St Helena Government

Artificial reefs

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Environmental Management Division

Saint Helena Government

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Environmental Management Division

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Executive Summary

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The construction of artificial reefs has been highly debated in many countries with both advocates and opponents to their creation. It is essential for countries to ensure that the correct mechanisms are in place to decide on the necessity of an artificial reef. Prior to approval being given for the establishment of an artificial reef the objective, target species, construction materials, location, social benefits and cost must be well thought out. St Helena has historically had several artificial reefs set up in the inshore waters including both scuttling of shipwrecks and the disposal of old vehicles. Although the benefits in terms of increased diversity and abundance of marine species can be seen on the reefs compared to surrounding habitat, there is a large quantity of high quality natural reefs around St Helena and the need to create extra fish habitat is highly debateable. In future the creation of reefs should only be considered for dive tourism and using suitable materials (ie ships not cars) with the emphasis on ensuring these have been thoroughly cleaned prior to disposal. Fish Aggregating Devices have also been utilised on St Helena to attract fish for the local inshore fishing fleet. As with artificial reefs, for FAD's there is the need for well thought out siting and construction as well as ensuring good data collection to ascertain their benefits. All catch and effort data for all fishing should be collected in future pre and post FAD deployment.

1 Introduction

An artificial reef is a man-made structure in the marine environment. Over recent years there has been a global degradation of natural coral reefs and this has generated the need to restore marine habitats resulting in the growing interest in the use of artificial reefs (Perkol-Finkel et al, 2006). They can be created for a variety of reasons most commonly to increase habitat for marine species or to increase fishing, however they have also been shaped to create surf areas, to prevent shipping traffic and as tourist dive locations . Globally artificial reefs have been created using a wide range of items usually which were designed for other purposes including rubble, tires, concrete sewer pipes, airplanes, ships, cars, waste construction items, however more recently purpose built structures of specific materials have also been used.

2 Creating an artificial reef

When considering the construction of artificial reefs countries need to have clear plans/policies for their development taking into consideration social, economic, biological and environmental impacts (Murray 1994). The following criteria should to be considered (these are discussed further in the sections below):

- Objective
- Target species
- Construction materials
- Location
- Social benefits
- Cost

Prior to construction of any artificial reef there must be a well thought out viable objective which will not cause any detrimental impacts on the natural environment. The reasons for the reef and the target species will determine what it is made of and where it is sited. The cost will need to be considered in relation to the extent of the environmental or social benefit.

2.1 Objective

What would be the objective of a new reef?

1. To create fish habitat (is there a lack of natural habitat or is the available natural habitat degraded?)
2. For marine tourism (who will use it – the target users will determine where it is sited by considering travel time from Jamestown, depth it is put in)
3. To attract bait for fishermen (consideration will need to be given to travel time from Jamestown, where do bait fish congregate naturally)

2.2 Target species

What is the target species (and which life stage of that species) is the reef aiming to benefit? There is the need to understand the biology and ecology (including species behaviour, life cycles, and food web dynamics) of the species in its natural habitat to allow the creation of appropriate artificial habitat. Reasons for selecting habitat include predator avoidance, availability of prey species, intraspecific relationships, and suitability for spawning.

Spanier (1993) examined natural habitat selection for clawed, spiny and slipper lobsters (adults and juveniles). He determined that the preferred habitat by the lobsters studied were horizontal non transparent structures with numerous openings. However he noted that the majority of artificial reefs created in the last 10 years were not inhabited by lobsters and that these artificial reefs had not taken into consideration the biology of the species and were created inappropriately.

For most artificial reefs their purpose has been to improve fisheries by increasing the yield of algae, lobster or commercial fish species. Many are designed to attract adult fish although (especially in Japan) reefs have also been built to improve spawning, recruitment, and survival of earlier life history stages (Bohnsack and Sutherland 1985).

If artificial reefs are created to reproduce the species assemblages on nearby natural reefs then it is important to understand the features of reef. Perkol-Finkel et al (2006) found that artificial reefs will mimic their adjacent natural reef communities only if it possesses structural features similar to those of the natural surroundings. However, if the two differ structurally, their communities will remain distinct.

2.3 Construction materials

What would be the most suitable materials from which to construct the artificial reef? Materials which will rapidly disintegrate in seawater should be avoided including thin ferrous metals or wood. Inert materials should be considered which do not leach any toxic chemicals into the water. Concrete has been reported as a favourable material for reef construction as it is found to be durable in seawater, mouldable to different shapes and, within tropical waters, to have a similar community development to natural coral reefs (Pickering and Whitmarsh 1997).

Table 1. Materials used for construction of artificial reefs, degradation lifespan and suitability for use as an artificial reef (From Yip 1998)

Type	**Life time**	**Recommended**
cars and buses	~ 6 years	No, they are subject to corrosion to debris
wooden materials	< 1-6 years	No, they collapse even sooner from wave surge and destruction by marine borers.
household appliances (ovens, refrigerators and freezers)	~ 6 years	Not recommended because they are buoyant and difficult to sink and keep in place
tires, rock, concrete rubble and others	Very durable	Not recommended because they are difficult to keep in place
ships, barges, dry docks, culverts, toilet bowls, trees, bricks prefabricated shelters and artificial seaweed	Varies	Yes

Historically in the United States artificial reefs were constructed from discarded materials, from car tires, concrete blocks, solid waste items, rock and barges for example. In contrast the Japanese National Government only funds construction of artificial reefs built from approved materials including steel reinforced or pre-stressed concrete, rubber, polyethylene concrete, and fiberglass reinforced plastic (FRP) and not from waste materials which have low durability and low stability (Bohnsack and Sutherland 1985).

Depending on the target species for the reef construction design will vary including spatial arrangement, orientation, number of chambers and openings, and the amount of interstitial space. Composition and abundance of benthic organisms will also be influenced by the texture and composition of the artificial reef materials used. However the selection of materials is often based on availability and durability. Carr and Hixon (1997) compared colonisation of similar sized natural and artificial reefs and found species richness and fish abundance were greater on the natural reef, however the artificial reefs with the most similar fish abundance to natural reefs were those whose structure (both in regard to complexity of design and biotic features) best imitated the natural reef.

2.4 Location

Where and at what depth should it be located? Randall (1963) describes optimum locations for siting of artificial reefs as areas without soft mud or shifting sand bottoms because these areas would result in the possibility of reef material becoming covered in silt. The reef will lose its effectiveness if the material sinks into the sediments or is covered by silt. Randall states that consideration should be given to other environmental factors such as current, salinity and water depth (heavy surge in shallow waters can be destructive to the reef). The Atlantic Rose was sunk in St Helena in 12m as an artificial reef, however heavy seas moved the wreck around 100m inshore into depths of around 8m. The layout of the reef will be responsible for determining the species and abundance of these species which occupy the reef. The ideal location for artificial reefs is on solid substrate mainly bedrock with little sedimentation or firm gravel or sand will also provide a solid foundation Examining the scientific literature on artificial reefs Grossman et al (1997) did not find solid evidence that reef fish populations were limited by insufficient amounts of suitable habitat.

The size of the artificial reef will also determine what positive or negative impacts it may have. Large man-made structures in inshore coastal areas have the potential for causing significant hydrographical and biological changes in areas they are located (Wilding and Sayer 2002). It is important to gather pre-construction baseline data including examining current movements, species diversity and abundance and sediment levels. Oceanographic conditions, including wave direction and strength, tidal and oceanic currents, temperature gradients, as well as depth and seabed topography will all influence the design and success of artificial reefs (Bohnsack and Sutherland 1985).

2.5 Social benefits

Are there social benefits from the creation of the artificial reef? Communities usually view artificial reefs as an economic asset increasing either recreational or commercial fishing or marine tourism. Reefs created for divers usually are wrecks or archaeological items, appealing to divers both for the marine flora and fauna which they attract but also from a historical perspective. Local fishermen and anglers may benefit from the creation of artificial reefs if they result in fish shoaling in one area making them easier to catch and also requiring less fuel to search for. Economic gains from increases in fish catches however, may Social benefits may also include removal of unsightly waste from the

land; however the negative impacts on the marine environment do not justify this as a good reason to create a reef.

2.6 Cost

How much would it cost and who would pay for it? Ideally reef structures should be effective, inexpensive, long lasting and easily constructed. However often to reduce cost reefs are created haphazardly from scrap materials. In these cases it is vital all toxic materials are removed prior to sinking and the cost of cleaning the materials will need to be found. There is false economy in creating reefs from "free" waste materials if they are unsuitable habitat and are not long lasting. In Japan artificial reefs, are designed and constructed by engineers, built of durable, non-waste, prefabricated materials, however these are costly to construct and the long term economic benefits need to be considered to justify production.

Consideration should also be given for the continued cost of management of any artificial reefs created for fishing. The economic benefit generated by fishing on an artificial reef may be lost if exploitation rates are not well managed. If these areas are highlighted as profitable fishing areas a great increase in fishing effort in these areas may be non-sustainable both for the fishery and the fish stocks. The question of ownership of the artificial reef may also arise if conflicting uses of the artificial reef occur eg between diving and fishing, or recreational or sports fishing and commercial fishing.

2.7 Pros & Cons

2.7.1 Pros

- Artificial reefs can create habitat in otherwise barren areas. Artificial reefs, if properly constructed and properly buoyed, can be used to enhance existing rough bottom habitat. Artificial reefs provide shelter and could be used to increase local population sizes for reef species that are clearly limited by refuge availability.
- Artificial reefs can provide tourist features either by creating dive sites or develop quality fishing grounds close to access areas. The natural reefs of the Cape Verde Archipelago are under increasing pressure from the growing local fishing and eco-tourism industries, increasing the risk of damage or overfishing (Santos et al 2013). Artificial reefs whose fish assemblages are similar to the natural reefs offer a means to take pressure of the natural habitats allowing stressed areas to recover.
- Some construction material are very safe for use in the marine environment eg fired clay is chemically inert used in construction of artificial reefs for lobsters
- Artificial reefs influence water currents to provide areas of calm waters so that fish save energy while swimming against the current.
- Artificial reefs can attract smaller organisms which are vital sources of food for larger marine species.
- Artificial reefs can serve as visual reference points for fish that forage away from the reef and increase the all over reef area which can host a larger number of reef fish.
- Development of artificial reefs for aquaculture can help in fisheries management by removing the pressure on natural populations.
- Artificial reefs can encourage growth of filter-feeding organisms which act as biofilters and can improve marine ecosystems

- The development of environmental friendly, well designed and constructed artificial reefs can enhance marine communities in naturally poor or degraded areas.

2.7.2 Cons

- Certain materials can be toxic to the marine environment (benzene, heavy metals)
- Can cause damage to sedentary organisms of nearby natural ecosystems especially if parts of the reef are insufficiently weighted or poorly secured materials break free/are moved by heavy seas
- Artificial reefs may concentrate fish into one place making it easier for fishers and divers to catch them (worsening overfishing). Grossman et al (1997) reported that there were very few research studies which unmistakeably show that artificial reefs increase fish biomass in an area rather than just concentrating the numbers already present.
- They could potentially draw eggs and larvae that would otherwise settle in natural habitats
- Artificial reefs are sometimes not marked so fishing or other vessels are unaware of their location and can run into them if they are not located deep enough

3 Examples of worldwide artificial reefs

Historically millions of tires, usually bundled with nylon straps or steel cables, were used to create artificial reefs off Australia, New Zealand, Malaysia and off the U.S. states of New York, New Jersey, North Carolina, California and Florida. The idea was to provide habitat for fish while disposing of waste from the land, however the corrosive nature of the marine environment resulted in snapped nylon straps and rusty cables allowing the tires to break free. Thousands of tires have been washed up on shorelines especially during hurricanes. Off Fort Lauderdale, Miami more than 2,000,000 used vehicle tires were used to create an artificial reef in the early 1970's, however when the tire reef broke up due to bad weather they washed up onto the beaches destroying the living reefs in their path. Following 10 years of effort less than 100,000 of the tires have been removed and consequently now the U.S. no longer permits the creation of tire reefs.

Artificial reefs have been used for many years by the Japanese to improve coastal fisheries, both inshore for seaweeds (algae) and shellfish and in deeper water for finfish. The Japanese Government has invested millions into the creation of reefs including some as large as 30 000m^3. Scientific evidence exists that their high cost reefs created from specific materials act as nursery areas improving survival and growth of juvenile albacore.

The Australian government has been involved in sinking six decommissioned warships since the late 1990s for use as artificial reefs for recreational scuba diving and wreck diving enthusiasts from around the world travel to dive them. A survey in 2009 found that one of these wrecks, the EX-HAMS Brisbane, has contributed A$18 million to the Sunshine Coast economy.

4 Legislation on St Helena

The UK ratification of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (entered into force 1975) is extended to St Helena and Dependencies. This covers promoting the effective control of all sources of pollution of the marine environment and taking effective measures to prevent marine pollution caused by dumping at sea. Dumping at sea includes

deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures and any deliberate disposal of vessels, aircraft, platforms or other man-made structures. The Convention allows for the placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention (ie the creation of an artificial reef). The following substances are banned from being dumped at sea

1. Organohalogen compounds.
2. Mercury and mercury compound.
3. Cadmium and cadmium compounds.
4. Persistent plastics and other persistent synthetic materials, for example, netting and ropes, which may float or may remain in suspension in the sea in such a manner as to interfere materially with fishing, navigation or other legitimate uses of the sea.
5. Crude oil, fuel oil, heavy diesel oil, and lubricating oil, hydraulic fluids, and any mixture containing any of these, taken on board for the purpose of dumping.
6. High-level radio-active wastes or other high-level radio-active matter, defined on public health, biological or other grounds, by the competent international body in this field, at present the International Atomic Energy Agency, as unsuitable for dumping at sea.
7. Materials in whatever form (e.g. solids, liquids, semi-liquids, gases or in a living state) produced for biological and chemical warfare.
8. The preceding paragraphs of this Annex do not apply to substances which are rapidly rendered harmless by physical, chemical or biological processes in the sea provided they do not:

i. make edible marine organism unpalatable, or
ii. endanger human health or that of domestic animals.

In 2014 the Protection of Wrecks and Marine Archaeological Heritage Ordinance came into force. This ordinance protects the current shipwrecks but also makes provision for creating of new artificial reefs by scuttling of vessels or shipwrecks for the purpose of tourism providing steps are taken to avoid damage to sensitive marine habitats (see Annex B).

5 Current sites of artificial reefs on St Helena (cars and wrecks)

5.1 Artificial reef – cars

In 1987 an artificial reef made of old car bodies was established at a site off Breakneck valley. Its purpose was twofold - to provide “additional habitat for those species of fish that are in danger of becoming over-fished”, and as a convenient means to dispose of old car bodies from around the island. All vehicles were cleaned of oil and engines removed prior to disposal. As a conservation measure, fishing is banned on the reef, however this is only a verbal agreement with no formal restrictions in place. Records show four follow-up dives on the reef site were conducted, however only qualitative data was collected. Species composition and abundance is similar to that observed in most rocky areas around St Helena. Further disposal of old vehicles were made after the initial reef creation in 1987 and details of these, where available, are given in Table 2.

Dive survey reports after the creation of the initial artificial reef sites on St Helena:

1st dive: 6th November 1987 *Holocentrus adscensionis*: 20+, *Epinephelus adscensionis*: 12+, *Chaetodon sanctaehelenae*: shoal, *Prognathodes dichrous*: 2, *Aulostomus strigosus*: 2, *Diplodus*

sargus helenae: shoal, *Canthigaster sanctaehelenae*: 1, *Bodianus insularis*: 1 & 12+ juveniles, *Sparisoma strigatum*: 3.

2nd dive: 17th November 1987 "No close observation was made of fish stocks but in the vicinity of the reef there did appear to be an increase in numbers; this was confirmed by the other divers."

3rd dive: 16th December 1987 "Again unable to do stock tally but there is definite signs of increasing numbers of juveniles - numbers of matured fish seem the same as 17th November 1987." No dives have been carried out since. Therefore, no assumption can be made as to whether the artificial reef is of use to the local fishing industry or not.

1st July 1999 (area 50mx15m): "Cars were scattered all over the area. Could not see any whole cars – most of them had deteriorated flat onto the sand – therefore no hiding places. Did not do an exact fish count on site, just made general observations: *Heteropriacanthus cruentatus:* 36 (in a cage type structure), *Epinephelus adscensionis:* 10, *Diplodus sargus helenae*: shoal, *Chaetodon sanctaehelenae*: shoal, *Gymnothorax sp* (likely *moringa*): 2, *Holocentrus adscensionis*: shoal, *Sparisoma strigatum*: 2, *Acanthurus bahianus*: 2.

Table 2: Details of artificial reefs from old vehicles created in inshore waters around St Helena

Date	**What was disposed**	**Number disposed**	**Comments**
03-04/11/1987	cars	32	Off Breakneck valley on flat sand position 15°55.48, 5°43.70 31m
03/11/2003	Steel lighter, wooden lighter	2	Engines and any floating material removed. Sunk in positions 15˚55.553' S and 005˚43.727' W and 15˚55.562' S and 005˚43.737 W (within the vicinity of the car artificial reef)
01/12/2005	Old cars	unknown	
01/03/2006	Old cars	6	
22/03/2006	Old cars	6	
29/03/2006	Old cars	8	
29/03/2006	Old bakery equipment	2	
04/04/2006	Old cars + Bus	7	
24/03/2010	Old cars	17	Half tree Hollow clean up initiative

James Treymayne an environmental consultant reported on the construction of the artificial reef from used cars. He felt this was a poor choice of material and location for an artificial reef giving the following reasons:

1. The effects of decomposing industrial objects on the marine ecosystem is not fully understood or quantified.

2. The existing artificial reef is in 29 metres of water. Ideally, to encourage maximum growth of algae, etc. (i.e. the primary producers in the inshore marine ecosystem, which are required to support larger organisms such as fish) an artificial reef would be in rather shallower water, perhaps only 10 metres deep. The aggressive wave climate does cause problems with anchoring reef material in shallower water, so a compromise is required.
3. The reef is on a sandy bottom and is therefore fulfilling its desired function of providing "additional habitat". However it might simply be aggregating the fish resource away from the natural habitat.
4. If the real reason for the artificial reef is to remove old cars from the island then they should be disposed of in water deeper than 1000 metres. There is very little exchange between deep oceanic waters and shallow coastal ones, and there is considerably greater deep slope/abyssal plain in the Atlantic than there is St Helena island shelf.

5.2 Artificial reef – wrecks

Three vessels have been specifically sunk in St Helena's inshore waters as artificial reefs and a further five vessels were wrecked due to fire, weather or war.

Papa Nui 6-12m James Bay

The steam ship Papa Nui was built in 1898 in Plymouth and was a passenger cargo ship. Length 131m and gross tonnage of 6372 tons. She caught fire on 5th September 1911 but made it to St Helena where the remnants of the vessel was scuttled in the bay. The vessel was salvaged in the 1980's.

Spangereid 8m James Bay

Built in Glasgow in 1896. Carrying a cargo of coal from Africa to Sweden she caught fire in the coal bunkers while at her moorings in James Bay and sank in 1920.

Darkdale 33-48m outer James Bay

A British Royal Navy Fleet Auxiliary (8145 ton) which was sunk by German U Boat (U-68) on the 22nd October 1941. This wreck is a war grave.

Witte Leeuw (White Lion) 33m outer James Bay

A cargo ship sunk in action by two Portuguese carracks in 1613 in James Bay. She was carrying a cargo of spices and diamonds and a salvage operation in the 1970's recovered Chinese Ming porcelain, tons of pepper and some cannons but no diamonds. Today all that remains is the ballast stones, several cannons and an anchor.

Atlantic Rose 8m

The Atlantic Rose (originally called the Bridget 2) was brought by a German man to bring overseas good from South Africa into St Helena. The vessel was later converted it into a fishing vessel, however during bad weather it broke its moorings and was sunk.

Bedgellet 18m Near Long Ledge

Brought to the island from the UK to support the team which were salvaging the Papa Nui. Sunk in 2001 as an artificial reef.

Frontier 27m off Lemon Valley

A fishing trawler (originally from the Far East) caught smuggling a large amount of drugs. The vessel was confiscated and in 1994 the St Helena Government sunk the vessel as an artificial reef.

Portzic 27m off Lemon Valley

Tuna fishing vessel mainly fished at the seamounts (Bonaparte and Cardno) around St Helena. In 2008 it was too old and unrepairable so was sunk as an artificial reef.

Figure 1: Locations of artificial reefs/wrecks around St Helena

Examination of the species diversity and abundance was carried out by underwater visual census on the wrecks sites around St Helena compared to nearby habitat (the dominant habitat less than 100m from the wreck site). The survey comprised of two divers each recording fish and invertebrates within a 2m wide belt for a 10 minute period swimming at a constant speed. For each site one survey was conducted over the wreck and one on the habitat nearby (at least 20m away from the wreck). Results are given in Table 3. For all sites there was greater species diversity and a greater abundance of fish on the wreck compared to the nearby habitat. At three sites the nearby habitat was sand (no nearby habitat site was conducted at the wreck of the Darkdale due to depth). Sand habitats generally have very low species diversity and abundance and this is why these locations were chosen for sinking these wrecks/waste vehicles. The wrecks at these sites have achieved their desired effect of increasing fish numbers in these areas but as discussed in the sections above, it is impossible to determine if they have actually increased biomass or have actually just attracted species from the inshore natural habitats with no net biomass increase. To more robustly compare artificial and natural reefs you need sites which are in a similar location and depth and are a similar

age and similar structure. The nearby habitat sites which consisted of some amount of rocks had much higher biodiversity and abundance than the all sand sites, although this was still lower than the diversity and abundance on the wrecks. For a closer comparison between the artificial and natural habitats, the natural habitats would need to be selected to better represent the artificial site ie all rocky habitat with crevices vertical faces.

Table 3: Species diversity and abundance surveys conducted on artificial reefs and on habitat near the artificial reef

Site	Habitat	species diversity	total count invertebrates species	total count individual invertebrates	total count fish species	total count individual fish	total number feather stars	total count juvenile fish species	total count of individual juvenile fish
Darkdale	wreck	22	1	20	21	2851	0	5	87
Frontier	wreck	17	0	0	17	675	0	4	259
Frontier habitat nearby	Fine sand	5	1	0	4	7	0	0	0
Bedgellett	wreck	23	5	455	18	734	450	4	481
Bedgellett habitat nearby	cobble and medium sand	13	4	15	9	273	1	3	108
Spangereid	wreck	23	5	174	18	401	165	8	205
Spangereid habitat nearby	medium sand with small round boulders	15	4	230	11	178	228	3	79
Papa Nui	wreck	29	7	20	22	662	0	7	437
Papa Nui habitat nearby	medium sand with small round boulders	18	4	139	14	443	131	5	316
Artificial car site	cars, lighters and fine sand	24	4	52	20	918	48	4	81
Artificial car site habitat nearby	fine sand	3	1	0	2	4	0	0	0
Atlantic Rose	wreck	21	4	816	17	617	805	6	199
Atlantic Rose habitat nearby	medium sand	1	1	0	0	1	0	0	0

5.3 Fish Aggregating Devices (FAD's)

Two FAD's have been deployed by the Fisherman's Association with the aim of attracting fish to improve fishing. The first was deployed on the 21st September 2013 on the wahoo grounds near Egg Island in around 50m depth. The second FAD was deployed on the 30th January 2014 near the fishing ground called Guinea House. It was in in 68 fathoms (swinging over 74 fathoms). On the 18th February 2014 a fishermen was attached to the FAD at Guinea House and it dragged out over deeper water and was lost, however it is still on anchor and so will still be attached but too deep to see from the surface.

Figure 2: Fish aggregating device deployed off Egg Island

Data collected on species present around the FAD (by marine section via snorkelling) post deployment:

- 23/09/13 at 11.00 – 0 fish present, no growth under FAD
- 11/10/13 at 13.30 – 25 juvenile silver fish (*Pseudocaranx dentex*) present near buoys, 1 juvenile silver fish underneath FAD. Slight algal growth (slime) on sides of FAD. Photographs of fish taken.
- 30/12/13 at 14.30 – 7 juvenile pilot fish (*Naucrates ductor*) directly under the FAD. 90% sea lettuce coverage and goose barnacles. Found a number of unidentified green shrimp on sea lettuce, 2 specimens collected and preserved in 95% ethanol.
- 04/01/14 at 16.20 –2 pilot fish directly under the FAD. 90% sea lettuce coverage and goose barnacles. 13 wahoo circling underneath the FAD in about 10m. Photos taken
- 11/01/14 at 14.00 –12 juvenile pilot fish directly under the FAD. 90% sea lettuce coverage and goose barnacles. 22 wahoo circling underneath the FAD near surface. Photos taken
- 29/01/14 at 15.00 –10 pilot fish and 3 juvenile jack (*Seriola fasciata*) directly under the FAD. Less (50%) sea lettuce coverage and some goose barnacles. 5 wahoo deeper underneath the FAD near surface. Photos taken
- 30/01/14 at 14.00 –10 pilot fish and 3 juvenile jack (*Seriola fasciata*) directly under the FAD. One ocean triggerfish seen near FAD on first arrival at FAD. Less (50%) sea lettuce coverage and some goose barnacles.
- 07/03/14 at 14.30 –2 juvenile seabream (*Diplodus sargus helenae*) directly under the FAD. One unicorn fish and 3 wahoo seen near FAD in deeper water. No sea lettuce coverage and no goose barnacles. Some large *Megabalanus* barnacles. Numerous crabs seen on rope.

Unfortunately no records were kept by fishermen before and after deployment of the FAD of catches taken in the area. It is recommended prior to any further deployment of FAD's that full fishing data (catch and effort) is collected for the proposed area prior to establishing the FAD and also all catch and effort data for all fishing around the FAD post deployment.

Fish Aggregating Devices had been deployed historically but were lost in adverse weather conditions indicating the need for well-planned siting and construction.

6 Discussion

Reefs either natural or man-made are areas where oceans currents encounter structures, creating upwellings of plankton-rich water which provide good foraging areas for small fish, which in turn attract larger pelagic predators. Reefs also provide refuge in holes and crevices in which species can avoid predation; however opportunistic predators wait around the reef for these creatures to venture out from their safe hiding places. The reef structure also becomes encrusted with a variety of organisms, including algae, hard and soft corals, sponges, tunicates, sea anemones and hydrozoans over many months and years. Increases in species diversity and abundance on artificial reefs however can be caused by these individuals being attracted from other locations rather than being produced by the new artificial reef. This can give the false impression that the reef is highly beneficial to the marine environment and can also increase the likelihood of overexploitation of certain species if they congregate around the reef making them easier to target. To mitigate against this the artificial reef could be located away from natural reefs but consideration must be given to ensuring it does not cause extensive harm to the biota of the soft-bottom habitat.

The construction of artificial reefs has been highly debated in many countries with both advocates and opponents to their creation. Jack Sobel (2007), a senior scientist at The Ocean Conservancy, a Washington-based environmental group states that “the entire concept of artificial reefs needs to be re-examined” and that “there is little evidence that artificial reefs have a net benefit”. Pickering and Whitmarsh (1997) examined the attraction (ie that artificial reefs act only as an aggregating device causing fish numbers to increase on and around the artificial reef without any increase in overall biomass) versus production (ie that artificial reefs provide additional critical habitat allowing recruitment that would otherwise be lost and additional substrate for benthic fauna and thereby additional food for other species thereby increasing overall biomass) debate and they highlighted the importance of the artificial reef design in its effectiveness. For mobile species or for species which are not habitat limited evidence has been shown from several studies that artificial reefs result in the redistribution of biomass rather than an increase in biomass Polovina (1990).

Worldwide many reefs have been created for a variety of reasons, in varying habitats and out of different materials. Ensuring the necessary legislations, policies or approval processes are in place is required by any government considering the creation of artificial reefs to determine whether their construction is appropriate and essential. Due consideration should be given to the objective, target species, construction materials, location, social benefits and cost prior to approval of the establishment of any artificial reef. St Helena has historically had several artificial reefs set up in the inshore waters including both scuttling of shipwrecks and the disposal of old vehicles. Although the benefits in terms of increased diversity and abundance of marine species can be seen on the reefs compared to surrounding habitat, there is a large quantity of high quality natural reefs around St Helena and the need to create extra fish habitat is highly debateable. In future the creation of reefs should only be considered as part of an overall management plan and ensuring the use suitable materials (ie ships not cars) with the emphasis on guaranteeing these have been thoroughly cleaned prior to disposal.

Figure 3: Bountiful natural reefs exist in the inshore waters of St Helena

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8 Appendix

Appendix A. Shipwrecks off St Helena

Name	Origin	Sources	Date	Location area	Easting	Northing	Notes
Unknown (Portuguese East Indiaman	Portugal	Hearl;	1604				
4 de Marco		Sharon Wade;	21 Feb 1846	Jamestown, West Rocks			Thrown onto West Rocks with the Julia; one of at least 12 ships lost in a major storm that hit the island.
Acquilla		Sharon Wade;	21 Feb 1846				Schooner, defended slave vessel broken on the beach along with another un-named vessel, one of at least 12 ships lost in a major storm that hit the island.
Atlantic Rose		Graham Sim;			5º43.832’	15º55.764’	used in Papanui salvage, then scuttled?
Aurora I	Austria	Sharon Wade;	1880s	Jamestown, The Shears			Arrived with a cargo of sugar on fire; the vessel was backed onto the Shears and burnt down to the waterline.
Bedgellett		Graham Sim; Divestyle SA; Sharon Wade;	4 Apr 2001	Long Ledge 8.8-18m	5°45.274'	15°56.738'	Brought to the island by Dave & Steve Harris to use in salvaging the Papanui; Registration no. SSR 61580; Broke away from its mooring several times, eventually decided to sink it as an artificial reef
City of Cairo		Sharon Wade;	6 Nov 1942		500 miles S of St Helena		Not strictly a wreck on the island, but the survivors made their way to St Helena after the vessel had been torpedoed by the same U-boat that sunk the Darkdale; The vessel was said to be carrying silver bullion, general cargo and passengers
Conceicaa	Portugal	Sharon Wade;	1624				Portuguese East Indiaman
Unknown (Portuguese East Indiaman)	Portugal	Hearl;	1623				same as the Conceicaa?
Cornelia		Sharon Wade;	21 Feb 1846				A hulk (also listed as a schooner) belonging to Mr T Cole, thrown ashore; one of at least 12 ships lost in a major storm that hit the island.
Cospatrick		Sharon Wade;	1874	at sea near St Helena			Burned at sea near the island.
Darkdale	British Royal Navy Fleet Auxiliary	Graham Sim; Divestyle SA; Sharon Wade;	1941	James Bay, 42m	5°43.411'	15°55.112'	Anchored in James Bay from 6 Aug 1941, and torpedoed on 22 Oct the same year. Sunk by German U-boat (U-68) during WWII, oil still leaks from tanks; survey in 2012; Many casualties who are remembered on the Cenotaph on the wharf, the vessel is a War Grave
Descobrador (127 tonnes)		Sharon Wade;	21 Feb 1846				Slaving vessel apprehended by the Royal Navy and brought to St Helena, one of at least 12 ships lost in a major storm that hit the island.
Esperanza		Sharon Wade;	21 Feb 1846				Schooner wrecked by another - the Euphrasia - as it capsized; one of at least 12 ships lost in a major storm that hit the island.
Euphrasia		Sharon Wade;	21 Feb 1846				Schooner that capsized, wrecking another - the Esperanza - in the process; one of at least 12 ships lost in a major storm that hit the island.

Frontier		Graham Sim; Divestyle SA; Sharon Wade;	14 Dec 1994	Lemon Valley, 27-30m	5º44.64'	15º56.224'	Drug-running fishing boat, confiscated, then sunk as artificial reef; fishing trawler was caught smuggling a large amount of drugs. During the subsequent court case and imprisonment of the captain and crew it was anchored in James Bay, then, in 1994 the St Helena government finally decided to sink it. It now lies in approximately 30 metres
Julia		Sharon Wade;	21 Feb 1846	Jamestown ,West Rocks			Thrown onto West Rocks with the 4 de Marco; one of at least 12 ships lost in a major storm that hit the island.
Middleburgh	Portugal	Sharon Wade;	1626				Portuguese East Indiaman
Unknown (Dutch East Indiaman)	Dutch	Hearl;	1625				same as the Middleburgh possibly?
Papanui (430 ft long, 6372 tonnes)		Graham Sim; Divestyle SA; Sharon Wade; Duncan Haws;	11 Sep 1911	James Bay, 8-13m	5º43.200'	15º55.350'	Early steam ship, built 1898 in Scotland; one funnel, two masts, square rigged foremast; single screw, 13 kts speed. Chequered career, struck rocks off Tasmania earlier. 479 passengers, 108 crew. Immigrant ship b/w UK & Australia, caught fire & sunk in James Bay, after all passengers rescued; Later "salvaged" by blowing it apart, then removing many articles; these now with SHNT for safe-keeping; ownership David & Freda Harrison (UK); The vessel was on its way from England to Western Australia with new immigrants and cargo.
Polar Star		Sharon Wade;	1850s	some miles SE of the island			Caught fire and sank near the island.
Rocket		Sharon Wade;	21 Feb 1846				A hulk belonging to Mr J Scott, thrown ashore; one of at least 12 ships lost in a major storm that hit the island.
Spang(e)reid (prev. Fairport)	Norwegian	Graham Sim; Wikipedia; SW Maritime; Sharon Wade;	Oct 1920	James Bay, West Rocks, 8m	5º43.220'	15º55.380'	Built in Glasgow as the *Fairport* in 1896; In 1920 the Norwegian ship Spangereid carrying coal from Africa & bound for Sweden, caught fire and sank at her mooring at James Bay, depositing quantities of coal on the beach below the wharf. Originally named *Fairport,* she was renamed *Spangereid* by her Norwegian owners. She survived WW I, but came to a sad end in 1920, catching fire when off St Helena and sinking at her moorings near W Rocks. The final view of her is from a skin diver, in his letter to Sea Breezes published in April 1965, whose examination of the old wreck was cut short, when he discovered that she lay uncomfortably close to Jamestown's refuse dump and sewage outlet! At least one relic was preserved. A more recent letter to the editor of Sea Breezes (July 1980), reported the finding of a small ship's bell, clearly marked Fairport amongst garden rubbish in a Jamestown garden.
Witte Leeuw (White Lion)	Dutch	Sténuit; Graham Sim; Divestyle SA; Sharon Wade;	1613	James Bay, off Munden's Battery, 33-35m	5º43.441'	15º55.043'	Sunk in action with 2 Portuguese carracks; now just a ballast mound can be seen; Carrying a cargo of spices and diamonds; Salvage in the 1970s recovered Chinese Ming porcelain, tons of pepper, and some canon, but no diamonds - the ship had exploded as it sank scattering items far and wide.

Appendix B. Protection of Wrecks and Marine Archaeological Heritage Ordinance, 2014

Assented to in Her Majesty's name and on Her Majesty's behalf this 27th day of August, 2014.

Mark Capes
Governor

ST HELENA
NO. 7 OF 2014

Enacted……..…..……..…27 August 2014
Date of Commencement…….....27 August 2014
Published in the Gazette……..…..……27 August 2014

AN ORDINANCE

to protect the marine archaeological heritage of St Helena, including sites of wrecks, from interference by unauthorised persons; and for connected purposes.

Enacted by the Governor of St Helena with the advice and consent of the Legislative Council of St Helena.

Citation and commencement

1. This Ordinance may be cited as the Protection of Wrecks and Marine Archaeological Heritage Ordinance, 2014, and shall come into force on 27 August 2014.

Interpretation

2. For purposes of this Ordinance—

"bait fishing" means fishing for bait fish, including species of *Decapterus* and *Scomber japonicus*;

"certified diver" means a person with an internationally recognised scuba diving qualification;

"heritage sector of St Helena" comprises the St Helena Government, St Helena Museum, St Helena National Trust, the Heritage Society and any other recognised heritage body on St Helena;

"permanent anchor point" means a rope and marker buoy which has been fixed to the wreck, or attached to a block on the seabed near the wreck, in a specific position;

"**protected artefact**" means—

(a) any object made by a human being, especially but not restricted to those objects generally regarded by the heritage sector of St Helena as being of cultural or historical interest;

(b) any environmental object that has been altered or refashioned by human beings (referred to as 'ecofacts' and include, but not limited to, perforated cowrie-shells used as beads or perforated bird bones used as whistles or flutes);

(c) any natural object, unaltered by human beings but not native to the area, that has acquired cultural value by virtue of having been transported to the area by human beings.

"**protected wreck"** means a wreck listed in the Schedule;

"restricted area" means an area referred to in section 3;

"**site of wreck**" means an area which once contained a wreck but from which the wreck is now lost to erosion or some other destructive force;

"St Helena resident diver" means a certified diver who is lawfully on St Helena and who has been, or intends to remain, lawfully on the island for a period longer than six months;

"territorial sea" means the territorial sea of St Helena as determined in the St Helena and Dependencies (Territorial Sea) Order 1989.

Determination of sites of historic wrecks

3. (1) The site of any protected wreck listed in the Schedule shall be a restricted area for purposes of this Ordinance.

(2) The Governor in Council may amend the Schedule by Order to add wrecks or sites of wrecks in the territorial sea based on historical or archaeological importance of the artefact or wreck, or of any objects contained or formerly contained in a wreck which may be lying on the sea bed or near the wreck and which should be protected from unauthorised interference.

(3) The restricted area around any protected wreck shall be a radius of 100 metres centred on the position specified in the Schedule, but does not include any area above the high water mark.

Restrictions on wrecks, areas of marine archaeological interest and protected artefacts

4. (1) No person shall, without written authority granted by the Chief Enviromental Officer —

(a) penetrate any protected wreck, tamper with, damage or remove any part of a protected wreck, or any object formerly contained in such wreck;

(b) deposit anything within a restricted area so as to fall to the sea bed which would, if it were to fall on the site of a wreck (whether it so falls or not), wholly or partly obliterate the site or obstruct access to it, or damage any part of the wreck;

(c) pump sand in any area of the seabed or water within a restricted area;

(d) anchor any vessel within a restricted area otherwise than at a permanent anchor point, subject to any further restrictions under the Harbours Ordinance;

(e) conduct any spearfishing or fishing activities (other than bait fishing) within a restricted area;

(f) scuba dive within a restricted area unless such person is a St Helena resident diver or is accompanied by a St Helena resident diver.

(2) No person shall, without written authority granted by the Chief Enviromental Officer, tamper with, damage or remove any protected artefact within the territorial sea.

(3) Nothing is to be regarded as constituting an offence under subsection (1) where it is done by a person—

(a) in the course of any action taken for the sole purpose of dealing with an emergency of any description; or

(b) in exercising, or seeing to the exercise of, functions conferred by or under any legislation; or

(c) out of necessity due to stress of weather or navigational hazards where immediate action is required to avoid imminent danger.

(4) A person guilty of an offence under subsection (1) shall be liable on conviction to a maximum fine of £20,000 or imprisonment for a period not exceeding five years, or both.

Regulations

5. **(1)** The Governor in Council may make regulations for carrying into effect the provisions of this Ordinance.

(2) Regulations under subsection (1) may—

(a) make provision for scuttling of vessels or shipwrecks for the purpose of creating artificial reefs having regard to the potential tourism benefit but subject to implementing steps to avoid damage to sensitive marine habitats; and

(b) prescribe provisions which require any person, who is convicted of an offence under this Ordinance which has resulted in any damage or pollution of the environment, to take measures to clean up or rehabilitate the environment.

SCHEDULE

Name of Wreck	Location
Papanui	15º55.350 S and 005º43.200 W
Spangereid	15º55.380 S and 005º43.220 W
Darkdale	15º55.086 S and 005º43.394 W
Witte Leeuw (White Lion)	15º55.048 S and 005º43.205 W
Bedgellet	15º56.735 S and 005º45.281 W
Frontier and Portzic	15º56.224 S and 005º44.640 W
Atlantic Rose	15º55.764 S and 005º43.832 W

EXPLANATORY NOTE

(*This note is not part of the Ordinance*)

This Ordinance makes provision for the protection of wrecks and other historical and archeological heritage in St Helena waters.