THE SINKING OF SHIPS AS ARTIFICIAL REEFs

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ABSTRACT

At the present time there are hundreds of Navy, Coast Guard, merchant, Canadian and other foreign vessels awaiting proper disposal. Utilizing these ships to construct artificial reefs creates new habitats for underwater life through the use of environmentally safe methods at costs that are less than scrapping. Although there is no standardized procedure to sink ships within the U.S., many organizations are working together to share experiences and to streamline the process. This report discusses the high-level process that several organizations have used to sink ships as artificial reefs.
# The Sinking of Ships as Artificial Reefs

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SCOPE

This scope of this report shall be a discussion of the high-level flowchart, shown below, indicating the common, primary steps currently followed to sink ships as artificial reefs. Examples from several recent projects shall be used to illustrate best practices and lessons learned.

Flowchart for Sinking a Ship as an Artificial Reef

```
IDEA -> COMMITTEE -> FUNDS

SELECT SHIP <-> SELECT SITE

PERMITS

PUBLICITY

PREPARE SHIP

TRANSPORT SHIP TO SITE

SINKING & SAFETY

DAY OF SINKING

DOCUMENTATION <-> MONITORING & MAINTENANCE
```
INTRODUCTION

National Artificial Reef Plan
In 1984, the Secretary of Commerce developed the National Artificial Reef Plan (“Plan”) as required under the National Fishing Enhancement Act. The purpose of the Plan is to promote and facilitate responsible, effective artificial reef use in the navigable waters of the US and those waters super-adjacent to the outer continental shelf. The term artificial reef is defined as “…a structure which is constructed or placed in waters...for the purpose of enhancing fishery resources and commercial and recreational fishing opportunities.” The Plan specifies that artificial reefs “…shall be sited and constructed, and subsequently monitored and managed in a manner which will:

1) Enhance fishery resources to the maximum extent practicable,
2) Facilitate access and utilization by US recreational and commercial fishermen,
3) Minimize conflicts among competing uses of waters covered under this title and the resources in such waters,
4) Minimize environmental risks and risks to personal health and property, and
5) Be consistent with generally accepted principles of international law and shall not create any unreasonable obstruction to navigation.”

Artificial Reef Structures
Early reef development projects used natural or scrap materials almost exclusively because of their relatively low cost and ready availability. With increased funding assistance through the U.S. Fish and Wildlife Service Federal Aid in Sport Fish Restoration Program and with increased support from state resource management agencies, many coastal states are now taking advantage of advanced technologies and methodologies to design materials and structures for specific artificial reef objectives. Examples of the diversity of artificial reefs around the U.S. include:

- Texas which has 45 rigs-to-reefs (decommissioned oil and gas platforms whose upper portions have been severed and toppled underwater); 18 sunken vessels; 132 reef balls; and 390 concrete, fly-ash and quarry rock structures, and
- New Jersey which has a network of 14 ocean reef sites and over 1300 patch reefs.

During the last 25 years, it is estimated that ~850 vessels have been used as artificial reefs in the U.S. Florida has the largest artificial reef program with ships, barges and other vessels deployed on both the Atlantic and Gulf of Mexico coasts.

Florida’s Sunken Vessels as Artificial Reefs

<table>
<thead>
<tr>
<th>Number</th>
<th>Material</th>
<th>Ship Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aluminum</td>
<td>Yacht</td>
</tr>
<tr>
<td>22</td>
<td>Fiberglass</td>
<td>Recreational Vessels</td>
</tr>
<tr>
<td>4</td>
<td>Ferrocement</td>
<td>Sailboats</td>
</tr>
<tr>
<td>146</td>
<td>Steel</td>
<td>Barges</td>
</tr>
</tbody>
</table>
Sinking of a Ship as an Artificial Reef

<table>
<thead>
<tr>
<th>191</th>
<th>Steel</th>
<th>Freighter and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>Steel</td>
<td>Tugboats</td>
</tr>
<tr>
<td>10</td>
<td>Wood</td>
<td>Shrimp boats and others</td>
</tr>
</tbody>
</table>

Today advanced technologies and methodologies are used to environmentally prepare ships for sinking and during the scuttling process itself. Due to the purposely vagueness of the Plan, which allows for the use of the best scientific methods available, there is no standardized procedure for creating artificial reefs. However, many organizations, including groups from Canada and Australia, are working together to share experiences and to streamline the process of sinking ships as artificial reefs. (Many other countries, including Mexico, Cayman Islands and Honduras, have also recently sunk large vessels as artificial reefs; however, less information on these projects is readily available to the general public.) The details of each specific project will vary, thus the scope of this report shall be limited to only the high-level process steps commonly used to sink ships as artificial reefs.

THE IDEA

The idea to sink a ship as an artificial reef is the start of the project. This idea can come from any number of sources. For example:

The *Yukon Project* was started to bring focus and attention to the San Diego Ocean Foundation’s overall goal for habitat enhancement within the county of San Diego and to build the political and financial base for creative projects. This project culminated in the sinking of the *HMCS Yukon* in San Diego in July 2000.

The Artificial Reefs of the Keys (ARK) organization was initially formed by two individuals with the goal of sinking the *Gen. Hoyt Vandenberg* as a world-class scuba diving destination. Currently the sinking is scheduled to take place near Key West in May 2002.

The Key Largo Chamber of Commerce Artificial Reef Committee is working to sink the *Spiegel Grove* offshore of Key Largo in the Florida Keys National Marine Sanctuary in Spring 2002. They estimate that the new shipwreck will attract 60,000-70,000 divers annually, resulting in ~$10 million for the local tourism economy.

The Artificial Reef Society of British Columbia (ARSBC) is dedicated to the enhancement of British Columbia’s marine environment, to the advancement of sport diving through public education, and to the creation and preservation of artificial reefs. They have successfully completed six artificial reef projects since 1991, most recently the *HMCS Cape Breton* that was sunk off of Vancouver Island in October 2001.

The Geographe Bay Artificial Reef Society (GBARS) sunk the *HMAS Swan* in Dunsborough, Western Australia in December 1997 to serve as a dive wreck, tourist attraction and artificial reef habitat.
THE COMMITTEE

A Cross-Section of People
While ideas can come from a variety of sources, it is a rare circumstance that such sources will have all of the experience needed to execute the project.

In a very honest, self-reflection the San Diego Ocean Foundation believes that its lack of experience with a project like Project Yukon was largely responsible for the project exceeding its estimated $500,000 budget and one year schedule. The actual expenditure was over $1.2 million and the project took more than two years in duration.

Similarly, those parties interested in sinking ships as artificial reefs may have difficulty envisioning, and therefore mitigating, the numerous opposing points of view. This situation can be remedied by involving a large cross-section of people throughout the duration of the project. The use of advisory committees and information-gathering meetings can help the project initiators determine major issues early on, which in turn helps determine how many people and of what backgrounds will be needed on the project committees. It is important to include many other disciplines especially those that could be considered adversaries and/or competitive users of the same ocean area.

The Texas Parks and Wildlife department’s “Reef to Rigs” program utilizes an advisory committee with the following representatives; sport fishing, offshore oil and gas, tourist industry, general land office, shrimping organizations, diving clubs, attorney general’s office, university and environmental groups.

Project Yukon started with organizational meetings involving everybody who would attend; including representatives from Scripps Institute of Oceanography, the City of San Diego, the California Coastal Commission, local Chambers of Commerce, the Convention and Visitors Bureau, California’s Department of Fish and Game, divers, fishermen and interested public.

Based on the feedback provided during these initial fact-finding sessions, the project originators can gather a group of people with mixed disciplines who understand the scope of such a project and who can commit their time and resources for the duration of the project. Common working committees are established for ship sinking projects:

- The Steering Committee consisting of community leaders, board members from the initiating organization, a Project Manager, and a Steering Committee Chairperson. This Committee, which may consist of ~20 people (half regularly involved, half ad hoc), will be responsible for the final decisions and oversight of the project.

- The Working Staff also includes the Project Manager (who is typically salaried) and various committee members and chairpeople (who are typically volunteers). Task specific committees such as the following are valuable:
  - Safety
    - Ship Preparation & Logistics
    - Security & Crowd Control
Sinking of a Ship as an Artificial Reef

- Blasting Crew (normally a hired expert firm)
- Diving Safety Officers
- Sinking Day Activities
  - Fundraising
  - Finance/Reporting
  - Marketing & Public Relations
  - Government Approval & Permits Committee

Of course many of these committees will have overlapping responsibilities, which should be delegated during initial organization meetings.

When selecting project team members, it is important to remember that the project may suffer through several normal things that are part of a volunteer organization, as the San Diego Ocean Foundation discovered:

- Personality/ego conflicts,
- Volunteers who are not paid to work with each other, sometimes will not,
- Volunteers will sometimes commit to doing something and then not do it, and
- Dedicated workers can burn out.

**Project Goals and Objectives**

Once the major players on the project team have been identified, the Steering Committee should develop project goals and objectives. Most large companies have Vision, Mission and Objective statements as should a project of such magnitude. In addition to “on time, under budget and with zero incidents” goals, various other project goals and objectives, such as those discussed below, will help measure success.

**Habitat Enhancement and Creation**

A goal of the project may be to:

- Restore, mitigate or create habitat,
- Improve recruitment and enhance juvenile survival, and/or
- Increase the population of reef-associated species

Such a goal may influence the type of ship and site selected. The larger the ship in surface and interior area, the more additional surface area available for colonization by marine plants and invertebrates. However, existing benthos (bottom-living animals) in an area equal to the footprint of the vessel may be permanently smothered when the vessel is sunk.

**Recreational Fishing Enhancement**

The Steering Committee must decide if it will allow recreational fishing to take place on the artificial reef. If so, this may create a conflicting use with scuba divers. (In the case of the Vandenberg, it is large enough to accommodate recreational fishermen and divers along its many buoys.)

If fishing is not desired, enforcement of a no-fishing area must be built into the maintenance plan.
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At issue will not only be the interests of recreational fisherman, but also those of the local economy as fishing is an important shore-based industry with private boat owners spending money on trip-related expenses such as bait, tackle, ice, fuel and food.

**Sport Diving Enhancement and Access**

The economic impact of sport divers frequently rivals that of recreational fishing activities in some regions. If sport diving is an objective, steps must be taken during the ship preparation and site selection to maximize diver access while minimizing potential diver injuries.

The *Vandenberg* will be as shallow as 50 feet deep, making it available to novice divers, while the bottom half would provide a challenge to advanced divers.

Also, the new reef may temporarily upset the status quo of other local diving destinations, creating resentment from those whose interests have been harmed.

**Research/Education**

Various academic organizations or firms may use the site to study fish and other marine organisms. This could open doors for increased funding. It could also be a means to advertise and promote the project.

ARK is setting a precedent by using the *Vandenberg* as an educational platform during its monitoring phase. Through collaborative efforts of the Florida Keys Community College, a distance learning class has been developed. Through agreements from remotely operated vehicle (ROV) manufacturers, a student in Middle America will be able to operate their device live over the internet.

**Marine Sanctuaries**

The use of a newly sited ship to create a marine sanctuary could provide hard substrate and habitat in an area of pre-existing fisheries, while leaving traditional fishing areas open. Conversely, a new reef could be strategically placed to take the pressures off adjacent reefs within a sanctuary. Either would require additional coordination with regulatory agencies to receive appropriate designation under or to ensure compliance with the Marine Protection, Research and Sanctuaries Act.

The *Spiegel Grove* project is intended to reduce the amount of scuba diving pressure on the adjacent natural coral reef. A monitoring plan, through which pre- and post-sinking data on diver pressure will be collected, has been jointly developed by the Florida Keys National Marine Sanctuary and Upper Keys Artificial Reef Coordinating Committee.
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Social and Economic Considerations

The enthusiasm of one community over another and the existence of shore-based infrastructure could effect the site selection. Local support of a ship sinking project is essential for timely permitting and as a source of funds. The carrot in front of community leaders and businesses is that reef construction stimulates local economies.

According to a British Columbia study, the benefits of a dive destination are broadly shared among retail sales, equipment manufacturing and distribution, diving services and hospitality services. Of diving tourist expenditures, 38% went to the dive industry, 36% went to food, accommodations and entertainment.

The Key Largo Chamber of Commerce Artificial Reef Committee estimates that the Spiegel Grove will attract 60,000-70,000 divers annually, resulting in ~$10 million for the local tourism economy.

Environmental Considerations

Some groups may chose to believe that a shipwreck is a hindrance to the environment, therefore it may be necessary to tone down or ignore the pro-environment angle when promoting the project. Justifying the artificial reef as a stimulus to diving and/or fishing may be more fruitful.

Funds

Upon putting all of the players in place and developing the organization’s objectives, funding becomes an immediate and continual priority. The project must be managed as if it is a business, which means the development of a financial business plan, workable budget and cash flow analysis.

According to a detailed RAND report regarding the disposal options of Navy and MARAD vessels, reefing preparations will cost between $480 - $500/ton. (RAND provides detailed information that can be used to refine cost estimates for specific vessel classifications.) Using RAND’s project breakdown estimates, the following funds should be budgeted:

<table>
<thead>
<tr>
<th>Activity</th>
<th>% of Cost</th>
<th>Equivalent $ for a 2000 ton ship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reefing Preparation</td>
<td>81%</td>
<td>$960,000 - $1,000,000</td>
</tr>
<tr>
<td>Transitional Storage</td>
<td>12%</td>
<td>$142,000 - $148,000</td>
</tr>
<tr>
<td>Outfit/Towing</td>
<td>7%</td>
<td>$83,000 - $86,000</td>
</tr>
</tbody>
</table>

Add to the above, costs for administrative and general overheads, salaries, contractor and consultant fees, monitoring and maintenance over the life of the project. (RAND uses a 20-year project life.)
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Fundraising and recycling are two primary sources from which to obtain the more than one million dollars in cash and services need to complete such a project.

**Fundraising**

A breakdown from *Project Yukon* show sources from where cash and services may come:

- 25% from individual donations via personal requests, public awareness campaigns, website and other printed solicitations, etc.
- 50% from corporations and actively involved sponsors,
- 15% from functions that include fund raising events, leases and rentals of the ship, and other third party uses,
- 10% from grants from government agencies, and
- Loans that cover gaps in cash flow during the fundraising efforts.

The Fundraising Committee will need to be very creative throughout its solicitation efforts. Although successful, the traditional product sales of t-shirts, mugs and ship memorabilia will not generate the income needed for such a large-scale project. In addition to cash, donations from companies for “in kind” services; such as environmental impact reports, equipment rentals, trash services, paint, printing and publication; can avoid expenditures of cash. Volunteer time is crucial, as over 7000-8000 man-hours are required to clean and prepare the boat. A professional fundraiser should be contracted to help raise third party corporate support. (Typically the fundraiser works on a commission basis for between 10 – 20% of amounts directly raised.) Several innovative sources of cash and services are shown below:

The Port of San Diego gave *Project Yukon* extra exposure by granting exhibit space within the airport and gave it reduced cost docking fees along the waterfront.

When ARSBC was preparing to sink the *CB Church* they received a donation from a bookstore. This store was able to quickly recover its money when it began carrying books and maps relating the wreck.

The GBARS instituted a system of charging dive operators $5/day per diver on the *HMAS Swan* and raised $50,000 in the first year. The success of the wreck created an unmanageable collection system so the GBARS now charges dive operators a flat $2000 per year to tie up to the mooring buoys.

Tex Enmark of ARSBC suggests selling divers an entertainment, accommodation and diving weekend package for the sinking. This could include a pre-sinking event, seating at the sinking, a post-sinking party, the privilege of being one of first 500 divers on wreck, restaurant discounts and a t-shirt. With donations or discounts from hotels, restaurants, and dive boat operators, this can be a huge fund-raiser.

Video sales can appeal to divers and the general public. The project committee should have a video created with interviews, before and after ship footage, historical information and sinking day celebrations. This can serve as stock footage for a generic video for sale as is. This can also be sold or licensed to local dive shops who can then use their own underwater video equipment to add in dive footage at the end for personalized vacation videos, a practiced currently used by many scuba diving destinations.
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Special recognition should be given to entice large donations. *Project Yukon* recognized its donors with the following, based on the size of the donation:

- Naming interior rooms after the donor (and having the name appear on dive boat charts and maps),
- Including company logo or identification on all project promotional, advertising materials, and acknowledgements in event publications,
- Preferred seating to view the sinking,
- Plaques located inside the ship on an honor wall,
- Tables at the celebrity sinking banquet, and
- Plaques with replicas of ship’s bell or other artifacts.

**Recycling**

Salvaging high value material that can be removed efficiently and that has minimal impact of aesthetic completeness of vessel can help offset the cost of the project.

Non-ferrous metals are the largest source of salvage revenue. Brass, bronze, stainless steel can be taken to a scrap dealer. A reputable dealer should structure the price according to total volume of material available from the entire project, not necessarily the volume delivered on any particular day. General items to consider for salvage include:

- Propellers – Bronze
- Piping – Copper, Copper Alloy or Brass
- Valves – Bronze or Stainless Steel
- Condenser tubes – Copper, Copper Alloy, or Brass
- Cabinets/Housings - Aluminum

MARAD estimates that ~10% of the total value of a ship can come from resalable equipment such as fire pumps and motors, galley equipment, bollards, anchors and anchor chain, and artifacts such as hatch covers from Liberty ships that are made into furniture. It may be possible to have the buyer remove the equipment thus eliminating the removal cost (plus the buyer is responsible for any damage).

The salvage value of steel will only partially offset the cost of removal labor. However, the delivery method has enormous impact on price. If delivered to the steel mill directly rather than to the yard of a broker or exporter, it will bring a higher price. The price is also directly related to the trading city’s proximity to the mills in which the scrap will be processed.

**SELECTING THE SHIP**

The Steering Committee must decide which ship it wants to sink. Fortunately, there are ~400 Navy and MARAD ships await disposal. A breakdown of the ships available through 2005 in shown below.
Sinking of a Ship as an Artificial Reef

<table>
<thead>
<tr>
<th>Ship Type</th>
<th># Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARAD Merchant</td>
<td>144</td>
</tr>
<tr>
<td>Navy Surface Combat</td>
<td>101</td>
</tr>
<tr>
<td>Navy Mine Warfare</td>
<td>11</td>
</tr>
<tr>
<td>Navy Aircraft Carriers</td>
<td>8</td>
</tr>
<tr>
<td>Navy Submarines</td>
<td>4</td>
</tr>
</tbody>
</table>

The Navy and MARAD will transfer titles for obsolete vessels to requesting states at no charge rather than spend the estimated $630/ton for recyle, $480-$500/ton for reefing or $120,000-150,000 per year for dry dock storage.

Although there is no charge for the vessel itself, selection must be based on the cleanup cost. All organizations pursuing the acquisition of surplus military ships should examine any available documentation regarding levels of regulated materials before committing further time and money. As a condition of purchase, project managers should collect the following information and certificates issued by competent authorities:

- Asbestos, PCB, refrigerant and halon certificates, either officially stating that all have been removed or detailing quantities and locations remaining,
- Ammunition-free certificates issued by defense authorities for warships and naval auxiliaries,
- Radiation inspection certificate for vessels that may have carried radioactive materials,
- Information on other hazardous materials left in the vessel,
- Information on exterior hull paint including paint type, detailed technical information of the paint and date of application,
- Drawings and diagrams showing the machinery, compartment and tank layout, and
- Information on the fuels carried and used by the vessel.

In addition to the time and cost associated with cleaning a particular vessel, the general suitability as an artificial reef must be considered when selecting a ship. Surface area, profile, shape, size and the number of holes, crevices, and overhangs create more hospitable habitats for marine life and make the wreck more interesting to divers. Open spaces allow adequate water circulation, thus preventing the stagnation of water in some parts of the vessel. A professional engineer should conduct a stability analysis of the ship to determine if it will remain stable during severe 50- or 100-year weather events at its proposed deployment location. Anything beyond the most rudimentary maintenance is impractical and limited by expense; therefore, the ship must be resistant to deterioration and breakup. If the analysis indicates instability, either a different ship or location will need to be found.

**Selecting the Site**

Proper site selection is vital to the overall success of an artificial reef. Reefs that are improperly sited will result in wasted time, money and effort. Improperly sited reefs can also result in a number of negative impacts including hazards to navigation, damage to naturally productive bottom, and environmental clean-up problems. To learn more about a specific site, project managers should do the following:
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- Acquire environmental and biological data known for the area,
- Coordinate with any biologists, oceanographers or engineers studying the area,
- Conduct multiple underwater dives to locate the most appropriate spot, and
- Obtain or create detailed site maps of the bottom to plan the location and orientation of ship.

When selecting a site, the project managers must evaluate underwater characteristics as well as intended use considerations as discussed below.

**Underwater Characteristics**

The underwater characteristics at an artificial reef site have a pronounced effect on reef stability, structural integrity and longevity and must be carefully evaluated in the site selection process.

Water depth must be sufficiently deep to avoid creating a hazard to navigation. Minimum clearance above the reef should accommodate the draft of the vessels expected to operate in the vicinity.

Storms, hurricanes, geologic events, and tidal and wave-generated currents can stir up bottom sediments causing siltation on the reef or ship destabilization. Planning for worst-case storms where movement of bottom materials would be detrimental or hazardous is necessary when selecting a site.

Artificial reefs intentionally placed near natural reefs should be designed to ensure the materials will not encroach on the natural coral reefs; significant beds of aquatic grasses or macro algae; oyster, scallop, mussel or clam beds; and “live bottom” (marine areas supporting growth of sponges, sea fans, corals and other sessile invertebrates generally associated with rock outcrops).

Water depth affects species composition at the reef site including invertebrates, plant life and fish. Depth is also a factor in the presence of desired life history stages of target fish species.

Water turbidity, salinity, dissolved oxygen, biological oxygen demand, temperature, nutrient loads, pollution levels and other water quality factors affect both the biological productivity and use value of artificial reefs. Reefs built in highly turbid water would have limited value to the diving community, but may be valuable as fish habitat. Polluted areas and areas affected by treated sewage effluent should be avoided to minimize resource exposure and possible human health risk.

Volunteer divers made hundreds of dives at various sites to find the best and most environmentally suitable piece of ocean bottom for the sinking of the *Vandenberg*. Divers aboard the liveaboard Tiburon used a roving–diver monitoring technique to count and record fish. Their findings will be used to gauge long-term effects of artificial reefs on the marine environment.
Intended Use Considerations

The intended use of the artificial reef will also impact the site selection process. General considerations include the following:

- Location of shoreline access points (ramps, piers, marinas, bridges, charter and party boat docks),
- General use patterns (fishing, vessel sizes of visiting boats, distances traveled offshore, skin and scuba diving),
- Traditional use of the site,
- Enforcement of any pertinent use restrictions,
- Potential conflicts with other users (commercial fishermen, divers, shipping, general navigation, military, mineral and energy extraction), and
- Proximity to other reefs, shipwrecks or underwater objects.

Texas Parks and Wildlife Department is considering placing the USS Clipper adjacent to an uncharted obstruction that was reported to the TPWD by shrimp fishermen. Creation of the artificial reef will allow the nautical charts to be updated and increase mariner safety.

Reefs proposed for divers should be sited at depths that will provide reasonable bottom time and minimize the decompression hazard. Factors such as water clarity, proximity to other popular dive areas and average current velocities should be also considered.

The success of the HMAS Swan in Western Australia is largely attributed to the choice of the scuttling site. This site caters to divers with all levels of experience, is sheltered from ocean swells and takes a minimum length of time to reach by boat.

Permits

The permitting process should begin as soon as the project appears feasible. Contact with the various regulatory agencies should begin while the ship and site are being selected. As soon as these are known, the applications should be submitted. The following information will be necessary to complete the various applications.

- A description of the project with an anticipated schedule,
- Detailed drawings and/or photographs,
- A complete written description of the vessel,
- Clean up plans,
- Coordinates of the proposed site identified on a hydrographic chart,
- A description of the site in relation to local communities, landforms and underwater objects,
- The proposed orientation of the vessel on the ocean bottom, and
- A description of the physical nature of the bottom and associated biological resources with videotape if possible.

Five federal entities – the US Departments of Commerce (DOC), Defense (DOD), Transportation (DOT), and Interior (DOI), and the Environmental Protection Agency (EPA) – have varying degrees of interest in, and responsibility for, artificial reefs. In
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addition state, local and municipals governments, interstate marine fishery commissions and private organizations and individuals will be involved. At the present time, there is only limited coordination between these agencies and due to the extremely varied responsibilities within each agency, an established protocol such as that which has been developed in Canada is not currently available in the U.S. Project managers must coordinate the agency reviews and permitting.

Federal Agencies
The National Fishing Enhancement Act designates the lead responsibilities regarding man-made reefs in the navigable waters of the U.S. and waters super-adjacent to the outer continental shelf as follows:

- The Secretary of the Army has lead responsibility to regulate and monitor man-made reef projects through pertinent permit programs of the Army Corps of Engineers.
- The Secretary of Commerce is responsible for the National Artificial Reef Plan that provides guidance on reef development.
- The Secretary of Transportation has authority to designate any “obsolete” vessel as being available for transfer to state artificial reef programs.

Other agency involvement is due to responsibilities designated by other regulatory acts as discussed below.

Department of Defense
As part of the DOD, the U.S. Army Corps of Engineers (Corps) is the first federal agency that must be dealt with in order to construct an artificial reef. The Corps is responsible for regulating certain activities in US waters under the Rivers and Harbors Act (RHA) to ensure that safe navigational clearances are maintained in all waterways under their jurisdiction. The Corps also has permit authority under the Clean Water Act (CWA) and the Marine Protection, Research and Sanctuaries Act (MPRSA) to verify that water quality is not impacted and living organisms are not adversely affected by reefing activities. Through the Corps permitting process, construction is also examined to confirm all aspects of both federal and state Coastal Zone Management Acts are not being violated. Prior to permit approval, other concerned agencies and departments within federal and state governments are given the opportunity to review the proposed work to ensure compliance with existing regulations and prevent the approval of projects that might negatively impact other existing or planned activities.

Although the final objective is the construction of an artificial reef, the permit issued by the Corps will be a dredge and fill permit. Also, due to the long-term liability associated with the creation of artificial reefs, the Corps only issues permits to state, local or municipal governments, not to the project organization. Therefore, the project managers must enlist a governmental entity to apply for the permit and agree to be responsible for compliance with all conditions.
Unfortunately there is no unified national approach to processing and approving of Corps permits for reef construction. The Corps is a decentralized agency that leaves regulatory interpretation to Corps Regulatory Branch personnel and/or local district offices.

**Environmental Protection Agency**

The second agency that must be involved is the EPA. The EPA, under MPRSA and the CWA, has the responsibility to regulate ocean dumping and point source pollution. The EPA may prohibit or restrict discharges of dredged or fill material at sites where discharge would have unacceptable effects on fish, shellfish, wildlife, recreation or municipal water supplies. Under the Toxic Substances Control Act, the EPA also regulates PCBs, asbestos, heavy metals and other hazardous materials that may be present in the ship prior to cleaning.

**Department of Transportation**

The last agency that must authorize the sinking of a ship is the U.S. Coast Guard (USCG). Their primary responsibility is to ensure that all petroleum products, hydraulic fluids and fire retardant chemicals have been properly removed. Additionally, the USCG conducts an inspection to certify the seaworthiness of the ships for the towing operation and determines if the newly created artificial reef must be marked by an aid to navigation. The USCG may also need to issue a marine event permit for the sinking.

**Department of Commerce**

Although not a regulatory requirement, the DOC can get involved in artificial reef projects through two of its agencies.

The National Marine Fisheries Service responsibilities include:

- Restore, maintain and enhance fishery resources in the Exclusive Economic Zone,
- Develop and provide regional Fishery Management Councils with guidelines on essential fish habitats, including artificial reefs,
- Cooperate with the states to conserve and manage fishery resources in the territorial sea,
- Be the lead agency in the development of the National Artificial Reef Plan,
- Act in a general oversight capacity for activities such as providing comments on artificial reef permits; research; establishment of acceptable standards for the transfer, cleaning and preparation of ships; and in the establishment of fishery regulations pertaining specifically to development of artificial reef sites.

The National Ocean Survey of the National Oceanic and Atmospheric Administration needs to be notified so that the appropriate information can be place on nautical charts and maps and a Notice to Mariners can be issued. This obligation is often included as a special condition within the artificial reef permit issued by the Corps or the USCG.
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Department of Interior
The US Fish and Wildlife Service (USFWS) administers the Federal Aid in Sport Fish Restoration Program that provides matching grants to the states to undertake sport fish restoration and boating projects, which may including ships as artificial reefs. The USFWS also provides a critical function in co-chairing the National Recreational Fisheries Resources Conservation Council with the National Marine Fisheries Service.

State Natural Resource Agencies
Since the establishment of the National Artificial Reef Plan, some coastal states have aggressively pursued artificial reef programs while others have made financial and technical resources available to local governments, private interests, and universities to encourage responsible reef development and research.

In Florida, there are only 3 permanent staff members in the state artificial reef program. Therefore the majority of the projects are accomplished at the local county and municipal level with the state proving technical expertise and financial assistance. Because the program has been undertaken by over 20 separate local government entities, there is no established protocol for the construction of artificial reefs.

Regardless, states must get involved in at least two areas of all projects to sink ships as artificial reefs.

1. The Corps will only issue permits to state agencies since they are the only entities that can demonstrate long-term commitment and responsibility to the resource and resources users. The states also may be the only entities that can demonstrate an ability to assume liability for the projected life of ship not just for the duration of the permit. While the states to have first denial rights to hold permits for any proposed project, they have the option to further delegate this authority to county and municipal agencies.

2. The Navy must transfer the title of its vessels to MARAD. Then MARAD transfers ownership to the requesting state, which can pass it on to county and municipal agencies. Once again, private organizations are not allowed to hold title due to long-term liability concerns.

States will also be involved in the review of the permit applications, cleanup plans, and safety procedures to ensure compliance with state regulations.

Since the California Department of Fish and Game determined the *HMCS Yukon* was not an artificial reef as defined in its program, but rather was designed as an underwater recreation area, a standard reef permit from the Corps was not required. Instead, the Corps issued a Letter of Permission under the Rivers and Harbors Act. Similarly, a permit from the California State Land Commission was not required because the designated underwater recreation area is contained within sovereign submerged lands regulated by the City of Sand Diego.
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**Interstate Marine Fisheries Commissions**

The role of the Interstate Marine Fisheries Commissions is to provide an open forum for discussion and debate on issues facing state artificial reef program managers, respective federal agencies and affected fisheries interests. They meet periodically to exchange information, identify and resolve interstate issues, and assist member states in developing and implementing individual state plans. The Atlantic, Gulf and Pacific States Marine Fisheries Commissions have also worked together to update the National Artificial Reef Plan.

**Local Governments (County and Municipal)**

Local government agencies have been involved in almost all activities that are part of a project to sink a ship as an artificial reef:

- Directing or coordinating artificial reef programs,
- Serving on Steering Committees and advisory panels for other organizations,
- Holding titles to vessels,
- Applying for state and federal permits,
- Issuing local permits,
- Providing technical support or supervision for community efforts,
- Providing financial support,
- Obtaining state monies as matching grants for local reef efforts, and
- Publicizing local reef efforts.

Some of the local government agencies involved in the Project Yukon regulatory process included the California Coastal Commission, the City of San Diego, and the Regional Water Control Board (San Diego Region).

**Private Organizations and Individuals**

Artificial reef construction projects have been initiated by individuals, sport fishing clubs, local artificial reef committees and diving clubs. The private sector has communicated the needs of end users, lobbied for the development of local and state artificial reef programs, and undertook fundraising activities.

On March 28, 2000 the newspaper, The Key West Citizen, ran an opinion poll about the Vandenberg artificial reef project. The poll received a level 3 response (51 – 100+ readers responding), with 100% favoring the project. Such an unbiased poll helps confirm to government officials that their constituents back such projects.

In addition, private individuals and clubs often provide the volunteer services for the cleaning, modification, construction, transportation, and deployment phases of artificial reef projects. Scuba divers have contributed to monitoring and evaluation studies.

**PUBLICITY**

Publicity starts as soon as the project originators begin talking to the public and to other groups about a potential artificial reef. It continues through the recruitment of local government supporters, initial fundraising efforts and the permit application process.
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However, once the preliminaries are over and the projects have been approved, it is time to spread the word. Publicity is essential to fundraising campaigns, to finding volunteers and to getting fishermen and divers to visit the site well after the project is completed. Several projects have used the following methods to publicize their efforts:

- Newsletters
- Websites
- Hiring marketing and public relations firms to properly represent a project nationwide
- Industry trade shows booths
- Local TV and radio talk shows.
- Invite magazine and newspaper reporters to events
- Grant interviews
- Enlist celebrities and other dignitaries to be part of the events
- Solicit television networks to film a documentary

Once the ship is transported to the scuttling site, the demand for interviews and publicity tours will increase. The Publicity Committee should make certain that all tours are of high quality by working with the other committees to develop and map tour routes, train guides, mark hazards and set barricades, and provide appropriate handicapped access and toilet facilities. Different public tour packages can be developed to raise funds. Local officials (sheriffs, lifeguards, navy, coast guard, harbor police, government) should be invited to visit the ship.

Of course, sinking day will be a major publicity event.

Preparing the Ship

After all permits are obtained, a sampling plan to determine the presence or absence of regulated materials is submitted to the EPA. Following approval and completion of the sampling plan, the locations and types of materials to be remediated during the cleanup process are identified. A cleanup plan for all regulated materials is then submitted to the EPA and USCG for approval. (This plan also normally includes towing and sinking procedure details.)

After cleanup is complete, the ship must pass inspections by the EPA, USCG, and other state or local regulatory agencies. When all clearances have been obtained, the ship’s title can be transferred to the state, which may in turn transfer it to a county or municipal agency. Once title transfer is complete, the ship may be moved from its current storage location to the shipyard where the cleanup will be conducted.

Salvage and Cleanup

The two main operations, salvage and cleanup, will typically overlap and may proceed in parallel in different sections of the vessel. Failure to develop and use a comprehensive plan detailing the activities to be undertaken, may lead to repetitions of the same cleaning operation or the inability to salvage certain components due to access issues or lack of time. For example, if the use of a heavy crane is needed, all heavy lifts should be prepared to be done at once (propellers, generator, masts, heavy equipment, ballast).
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In general terms, salvage operations should come first, taking care to minimize debris and contamination with products that will have to be cleaned up later. Cleanup would typically be the last operation in the continuum of activity and normally starts at the highest part of the compartment or tank and proceeds downwards to the bilge.

**Environmental Standards**

Environment Canada (EC), the Canadian counterpart to the EPA, has been working with organizations such as ARSBC since 1992 on projects to sink ships as artificial reefs. Initially its cleanup standards were not well defined and could change with the mood of any given inspector. As a result, EC has developed a cleanup standard with a scope limited to defining only the required end state of the vessel – how clean it has to be as mandated by Federal authorities. Canada used a “reasonableness” approach: Vibrant reefs have grown around ships that have sunk on their own or with the help of nature or wars, even though most of these vessels were not cleaned in any way. Therefore, standards should be reasonable, environmentally sound, repeatable and have quantifiable methods that reduce subjectivity.

The Canadian Environmental Protection Act does not distinguish between the sinking of ships for disposal, artificial reefs, or scuba diving attractions; therefore, all vessels must be cleaned to the same standard. EC deliberately did not dictate how to clean the vessel. This omission has created a standard that will not become obsolete due to changing technology. Also, the clean-up standard does not address worker safety; requirements for lay down areas; or debris disposal; only that all of these meet their respective local regulations which vary by jurisdiction. Also, since the standard does not differentiate between the final use of the vessel, it does not address potential liability regarding the uses.

EC graciously shares its cleanup standards with foreign organizations as a starting point for other projects. There is currently a draft of standards for cleaning ships by the EPA out for comment.

**Hazardous Materials**

According to generally accepted cleanup guidelines, different materials must be treated as follows prior to transporting the vessel to its sinking location:

- Hazardous materials, unknown materials, spills and residues require complete removal.
- Other materials are subject to fitted/non-fitted tests: liquid paint and glues in containers are removed, but paint and glues applied to the vessel may remain. (An exception is anti-fouling paint because they are deleterious.)
- Asbestos is not an environmental concern (as it is not hazardous when wetted as it will be in the marine environment). However, it remains a safety issue for those preparing the ship for sinking and if the ship scuttling process could
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release fibers into the environment. Removal should satisfy health and safety authorities.

- Small accumulations of grease in sealed bearings and housing can remain provided that all are intact.
- Some debris is allowed to remain if it is clean and it must be part of the ship.

Anything that is left in the ship must be proven clean and explained. Open communications from the project leaders can diminish the mistrust and resistance by government and environmental groups that fear:

1. What has been left in the ship that can be hazardous to marine life, people and the environment?
2. What hazardous materials may leak and leech out of the ship?
3. What proof is there that the artificial reef will not cause damage in the future?

Unfortunately, each component system of a typical ship is a potential source of hazardous materials and must be examined. For example:

- Hulls and superstructures may contain paints or coating with heavy metals or PCBs, bottom paint with anti-biologic compounds;
- Propulsion systems may have fuels, lubricants, solvents, water treatment chemicals, mercury-containing gauges, radioactive materials, and combustion by-products;
- Ship control systems may include electronic and electrical equipment as sources of heavy metals and/or insulation and dielectrics with PCBs, mercury and phosphorus;
- Functional systems for warships may include weapons systems and associated storage;
- Cargo ships may have extensive deck machinery with hydraulic fluids, petroleum-treated rigging, and cargo refrigeration equipment; and
- Personnel support and utility systems likely encompass food preparation equipment, lighting systems, air conditioning equipment and a sanitary system.

The most common contaminants will be hydrocarbons such as oils and fuels. Every structural tank, whether designated for hydrocarbons or not, must be opened and examined. Non-structural tanks; fuel systems including pipes, valves and fittings; sections of engines, gearboxes, and bilge areas; hydraulic systems; and bulkheads, decks and floor coverings; that could be contaminated during the life of the vessel must also be checked. It may be more cost effective to remove these items rather than clean them to meet regulatory compliance.

Some materials removed from the vessel can become significant safety hazards or environmental liabilities if mishandled, disturbed or spilled. Materials should not be allowed to accumulate at the site. Personnel involved
in the cleanup and salvage operations must be aware of both safety and environmental responsibilities.

**Preparations for Use by Scuba Divers**

If an objective of the project is to use the ship as a scuba diving destination, additional preparations must be made to increase diver safety.

- Materials necessary for diver access must be removed (steel hull plates, framing and brackets, aluminum plates, cabin sides or bulkheads).
- Areas that cannot be made safe, such as boiler rooms or doors that can close behind a diver, should be sealed off via welding or filled in with concrete.
- Because many divers that visit the site will not be wreck certified, access holes should be cut at distances so that an exit is always within sight.
- Items that could injure divers must be removed (head bangers such as fixtures, lights and switches; copper electrical cable, furniture and equipment)
- Although divers who visit the sunken vessel are personally responsible for the risks they are assuming, warning signs and directional arrows should be installed along diver routes.

Whenever possible, items should be left in place so divers can have something to maintain their interest. However, these items should be firmly secured so as not to be stolen by divers.

**Security**

Security issues are not static and need constant attention over the life of the project. Security of the vessel and surrounding site should be addressed in the cleanup and salvage plans.

*Public Safety:* Vessels undergoing salvage operations are dangerous sites. The public must be prevented from accidentally or casually accessing the interior of the vessel and cleanup site.

*Salvage Security:* Inevitably some members of the public will actively seek to gain illegal entrance to the site and vessel. Tools, salvage items and hazardous materials should be kept in locked and/or guarded areas.

Once the ship is at anchor and until the morning of the sinking, 24-hour security must remain aboard the ship to prevent curious spectators, vandals and thieves from boarding the boat. Two days prior to the scuttling, all explosives are in place and the ship is considered a blasting area. After the explosives are on board, tight security must remain on board at all times to prevent deliberate tampering with or theft of the explosives until the vessel is turned over to the blasting crew immediately before scuttling.

**TRANSPORTING THE SHIP TO THE SITE**
Transportation procedures for the ship are normally included as part of the cleanup plans submitted to the EPA and USCG.

Details for transporting the ship are not provided in EC’s cleanup standards and guidelines. However, the Ontario Ministry of Natural Resources is drafting a policy for sinking ships in the Great Lakes that shall require the following to be part of a project Transportation Plan:

- Means of transporting the vessel to the sinking site,
- Transportation route from source to sinking location,
- Source and handling of any water on board, including bilge water (potential introduction of foreign species), and
- Marine surveyors report indicating the vessel will safely make the transit to the site and will remain on site once scuttled.

**SINKING AND SAFETY**

As cleanup of the ship is completed and as transportation to the site is underway, preparations for the sinking become a primary focus for project managers. Plans must take into account various weather and water conditions as well as daylight and other operational constraints. Back up plans must also be made in the event that it becomes necessary to cancel operations to ensure the safety of participants and the proper placement of the ship. Emergency Procedures, including search and rescue plans, must be in place and preferably rehearsed with local rescue personnel, lifeguards, and sheriffs.

Diving Safety Officers must recruit sufficiently trained and insured divers (divemaster rating and higher) to conduct the post sinking exercises. Their responsibilities include:

- Develop diver and dive boat safety procedures documents,
- Develop waivers and releases and ensure all divers complete forms,
- Check certifications and qualifications of all divers diving on the project.
- Assign divers to all dive tasks, and
- Supervise all diving operations on the project.

If the ship is to be open to recreational divers and enough dive team members are available, it may be possible to have the dive team lead charter groups on underwater tours during the sinking day events. This will ensure that the dives remain on schedule and that no divers get lost.

**Explosives**

Explosives must be ordered in advance. Although the scuttling experts will be responsible for handling the explosives once delivered, they are not necessarily familiar with local importation laws for the transportation of explosives or local ordinances for the storage and use of explosives. Local explosive vendors/distributors will likely be contracted to handle these activities. Another option is to involve the military. They may have explosives in stock and may able to assist in the transportation and storage. In the past, the Navy has used the scuttling of ship by other organization as opportunities for training exercises.
Charges are custom made and fitted to the contour of the ship to ensure a precise cut using the lowest amount of explosives possible. The explosives team will need a secure area in which to bend and shape the charges. Since the explosive frames are also custom fit, the team will need access to a local wood working shop and tools. Once the explosives are attached to the frames, they have to be stored in a magazine or licensed facility. Options include:

- Licensing the ship as a magazine using one of the secure compartment for magazine storage,
- Involving the military and use their facilities, and
- Using a commercial explosive vendor’s facilities.

The use of controlled charges greatly hastens the sinking and minimizes the time the ship has to react to the elements of nature. Typically the time from detonation until the ship is embedded in the bottom is less than four minutes. In comparison, flooding and sinking the ship is slow, taking from one half to several hours. During this time delay, the ship may list and its attitude may be further altered by wind, current, tide and the prevailing sea conditions. When this occurs, control over the stability and position of the ship is lost, which may cause it to drift and sink in an undesirable location. It is impossible to correct a list or reposition the ship once the sinking process has started.

For proper scuttling, the goal is to sink the bow first. A series of calculated explosions are designed not only to sink the ship but also to control the air vented and the rate of descent. The forward momentum of the vessel overcomes the external natural causes that can move the ship from its desired location. Once the bow is embedded into the bottom, the stern begins to sink. The momentum drives the ship forward and 4-5 feet into the sand or bottom. Ideally, the ship is stable upon sinking and ready for diving.

The underwater pressure impulse and air overpressure effects of the detonation sequence are evaluated and analyzed prior to explosive selection and delay timing. These calculations set the impulse below the threshold to marine mammals and fish at a set distance.

During the sinking of the *HMAS Swan* in Western Australia, it was decided not to use seal scares or thunder flashes as they are more likely to attract the attention of whales and dolphins than deter them. A spotter plan was utilized on the morning of the sinking to circle the designated area and watch for marine mammals. The explosive charges were not detonated until the spotter plane gave the all clear signal.

*HMCS Columbia* was scuttled near a fish farm. To prevent collateral damage from the shock wave to the fish farm, a series of bubble wrap blankets were suspended over the side of the ship directly in front of the explosives. The air spaces in the bubble wrap absorbed the shock wave produced by the explosion thus preventing injury to the fish.
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THE DAY OF THE SINKING

All committees will be involved in various activities on the day of sinking. Most will be coordinated by the Safety Committee to ensure public safety and the proper scuttling of the ship.

Crowd control will be a major issue on sinking day. All blasting operations are capable of producing fly material that can cause serious injury or damage. A safe area 360 degrees around the ship of a distance prescribed by the scuttling team must be cordoned off. Cordons will be hard to maintain and will have a tendency to converge as spectators try to get a better view. Coast Guard, Police and/or Navy security boats will need to patrol the perimeter to prevent this creep.

For Project Yukon, the San Diego Yacht Club placed a ring of orange buoys in a 100-yard perimeter around the ship. The buoys were securely anchored to the bottom. Only boats displaying official orange flags were allowed inside the safety zone, which was patrolled by official boats and City Lifeguards and Police with citation authority.

Areas must be reserved for VIPs and those who have been awarded “preferred seating” due to their contributions to the projects. Other areas must be available for media coverage of the event.

During the scuttling, some fireballs are purposely produced for the enjoyment of the spectators and are not related to the scuttling charges. All scuttling charges are detonated below the water line and have very little visual effect. After scuttling, the blasting area remains in effect until the dive safety team has ensured that all charges have in fact detonated. If the boat is to be open to recreational divers, another team of safety divers will inspect all areas of the boat to ensure that no changes occurred during the sinking that could cause potential underwater hazards. If the blast occurs at sunset and these dives cannot be made until the following day, security must remain on site overnight.

Once all official activities are concluded, the vessel is declared open to public.

DOCUMENTATION

Documentation of the entire project is essential for historical purposes as well as comparative information for future projects.

The San Diego Ocean Foundation, Marine Technology Society and ARSBC hosted an Artificial Reef Conference to share the Project Yukon experiences and lesson learned.

Diligent record keeping of the project includes the following documentation:

- Ship history
- Video and photographs
- Documentation of all committee activities and meetings
- Timelines/Gant charts
Sinking of a Ship as an Artificial Reef

- Financial Records
- Marine surveys and maps
- Environmental standards and acceptance criteria
- Permits
- Sampling, cleanup and explosives record plans
- Project, training, and safety manuals
- Job safety analysis
- Diver safety manual with waivers/releases
- Incident reports

Additionally, public information brochures and/or flyers should continue to be developed and distributed even after the sinking is complete. These should include descriptions of the reef, conditions at the site, and use guidelines such as observance of diving flags, anchoring restrictions, mooring etiquette, fishing gear restrictions, catch limitations, and courtesies which should be extended to other reef users.

**MONITORING AND MAINTENANCE**

Although the sinking is complete, monitoring and maintenance will continue for many years to assure compliance with the conditions defined in any authorizing permits and to demonstrate that project objectives have been met.

Compliance monitoring should involve the documentation of stability and structural integrity throughout the life of the reef. Accurate and repeatable navigational data establishing reef positions are essential. Navigational aids must be monitored for compliance with the USCG authorization for color and signal characteristics and to ensure that the aids stay on station. This may involve painting, repair, or complete replacement of badly deteriorated buoys or mooring systems. Additional maintenance, although not required by law, can enhance reef effectiveness (removing entangled fishing gear, repositioning buoys, and adding materials to or around the wreck).

Performance monitoring assesses the physical, biological and socio-economic factors essential in documenting the degree of successes as well as all impacts of a given artificial reef. It can detect unexpected negative consequences as well as provide insight into the need for future modifications to preparation and scuttling techniques, identify research priorities and document the need for alternative management strategies or new regulations.

Biological monitoring of the fish community on the *HMAS Swan* over a two year period showed an increase from 2 to 32 species and from 10 to ~1300 individuals when compared to a nearby control site. The fish community on the vessel shifted from omnivorous weed/sand fishes to one dominated by planktivorous and carnivorous reef fishes. Video cameras were used in conjunction with scientific assessment to survey and monitor benthic communities.

An assessment of the attached biological community has been completed for the *G.B. Church* artificial reef in British Columbia. Within months, the outer hull was encrusted with several hundred individuals. After 2.5 years, nearly 100 species, including 62
invertebrates, 20 fish and 14 algae, had colonized the reefs. The dominant group among the invertebrates is crustacean with 17 species.

ARSBC continually evaluates its artificial reef creation program effectiveness and incorporates new findings into future planning. Current research projects underway include examination of the effect of ship’s paint on recruitment and settling pattern of marine invertebrates and fishes and rate of colonization of various substrates including steel and aluminum. In addition, an experimental attempt to increase the complexity of the ship’s exterior surface has been initiated to encourage rapid utilization by motile animals.

**SUMMARY**

Recent projects to sink ships as artificial reefs have taken up to six years and have cost in excess of one million dollars. Yet to the multitude of end-users, this is time and money well spent. As governmental agencies and private organizations continue to work together to standardize procedures and streamline the process, hopefully more ships will be intentionally sunk to create these new habitats for precious underwater life.

**ACKNOWLEDGEMENTS**

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The Sinking of Ships as Artificial Reefs
Abbreviations

**ABBREVIATIONS**

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<td>ARK</td>
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