater derelict fishing nets identified during shallow water dive removal operations occur in rockfish habitat. Previous research completed by NWSI and Natural Resources Consultants (NRC, 2011) that included sidescan sonar and camera surveys in rockfish habitat images of suspended derelict fishing nets that risk entangling rockfish and other marine animals. Additionally, deepwater derelict nets observed in rockfish habitat area have been reported to NWSI by agencies conducting scientific research and private citizens. Lost fishing nets and their associated damage to habitat have been identified as potential stressors to rockfish populations in Puget Sound (WDFW, 2010).

Using a mortality projection model derived from research reported in Gilardi et al. (2010), analysis of rockfish impacts recorded during net removal operations conducted by NWSI in Puget Sound indicate a mortality rate of 1.55 rockfish per derelict net per year. The WA DGDB currently holds records of 207 deepwater nets in Puget Sound, and if left in place these nets are projected to account for the mortality of 322 rockfish each year; assuming a similar rate of rockfish entanglement from deepwater nets as has been documented for shallow water nets. This figure does not take into consideration the impact to rockfish habitat caused by the derelict fishing gear, nor does it account for the unknown number of additional deepwater derelict nets presumed to be present in the Puget Sound.

Extending net removal operations in Puget Sound beyond a depth of 105 feet creates issues surrounding safety of the dive removal team, efficiency of net removal including time and cost issues, and effectiveness of operation in regard to complete or partial removal of net. The impacts these nets pose to the already stressed rockfish populations in the Puget Sound has provided impetus to evaluate the methods, costs and effectiveness for removal of deepwater nets. Deepwater removal operations that have taken place elsewhere provide a framework to assess removal protocols that could be applied in Puget Sound.

This report will provide an assessment of alternative techniques for deepwater net removal operations drawing upon examples from the United States and internationally. In the following sections five techniques used for deepwater derelict net removal will be described and evaluated for safety, cost and effectiveness. Based on this review the most promising techniques for deepwater net removal in Puget Sound will be identified and further described. Areas of future research and a pilot deepwater derelict net removal project will be suggested and a prioritized list of recommendations to reduce deepwater net impacts to rockfish populations will be included.

Methods

In order to develop an understanding of current protocols and feasibility of deepwater net removal, an online literature search was utilized along with expert interviews. The online search included investigations of existing deepwater net removal applications within the United States and international marine waters. Online searches identified key personnel involved in removal operations and provided contact information for several interviews. Other interviewees were identified by the authors through years of experience in the marine surveying industry. Interviews were typically structured semi-formal phone interviews that lasted from 30 to 45 minutes.

Identified protocols for deepwater net removal methods were evaluated based on a combination of factors including environmental impacts, removal effectiveness, safety of personnel involved in operations, cost effectiveness and total cost of operations.

Findings

Five potential deepwater removal techniques were identified and considered separately (Table 1).

Table 1. Deepwater derelict gear removal methods with attribute (safety, cost effectiveness and environmental) ranking with cost estimates and examples of applications.

<table>
<tr><th rowspan="2">Removal Method</th><th colspan="3">Attributes</th><th rowspan="2">Cost</th><th rowspan="2">Examples of Location Applied and Purpose</th></tr>
<tr><th>Safety Ranking</th><th>Cost Effectiveness</th><th>Environmental Ranking (minimal impact)</th></tr>
<tr><td rowspan="4">ROV</td><td rowspan="4">High</td><td rowspan="4">Moderate</td><td rowspan="4">High</td><td rowspan="4">$13,000/day plus fuel, $390,000/month plus fuel</td><td>Cordell Bank NMS: Net and Pot Removals</td></tr>
<tr><td>Montery Bay NMS: Net and Pot Removals</td></tr>
<tr><td>Stellawagen Bank NMS: Lobster Pot Removal</td></tr>
<tr><td>Puget Sound: Crab Pot Removals</td></tr>
<tr><td>Divers -Surface Supplied Air</td><td>Moderate</td><td>Moderate</td><td>High</td><td>$13,000/day plus fuel, $390,000/month plus fuel</td><td>Puget Sound: Net Removals</td></tr>
<tr><td>Divers - Saturation</td><td>Low</td><td>Low</td><td>High</td><td>$175,200/day plus fuel, $5,250,600/month plus fuel</td><td>Not Avaliable</td></tr>
<tr><td rowspan="5">Grappling</td><td rowspan="5">High</td><td rowspan="5">High</td><td rowspan="5">Low</td><td rowspan="5">$8,000/day plus fuel, $240,000/month plus fuel</td><td>Oregon Coast: Net and Pot Removals</td></tr>
<tr><td>Northeast Atlantic: Gillnet Removals</td></tr>
<tr><td>Long Island Sound: Lobster Pot Removals</td></tr>
<tr><td>Stellawagen Bank NMS: Net and Pot Removals</td></tr>
<tr><td>East Sea: Gillnet Removals</td></tr>
<tr><td rowspan="2">Trawl</td><td rowspan="2">Moderate</td><td rowspan="2">High</td><td rowspan="2">Low</td><td rowspan="2">$8,000/day plus fuel, $240,000/month plus fuel</td><td>US West Coast: Nets, Pots and Marine Debris</td></tr>
<tr><td>Gulf of Mexico: Marine Debris</td></tr>
</table>

While not strictly part of a deepwater removal technique, a Derelict Gear Removal (DGR) plan, pre-removal operations, post-removal operations, disposal and reporting are part of the overall protocol for conducting net removal operations. These activities are required by WDFW for removal operations in Puget Sound between 0 and105 feet and it is suggested that these guidelines are well suited for deepwater net recovery and should be applied to all of the techniques presented herein. Please see Appendix A for details.

Considering the expense of staging a deepwater removal, it is imperative that the derelict net locations are investigated prior to planning removal operations. It is recommended that a pre-removal survey be conducted using an ROV or drop camera (where conditions allow). Scoping the net location will provide data on the type of net, size of net and impacts to habitat and marine organisms. After which, a decision can be made to leave the derelict gear in place if associated habitat and benthic impacts are low and cost of removal is deemed greater than the environmental benefit of net removal. If the impacts from a derelict net appear significant and benefits of removal are greater than cost of removal, a removal plan for each location should be developed with information on depth range, current velocity and direction, type of habitat, and potential anchoring locations.

Method 1 – Remotely Operated Vehicle

One proposed technique for deepwater net recovery in Puget Sound is by utilizing Remotely Operated Vehicles (ROV) from an anchored support vessel. Successful examples of deepwater gear removals involving ROVs include removal operations at Cordell Bank National Marine Sanctuary (NMS) (2006), Monterey Bay NMS (2009, 2010, 2011), and Puget Sound crab pot removals (2008).

A Remotely Operated Vehicle (ROV) is a motorized underwater vehicle that is typically tethered to a power supply and a control unit on a surface vessel. ROVs range from the size of a softball to a truck. ROVs are commonly equipped with a wide range of gear such as cameras, sonars, lasers, manipulators, tracking systems etc.

An ROV that was designed specifically for the strain of pulling nets during derelict gear recovery could have a crash frame engineered to take the direct strain of pulling a net to the surface. It would be necessary for the vehicle to have powerful motors for working in strong currents. The ROV would also be equipped with cameras, sonar, tracking systems, and hydraulic manipulators with cable cutters.

Procedure

A thorough pre-dive inspection of the ROVs will be performed prior to deployment. Such inspections vary depending on the ROV type and configuration, but typically include testing the power supply, connectors, vacuum, lights, lift eyes, controls, thrusters, pan-tilt, cameras, manipulator functions and handling system. Additionally, an assessment of the umbilical condition, fluid levels, hardware integrity (i.e., shackles, cutters), hard drive space and software performance will take place. To ensure ROVs are functioning as desired, any ROVs that are to be used in removal operations would be deployed in port prior to embarking for removal operations. The party chief or safety officer would conduct a pre-removal safety meeting with the vessel crew to discuss the dive plan, safety procedures and confirm proper personal protective equipment (PPE) is being used.

Upon arrival at the work site, the ROV support vessel will maintain a position up-current from the derelict net location through either anchoring or dynamic positioning. The primary ROV will be deployed with a hydraulically powered handling system, which depending on the vessel is comprised of a combination of components such as A-frames, U-frames, cranes, davits, knuckle booms, string blocks and umbilical winches. The ROV operator will use a computer with navigational software and an ultra-short baseline (USBL) tracking system to drive the ROV to the derelict net location on the seafloor.

The ROV operator would then survey the net and assess the overall situation and make a determination where to attach the ROV to the net. The pilot will then move the ROV into position and grab the net by the lead line with two manipulators. If no leadline is available to attach the manipulator, as much web as possible will be secured with the manipulator. If the primary ROV cannot free the net with the aid of a surface winch, a secondary ROV can be launched to free the web as the primary ROV pulls on the net. This process will continue until the primary ROV has a manageable section of net, then the secondary ROV will cut the section of net free from the sea floor. The primary ROV will be pulled to the surface and then on to the surface vessel where chokers will be applied to the net and finally the net will be pulled onboard. The choker is a snare device that cinches tighter as tension is applied. This process will be repeated until the net is recovered.

For heavier nets such as seine nets an ROV can attach a cable from a winch on the surface vessel to the net and pull it to the surface while the ROV cuts it free from the net habitat.

Cost

Current experience with ROV net removals suggests a rate of approximately one net removed per day.

Daily cost for ROV operations would be $9,000/day based on a 30 day workload. Daily cost for a suitable vessel for ROV net recovery operations (for example DSV Prudhoe Bay) would be $4,000/day plus fuel expenses. Total daily operations cost for a 30 day workload would be approximately $13,000/day or $13,000/net removed and approximately $400,000 per month of operation.

Advantages

This technique allows for deepwater removal without endangering divers, and can provide sonar and visual images of the net and removal operation while in progress. The ability to see the removal in progress provides an advantage similar to having divers working the net. As the net is removed the ROV operator can maneuver on the target and adjust positioning and activities based upon how the net is coming off the seafloor. This can allow for a more discriminate and complete removal of the net, as opposed to grapple and trawl techniques that require a return survey to identify if complete removal of the net target had taken place.

Disadvantages

Poor visibility in the water column could impact when operations can take place. High current areas could impact maneuverability and handling of the ROV. There is some risk of entangling the ROV in the derelict gear as it becomes detached from the seafloor. Targets in locations that present snags create some risk of entanglement for the ROV's umbilical cord, but careful target selection combined with the ROV’s sonar should help reduce this risk. This technique is relatively expensive compared to shallow water operations but comparable to using divers between 105 and 150 feet. It is less expensive than using saturation divers at depths greater than 150 feet and significantly more expensive than deepwater grapple techniques.

Method 2 and 3 - Deepwater Diving: Surface Supplied Air and Saturation Diving

While diving at depths greater than 105 feet is not uncommon for commercial diving operations, no examples of deepwater net removal operations utilizing surface supplied air were identified beyond Puget Sound during the literature search and interviews. However, the authors have experience with net removals at depths greater than 105 ft in Puget Sound, in partnership with the US Navy deep submergence rescue dive team (2005), US Army deep sea divers (2008) and net removals taking place prior to the development of the NWSI Derelict Gear Program. Two separate methods utilizing divers are presented here. The first method describes the use of surface supplied air for operational depths ranging from 105 to 175 feet and the second method involves a technique referred to as saturation diving for depths greater than 175 feet. Both techniques will require a decompression chamber to be present on the dive support vessel.

Method 2 - Diving with surface supplied air: Depths 105-175 feet

Typically the removal operation involves a dive support vessel with hyperbaric chamber and a gear storage and transport vessel. The dive operation usually entails three or more trained divers using surface supplied air, bailout bottles and a two-way voice communication system. In some cases this system is augmented by a real-time helmet mounted underwater video feed to the dive support vessel. One diver removes the gear (the work diver) while a second fully suited diver stands by as a safety backup (backup diver) and a dive supervisor monitors all aspects of the dive operation.

Procedure

Preceding departure the entire dive team and vessel crew would ensure that all proper PPE is onboard and will be worn during removal operations. A dive plan would be included in the pre-removal safety meeting along with all other safety procedures. Before the dive begins, the dive supervisor provides the diver with direction and distance to the derelict net target. Once the derelict net is identified by the work diver, and prior to removal operations, the work diver surveys the length of the net and reports entangled animals, impacts of the net on the habitat, and provides estimates of the size of the net and the amount and type of habitat impacted. All data is recorded by a biologist on the dive support vessel. In some cases, underwater video or still photographs are taken to document these observations.

Nets are removed from the habitat by hand and, if necessary, cut loose where buried or encrusted. The diver attempts to bundle the net, followed by attaching a strap and airlift bag to the bundled net. The net is then floated to the surface where it is retrieved by the gear storage vessel. The diver will transit to surface making appropriate decompression stops and once on surface transfer to the onboard hyperbaric chamber. The specifics regarding diver retrieval will be based on the mixed-gases involved and varying protocols for each dive team.

Cost

A net removal rate of one net per day is expected using this technique. Cost of operations include a diver day rate of approximately $9,000/day based on a 30 day workload and $4,000/day plus fuel expenses for a suitable vessel for diver net recovery operations. Total cost for dive removal operations from 105 to175 feet deep will be approximately $13,000/day or $13,000/net.

Method 3 - Saturation Diving: Depths > 175 feet

Saturation diving is a diving technique that has been in use since about 1940. The technique enables a diver to reduce the risk of the bends or decompression sickness when diving for long periods of time at depths greater than 150 feet. Decompression sickness results from the expansion of gas bubbles in the body when a diver ascends to the surface resulting in a range of conditions from joint pain to paralysis and even death. The goal of saturation diving is to prevent a diver from experiencing decompression sickness by keeping the diver at the same pressure as the depth that the diver is working until that diver's task is complete.

Procedure

Preceding departure the entire dive team and vessel crew would ensure that all proper PPE is onboard and will be worn during removal operations. A dive plan would be included in the pre-removal safety meeting along with all other safety procedures. Upon arrival at the work site, the diver making a saturation dive would start the work day by entering a pressurized sphere called a diving bell on the deck of a dive support vessel or barge. The bell contains all the necessary breathing gasses, communication gear and tools needed for the diving task (i.e., cutting tools, chokers and shackles). Three divers will enter the bell which is then set in the water by a crane or handling system and lowered by a hydraulic winch to the desired depth where the diver will be working. After the pressure outside and inside the bell are equalized, the hatch may be opened, allowing the divers to exit the bell and begin working.

Two divers will exit the bell. The work diver will perform derelict net removal duties, while the safety diver stands by to be available for assistance in the case of an emergency. The diver remaining in the bell will act as tender. Upon completion of their task, the divers will return to the bell, close the hatch and ascend to the surface via hydraulic winch. Once on the surface, the bell is lifted onboard by crane, or handling system and is attached to a hyperbaric chamber or pressurized environment that has been adjusted to match the pressure of the work site from which the divers have ascended. The divers can then transfer from the bell into the chamber. The hyperbaric chamber provides accommodations for the divers to eat and sleep while onboard the dive support vessel between dive removal operations. Prior to re-commencing removal operations, the divers return to the bell, the bell is uncoupled from the hyperbaric chamber and the crane or handling system will lower the bell into the water and down to the work site where the divers will exit the bell and continue derelict net removal operations.

This process could be repeated for days or weeks depending on the number of nets planned for removal and the rate of net removal.

Once the diving bell has been positioned up-current from the net, the work diver will exit the bell and survey the net. The diver will assess the overall situation and make a determination as to where to attach the first choker. The diver then bundles the net and applies a choker. The diver is in communication with the surface and will ask for a hook and cable to be lowered from the surface to the diver. The onboard crane operator will lower the hook to the diver. The hook at the end of the cable will have an acoustic tracking device to help the crane operator efficiently navigate the hook to the diver without endangering the dive bell. Then the diver will attach the hook to the choker that is attached to the net. Communications should be "round robin", allowing for direct communication between diver, tender and the dive support vessel without relaying information. The diver will ask for the slack to be removed from the surface line. Meanwhile the diver is paying close attention to the attitude and position of the diver's umbilical in relation to the surface line, the net, the dive bell and any other snag hazards.

Once the diver is assured that there are no fouling hazards exist between the lines, nets and umbilical, the diver will request that the crane operator place stress on the down line/cable. As the net is slowly raised off the seafloor the diver will free the webbing and leadline from whatever it is attached to by hand. If the net is buried or otherwise incorporated into benthic substrate and removal will cause more damage to the substrate than leaving the net in place, the diver may use a knife to cut the net away thereby minimizing disturbance to the habitat.

With tension on the umbilical, the diver remains up-current from the net while it is being lifted to the surface to avoid potential risks if the net or other debris were to fall to the seafloor during removal. The diver will inform the surface support vessel to stop the motion on the down line as the diver bundles the net and applies additional chokers. The diver will continue bundling net with chokers until a large section of net can be safely recovered, or has as much net as can be removed while preventing excessive environmental disturbance. At this point the diver will again check the attitude of all lines and net material, and remove all slack from the umbilical and be sure that the diver is up-current from the net. The diver then informs the vessel personnel that he is going to cut that section of net free from the main body of net. After the net is cut free it will shift down-current as the net is raised to the surface by the lift line.

This is the most risky or dangerous part of the operation. On occasion there may be web and/or lead line that the diver is unaware of that is still attached to the body of net and being raised to the surface. These unseen parts of the net sometimes erupt from the sea floor under the diver's feet and all around the diver. Because one cannot control the current pushing the net away, the surface crew needs to be ready to stop the motion of the net by dropping the net back to the sea floor. At this point the diver will then cut newly discovered net free and dive support vessel will resume the lift.

While the divers are going through the process of recovering the net they will be describing to the biologist on board the vessel what kinds of bird, fish, mammal, etc. remains are laying in and about the net. The biologist will occasionally ask the diver to recover remains from the net or sea floor. These steps are repeated until all the net is recovered by the crew onboard the dive support vessel/barge. Similar to other net removal techniques the dive support vessel will use a crane or handling system along with manpower to pull the removed net onto the deck of the dive support vessel/barge. The protocol for recording data and disposal of removed nets is similar for all derelict gear removal activities and can be found below (Appendix A).

Cost

Operational expenses increase significantly as dive depths increase beyond 105 feet. Safety is of great concern. Anchoring over deep targets at pinnacles or near rock walls can be difficult (3 point anchor required), requiring a ship with dynamic positioning capabilities.

A net removal rate of one net per day is expected using saturation divers. Saturation diver day rate is $56,000/day based on a 20 day workload. A vessel suitable for saturation diver net recovery operations would cost $45,000/day plus approximately $6,000/day in fuel expenses for a total vessel cost of $51,000/day. Mobilization of the saturation dive team and gear to the work area costs $250,000 and demobilization of the team post-removal will cost an additional $150,000. Mobilization and demobilization of the dive vessel will cost $175,000 each. Total cost base on a 20 day workload would be $2,890,000, or $175,020/day of removal operations. Cost of operations for each net removed will be $175,020.

Advantages

This technique provides an advantage that is similar in some ways to current operations being conducted at depths less than 105 feet in that divers have great maneuverability and dexterity that is essential for removal of derelict nets, especially gillnets. Removal operations are well controlled and damage to the environment is limited by careful removal. Divers can attach lift bags and cut away net as it is raised in water column, gently hauling the net off the bottom and causing the least amount of potential damage to the environment during removal operations.

Disadvantages

Disadvantages to dive removal operations in deepwater are the high cost, and most importantly, the safety concerns that are associated with such operations being conducted by divers at such depths.

Method 4 – Grappling From Support Vessel to Snag Nets

Multiple techniques are being used worldwide, but in general this technique typically involves use of a surface vessel that can drag a long cable with a single or multiple grappling devices attached. The grappling device is typically made of metal with multiple hooks, or flukes attached to a line. Depending on its size, it may be deployed by hand or crane with the objective of catching at least one hook on a derelict net. The cable or line is dragged along the bottom until the net is snagged by the grapple, after which the net is winched aboard.

This technique is the most proven deepwater net removal technique. This technology is relatively simple and many different sub-techniques have been employed for different situations and with varying effectiveness. Net removal operations using grapple techniques have been performed along the East and West coasts of the United States and in the Gulf of Mexico. International examples include net removal operations supported by Canada, Ireland, Sweden, Norway and the UK in the northwest Atlantic, northeast Atlantic, Baltic Sea and North Sea (Large et al. 2009, Brown et al. 2005). South Korea has significant ongoing deepwater net removal operations utilizing several grapple type technologies. Jung et al (2010) provides some guidelines for grappling for deepwater nets from Korean experience in the East Sea. Commercial fishermen in the United States and in other nations have been using simple grapple techniques for years to recover their own lost nets, devising and adopting their own protocols for recovering lost gear. Past applications have shown success at removing gear at significant depths including crab pots 420 feet deep off the Oregon coast and net removal operations at over 5500 feet (1700 m) deep in the East Sea off Korea (Cho 2011).

Procedure

Preceding departure the entire vessel crew would ensure that all proper PPE is onboard and will be worn during removal operations. All safety procedures would be discussed with the vessel crew in the pre-removal safety meeting. A pre-removal survey with an accurate description of target location and bottom characteristics is especially important. With the aid of a computer loaded with a navigational package and USBL tracking system, the surface recovery vessel can guide the grapple hook to the desired area of the net. Grapple hook(s) are lowered on a line or cable to the appropriate depth for dragging through the target location. The angle of flukes coming into the stock of the grapple hook is important so that net/cable/leadline will bight and wedge and prevent sliding off. After snagging the net, it can then be hoisted to the surface and placed on the recovery vessel.

A modified grapple technique using bottom trawl vessels and gear has been used in several locations for derelict fishing gear removal including nets and crab pots. The general approach is to attach a cable between trawl doors, with a single or multiple chains attached to this cable. The chains can have single or multiple grapples attached along their length or at the ends. The trawl doors are lowered so that the chains and grapples are drug along the seafloor. The vessel gauges when gear is snagged based on changes in vessel speed (decrease) and engine RPMs (increase). When gear is snagged, the trawl vessel uses a power winch to pull the derelict fishing gear to the surface.

Examples of applications of this method include removal of crab pots and trawl nets off the Oregon coast (WCGA Marine Debris Action Team 2010, Scott Mullen personal communication 2013). This method is used in shallow waters in Korea and in the Yellow Sea blue crab grounds (Cho, 2011).

Cost

A net removal rate of 1 net/day is expected using grappling techniques. A vessel suitable for grapple hook net recovery operations will cost $8,000/day plus fuel costs or about $240,000 per 30 day operation.

Advantages

This removal technique does not put divers at risk but still is a dangerous activity (Jung et al. 2010), requiring a large vessel (90 to 300 tons recommended) with a crane, A-frame and appropriate deck space.

This technique has ability to be performed in deepwater and may be cost effective. Overall cost would be similar to the grapple operations discussed above. Diver safety issues are avoided; however deck work would still be dangerous for crewmembers (parting wires, potential snags).

Disadvantages

Removal of nets using this technique is not well controlled and impacts to benthic habitats may be a consequence. The removal device (grapple hook) has flukes that extend into the benthic substrate and causes some amount of environmental damage based on their length and the habitat encountered. Some of the fishing gear targeted may remain snagged on rocks and other obstructions, resulting in incomplete removal of the net and possible suspension of the remainder (increasing potential habitat impacts and trapping marine animals). Indiscriminate or blind grappling could haul up cable or other bottom snags causing safety issues for the removal team and potentially unacceptable environmental damage to the substrate.

Method 5 - Trawling for Derelict Nets

This method of gear retrieval uses typical bottom trawl fishing gear to "catch" derelict gear. Brown et al. (2005) describes this method as "a simple fishing ground cleanup method" that could be applied to areas with low-relief. This technique involves slowly dragging the bottom trawl in contact with the benthic substrate so that the open end of the trawl net sweeps the seafloor clean of debris which ends up in the closed "caught" end of the trawl net. The trawl net would then be winched to the surface, onboard the vessel deck and emptied of debris.

This method has been utilized for marine debris surveys and removals off the west coast of the United States (NOAA 2008) and has been utilized in the lower York River in the state of Virginia for crab pot surveys and removals (Havens et al. 2006).

Cost

The bottom trawl removal method would have many of the same gear requirements as the grapple techniques. Therefore removal rates and cost are expected to be similar between these two techniques. Operations in areas of high derelict net concentration would allow increase the removal rate and efficiency of operations. A vessel suitable for utilizing bottom trawl gear for net recovery operations would cost approximately $8,000/day plus fuel costs, or about $240,000 per 30 day operation.

Advantages

This method would likely be more cost efficient than ROV removals and would be safer than involving teams of divers. Commercial trawl fishermen could be engaged to take part in removal operations, directly involving stakeholders with removal operations.

Disadvantages

This method is the least discriminate of the deepwater gear removal techniques and recovery may be incomplete, leaving portions of the net behind. There is significant potential for environmental impacts to marine fauna and benthos. There is also a large potential to snag or remove non-targeted debris/substrate. Brown et al. (2005) recommends this technique not be used near reefs or in shallow water. Shallow water removals using bottom trawl gear could cause danger to the removal vessel and personnel.

Discussion and Recommendations

The ROV operations provide the best opportunity for successful deepwater removal operations in Puget Sound. This is the preferred choice due to the low impact to habitat, potential for careful and complete extraction of the gear, and reduced safety concerns associated with utilizing deepwater divers. Operational costs at approximately $13,000 per day are high compared to the grappling technique, but are relatively low when compared to utilization of deepwater divers.

The grappling technique is not recommended as an ideal option for deepwater derelict net removal in Puget Sound. However the use of a grapple technique could be effective in certain locations with specific bottom features and would be the most cost effective removal technique. This technique should not be used at sites where bottom topography could cause snags or where damage to marine habitat exceeds the benefits of gear removal. This method inherently causes damage to the benthic substrate. Therefore to limit excessive impacts to seafloor habitat and organisms, in no circumstances is blind grappling for nets recommended.

The majority of derelict nets lost in Puget Sound waters are gillnets. While recovery of large volumes of gillnets using grappling procedures has been well demonstrated in Korean waters, this method may prove less effective at removing gillnets in Puget Sound. The lack of control and tendency for gillnets to rip and tear during removal will likely cause incomplete removal of the gear with smaller pieces of web remaining and continuing to cause damage to habitat and benthic organisms.

This method might be considered where divers cannot be deployed and ROV operations are not possible or too costly. Substrate must be void of geology with any relief, and critical habitats for species of concern should be avoided. Shortening the length of tines/flukes on the grapple hook will help to limit penetration into the substrate and reduce environmental impacts to the benthic habitats. It is recommended that tines are 6 inches or 1 foot in length and should not exceed one foot in length (Scott Mullen personal communication). The location of the net target must be well identified and the derelict net should be a high priority for removal due to presenting risk to marine animals and human activities.

Deepwater diving techniques would be the most effective of the options in terms of precision and the complete removal of derelict net targets. However safety and work time would be limited and cost may be prohibitive.

Pilot Projects

We believe that the preferred method for deepwater derelict net removal in the Puget Sound is by ROV, and recommend a pilot project be conducted to test this method on previously identified derelict net targets. An initial pilot project would include conducting derelict net removal operations with ROV at one or more shallow water net locations. Conducting an entire net removal in shallow water as would be done in deepwater would provide the removal team the opportunity to observe and monitor the net removal with divers and cameras, and use the observations to fine-tune the removal methods and protocol without the risks and complications associated with operations beyond 105 feet deep. Results from this effort would be used to determine the effectiveness of the ROV removal method prior to proceeding with a larger pilot project in deepwater.

The WA DGDB currently contains the reported coordinates of over 900 derelict nets in the shallow waters of Puget Sound. Most of these targets are in the San Juan Islands and at Point Roberts, near the US – Canada border. A pilot project conducted at the Point Roberts area would provide the removal vessel the opportunity to use dynamic positioning and three point anchor system while conducting ROV net removal operations. Considering the high concentration of derelict nets in the shallow waters at Point Roberts, the removal methods could be tested on multiple net targets from a variety of substrate types (i.e., pinnacles, boulders fields, sand flats), exhibiting varying degrees of contact with the substrate and suspension in the water column (i.e., spread across reef, hanging over ledge, meandering through boulders). Pre-removal diver investigations could identify multiple derelict net targets for ROV removal that would truly test the efficiency of the removal methods by subjecting them to multiple variables associated with the disposition of derelict nets. Additionally, there are 38 known deepwater derelict net targets identified at Point Roberts (Figure 1). The proximity of these targets to port (Blaine, WA) and the high concentration of derelict nets in the area make this Point Roberts a favorable location for a pilot project for deepwater derelict net removals.

Two other locations identified as locations for potential pilot projects are Port Susan and Hood Canal (Figure 1). In Port Susan there are two deepwater derelict nets within close proximity to one another. If the Everett-based dive team employed by the Northwest Straits Foundation was used for this operation, the standard cost of mobilization and demobilization would be significantly decreased. In Hood Canal, recreational anglers have reported a large seine net on the seafloor on popular recreational and commercial fishing grounds. This net would provide the opportunity to test the ROV removal methods on what is assumed (and reported) to be a very large mound of net. However, removal of this seine net would not be representative of deepwater gillnet removals, which are presumed to be the most prominent deepwater derelict net type based on shallow water net removal operations.

Cost

Testing the ROV removal technique in a pilot project would cost approximately $13,000/day plus fuel costs and additional costs for monitoring the operation. A diver equipped with video camera would be used to monitor and record the removal operation underwater, providing the removal team with the opportunity to observe the effectiveness of the operations and adjust methods and protocol when appropriate.

It is assumed that the cost of a pilot project would be similar in all of the three proposed net removal locations.

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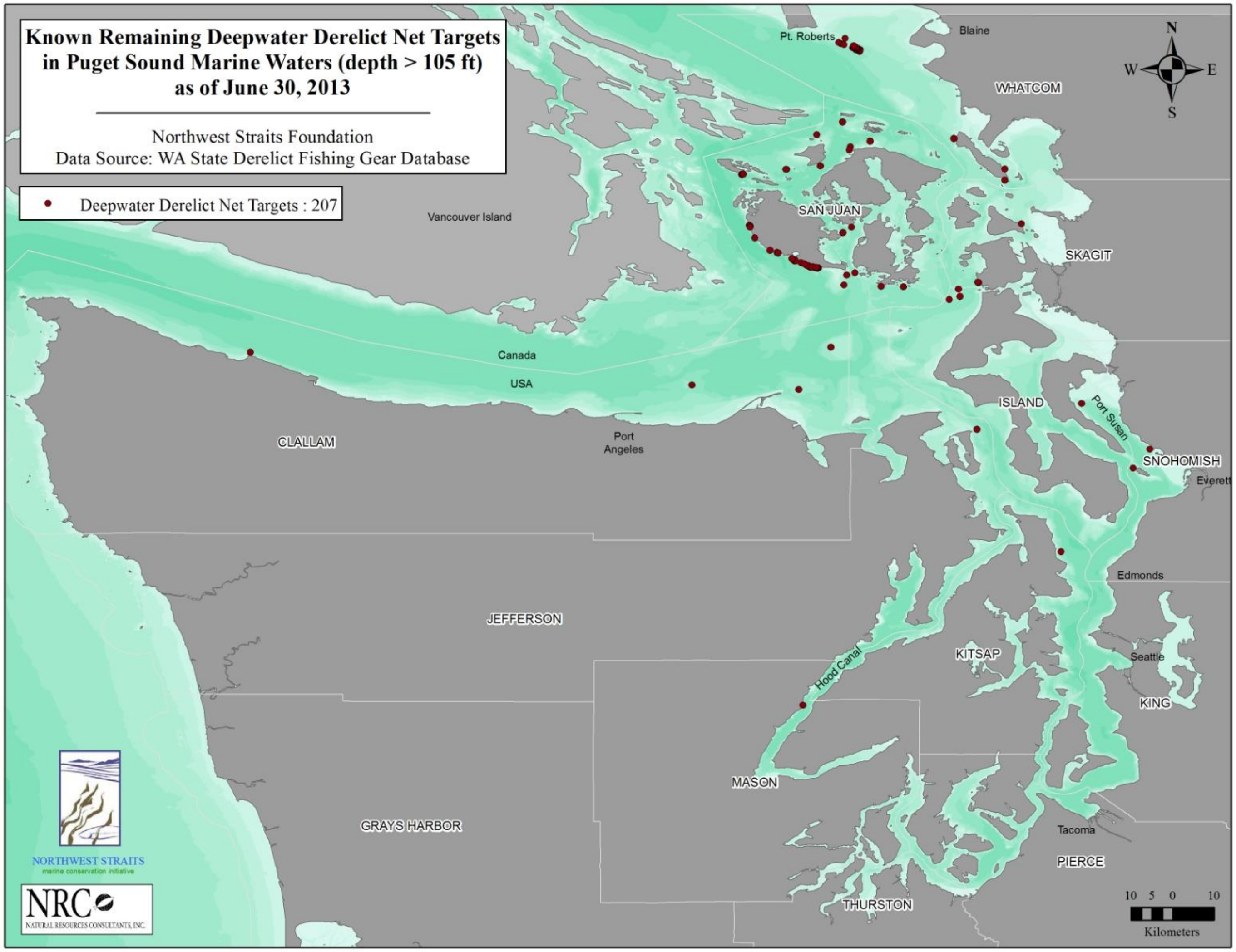

Figure 1. Known locations of deepwater derelict nets in Puget Sound. Source: WA State derelict fishing gear database, NRC.

Appendix A: DGR Plan and Pre/Post Removal Operations, Disposal, Reporting Guidelines and Insurance

Derelict Gear Removal Plan

In order to be exempt from acquiring state and federal permits for derelict fishing gear removal, it is necessary to submit and get approval for a derelict fishing gear removal plan. The WDFW reviews the derelict fishing gear removal plan and may consult with WDNR if the proposed removal operation impacts WDNR aquatic lands. The plan identifies the derelict fishing gear to be removed, the removal methods that will be employed, the type of habitat and any impacts that might occur, who will participate, the information that will be recorded and submitted to WDFW and what will be done with the derelict fishing gear once it is removed. The WDFW derelict fishing gear removal guidelines spell out what information is required in the derelict fishing gear removal plan. The typical derelict fishing gear removal plan costs about $1,800 to prepare and run through the review process at WDFW and WDNR. The product is a written plan for the removal operators to follow and a letter from WDFW exempting the removal operation from permits. The derelict gear removal plan and approval process typically takes three weeks to a month to complete.

Pre-Removal Operations

Once the derelict fishing gear removal plan is approved, the WDFW guidelines require several events to occur prior to the start of actual removal operations. Three days notification must be provided to the U.S. Coast Guard's Notice to Mariners system. This assures that all mariners are aware of the location and schedule of operations. The local WDFW fisheries enforcement office must also be notified three days in advance of operations and provided an opportunity to observe the removal operations if desired. If the removal operation occurs in an area with frequent Tribal subsistence or commercial fishing, the appropriate Tribal fisheries departments must be provide prior notification of the operations. If the derelict fishing gear removal occurs in an area frequented by the U.S. Navy, the local Naval environmental officer is notified three days prior to the start of operations to assure there will be no conflict with U.S. Naval operations. If survey or removal operations are planned in the vicinity of U.S. Fish and Wildlife Service's San Juan Islands National Wildlife Refuge, the director's office is contacted and permission to work in the area is acquired. Due to homeland security concerns, city and county marine police and vessel transit control systems are notified three days prior to any survey or removal operations. If work is planned around security sensitive areas such oil or natural gas terminals, the security offices for such facilities are contacted a week to ten days prior to survey or removal operations. Finally, under the Washington State Abandoned Property Law, the local county sheriff's office must be contacted and informed that derelict fishing gear is going to be removed, stored in a secure location and the owners contacted if they can be identified and allowed an opportunity to recover their lost gear. The cost of the pre-operation notification process is included in the derelict fishing gear plan costs.

Post-Removal Protocols

After the derelict gear has been pulled aboard recovery vessel an onboard biologist further inspects the gear for entangled animals and records this information along with the information reported by the work diver. A deck hose is used to wash as much of the biological growth off the nets as possible. All dead and live animals are returned to the sea after identification and counting unless specimens are requested by federal or state agencies. The NWSF has obtained scientific collection permits from NMFS, USFWS, and WDFW. Gillnets are typically bundled into large plastic drawstring bags. Purse seine nets are rolled onto an on-deck drum or stacked and bundled on the deck. The onboard project manager/biologist typically manages the removal operation, assures the guidelines are being followed, records the data and is available to meet with the media or the project proponent and explain what has been accomplished.

Disposal

Derelict fishing gear that can be identified as to the owner, such as gillnets with floats or crab pot tags showing the permit number, are set aside and stored in a secure area until the owners can be contacted. The project manager arranges for a secure storage area (typically an outside fenced area) and a truck to transport the identified gear to storage. WDFW and Tribal fishery offices are contacted for names and phone numbers of the owners of the gear. The project manager contacts the individuals, describes the condition of the gear held and provides the owner an opportunity to recover the fishing gear. Typically the gear is held for 5 days after notification. If the owner chooses not to recover their gear, the project manager will dispose of the gear. Unidentified or abandoned gear that is dilapidated and no longer useful is either sent to recyclers (if available) or disposed of in a county landfill. Typically, gillnets and purse seine nets are not reusable, cannot be recycled due to the vegetative material that remains on the meshes and they are typically disposed of in the landfill. Crab pots that cannot be identified to the owner or are unclaimed can be sold for salvage and the funds returned to the NWSF for additional gear removals. In some cases, useful pots are contributed to non-profit organizations such as the Ballard High School Marine Technology Program. Unusable pots can be sent to metal recyclers or the pots can be crushed and land filled.

Storage and disposal costs vary depending upon the amount of gear and the location. Typically disposal costs on a project run about $500 to $1,200.

Reporting

The WDFW guidelines require that a final report be submitted outlining what was accomplished during the removal operation, impacts observed, derelict fishing gear remaining on the fishing grounds and the disposition of the derelict fishing gear removed. The contents of the final report are provided in the removal guidelines. If a derelict fishing gear survey is conducted as part of the project, the location and description of derelict fishing gear found must be submitted to the WDFW in a format compatible with their derelict fishing gear database. This report may include formatted tabular output of the locations and types of derelict gear, a GIS chart of the area surveyed and charts showing the locations and types of derelict fishing gear removed and remaining. Additionally, the entity funding the project usually also desires a final report on the project and in some cases a media summary for press releases. If the project is being conducted as part of a state or federal mitigation measure, the permitting and consulting agencies may require a final report to assure that adequate mitigation action has occurred. Finally, often the county sheriff's department requires a report on the disposition of the derelict fishing gear removed with accounting for each gear item.

Insurance

Any group that is involved in the removal and disposal of derelict fishing gear in Puget Sound is required to have the correct insurance coverage for all participants as is required by the federal government and the State of Washington.

Appendix B: Industry and Agency Contacts

Name	Organization	Removal Experience	Phone	E-mail
Dave Aldrich	Aldrich Offshore Services	ROV	907-244-0060	dgaldrich@aldrichoffshore.com
Brian Delong	Fenn Enterprises	ROV, Divers	509-201-6030	bigdogdrywall@yahoo.com
Karen Grimmer	NOAA/Monterey Bay NMS	ROV	831-647-4253	Karen.grimmer@noaa.gov
Kirsten Gilardi	UC Davis/Sea Doc Society	ROV	530-752-4896	kvgilardi@ucdavis.edu
Mark Isaak	Future Vehicle Technologies	ROV	604-316-4387	massaak@telus.net
Scott Mullen	Oregon Fishermen's Cable Comm.	Grapple, Grapple/Trawl	503-325-2285	smcmullen@ofcc.com
Tim Nesseth	NOAA	Diving	206-459-1354	timothy.j.nesseth@noaa.gov
Cyreis Schmitt	Oregon Dept of Fish and Wildlife	Grapple	541-867-4741	cyreis.c.schmitt@state.or.us