Deep-Sea Fishing Impacts on the Shipwrecks of the English Channel & Western Approaches

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Odyssey Marine Exploration's Atlas Shipwreck Survey Project in the western English Channel and Western Approaches has recorded 267 shipwrecks across 4,725 square nautical miles. A high density of the sites displays evidence of detrimental impacts from the deep-sea fishing industry, predominantly trawler, scallop dredge and gill net fishing activities.

This report summarizes the effects of deep-sea fishing on all shipwrecks in the Atlas zone. The wreck of HMS *Victory*, a first-rate Royal Navy warship lost in October 1744, is examined in particularly focused detail. Three main sources are utilized and compared: side-scan sonar analysis, visual site reconnaissance of all targets using a Remotely-Operated Vehicle, and a statistical analysis of fishing in relation to wreck locations based on 73,385 VMS (Vessel Monitoring System) aerial sightings and 838,048 satellite observations of fishing vessels operating inside Odyssey's shipwreck survey zone between 1985 and 2008.

This research leads to the conclusion that the shipwrecks in the study zone have been, and continue to be, targeted, inadvertently disturbed and/or systematically exploited for deep-sea fishing due to their nature as nutrient-rich biological oases and shelter for an abundance of fish populations. Whereas steel wrecks display a level of expected structural robustness in many cases, the majority of the archaeologically significant wooden sites are at high risk, some extremely so. Largely isolated beyond the parameters of national and international legislative protection, the small percentage of surviving sites that constitute unique cultural heritage requires attention and a plan for preserving the archaeological data that can still be secured from them.

This report is intended to assess methodically and statistically a problem that is unquantified and poorly recognized to date within marine archaeology. The intent is not to cast blame on fisheries. Rather, it is to present the factual data in order to develop plans for taking into account all different user groups of underwater cultural heritage, particularly the crucial role fishermen serve society and the economy. This report is rooted on the principle that the relationships between fishermen, ecologists, archaeologists, historians, salvors, sport divers, heritage managers and marine construction companies working legally in the study region are, and must remain, respectfully symbiotic.

These results reflect specifically the conditions in one geographical area, but bring to the fore an issue that should be studied worldwide to help develop a rational and effective approach for protecting and preserving deep-sea maritime heritage.

1. Introduction

Between May 2005 and October 2008, Odyssey Marine Exploration documented 267 shipwrecks in the western English Channel and Western Approaches as part of the ongoing Atlas Shipwreck Survey Project. These sites date between the mid-17th century and the modern day and lie in depths of up to 190m. All fieldwork was conducted beyond the territorial waters of the UK and France.

The research compiled to date demonstrates that the preservation of archaeologically significant deep-sea shipwrecks in the English Channel seems to be generally extremely poor. The levels of wreck deterioration identified during Odyssey's non-intrusive survey program exceed those recorded by other organizations on shallow sites within the same body of water. Five dominant interlocking factors explain the poor preservation reality:

1. Extreme storm waves within the relatively shallow English Channel.
2. Significant bottom currents and resulting sediment transport.
3. Post-depositional trawler/dredging impacts.
4. Post-depositional wreck fishing.
5. The depth charging of sites during and after World War II to prevent submarines hiding in wreck shadows.

Evidence suggests that the most detrimental of these impacts on wreck deterioration today seems to be the modern fishing industry (Figs. 1-3). Although the far-reaching effects of this economic activity on marine ecosystems has been examined qualitatively and quantitatively in great detail since 1970, when the International Council for the Exploration of the Sea (ICES) initiated an inquest into the effects of trawls and dredges on the world's seabeds (Council Resolution 1970/5/1), its effects on shipwrecks of historical importance remain almost completely undocumented and undefined.

Of the 267 shipwreck sites inspected by Odyssey to date in the Atlas survey zone, 112 shipwrecks (including 25 wooden wrecks, 70 steel wrecks and 7 submarines) display direct trawler and wreck fishing impacts and

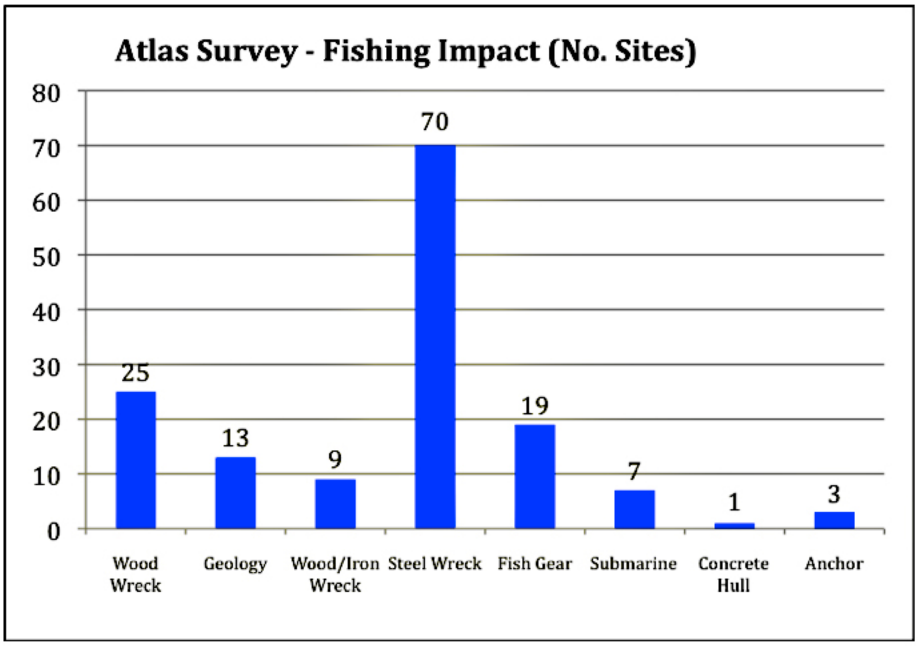


Fig 1. Wrecks and anomalies affected by all fishing impacts in the Atlas shipwreck survey zone (nos. of sites).

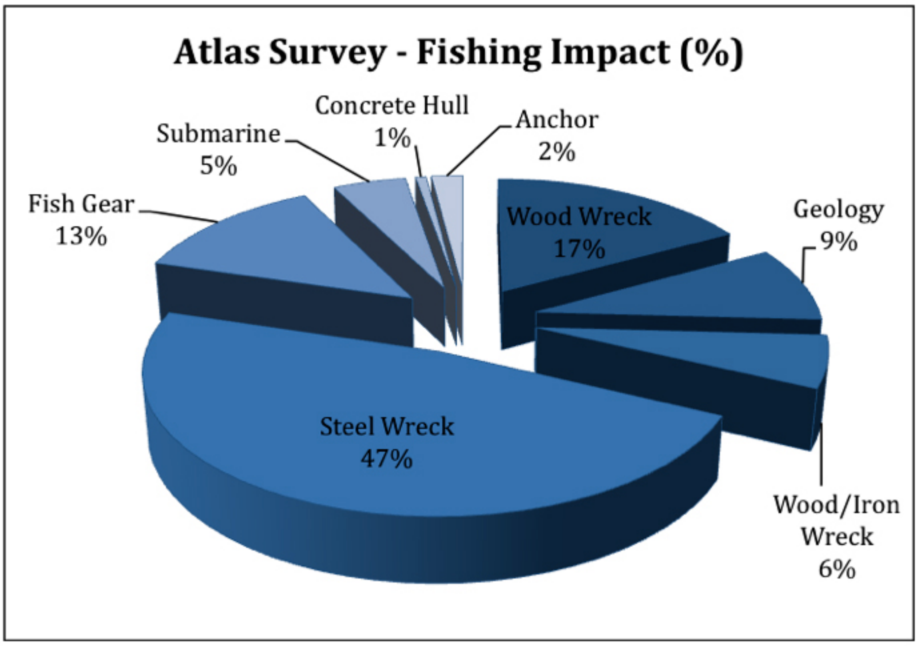


Fig 2. Wrecks and anomalies affected by all fishing impacts in the Atlas shipwreck survey zone (%).

damage that definitively proves that shipwrecks of all ages are at high risk.

Wreck Watch Int., in consultation with Odyssey Marine Exploration, is currently undertaking a comprehensive analysis of the character, distribution and scale of these impacts. The destruction of wooden wreck sites is especially worrying because after the effects of currents and trawling they typically display little relief above the sea bottom. Consequently, they are not easily identified by fishermen or avoided by trawlers. Hull remains and small finds are generally only preserved in sections of wreck sites where a sealing layer of cargo (such as concreted wooden barrels), cargo concretions or iron cannon have pinned archaeological remains *in situ* (Figs. 43, 45). Of the total number of sites discovered by Odyssey in the English Channel and Western Approaches, it is notable that very few pre-date 1800, which is an inaccurate reflection of the maritime history of this area (see Section 6 below). This suggests that many important shipwrecks have already been lost, along with the knowledge embedded within them.

Where no heavy and durable cargo, ballast or

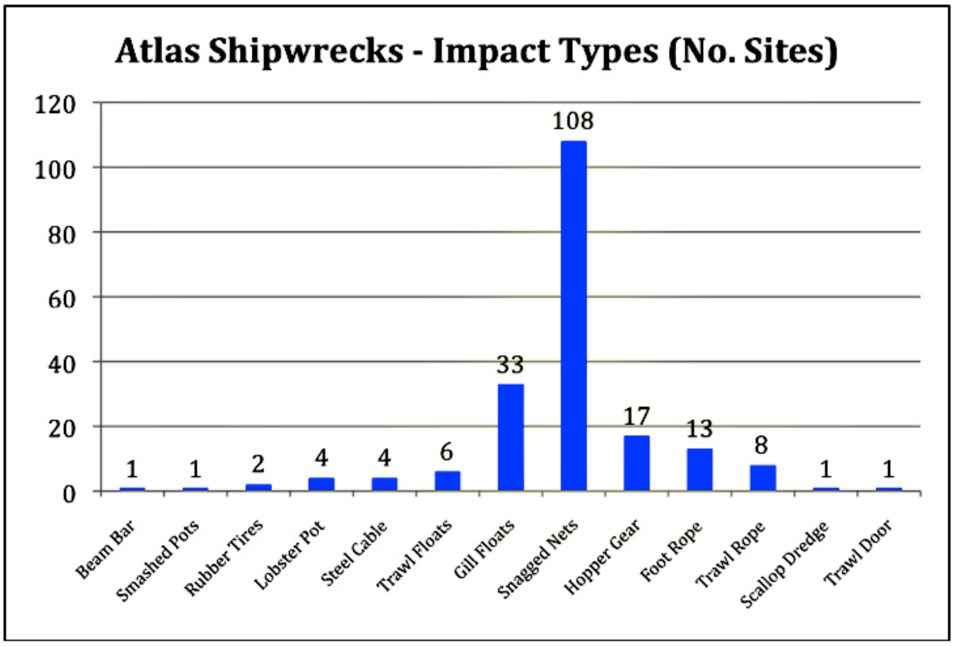


Fig 3. All fishing impact types on shipwrecks in the Atlas shipwreck survey zone.

ordnance has sealed sections of wreckage *in situ*, it is realistic to expect that sites of major archaeological significance have been – or are in the process of being – completely destroyed. The near-total absence of ceramic cargoes suggests that consignments of pottery wares are similarly insufficiently robust to survive trawler and dredging impacts.

2. Deep-Sea Fishing & Marine Ecology

A. History of Trawling

Environmental awareness of the potentially destructive power of fishing technologies on the marine environment is a centuries-old dilemma. As early as 1376 a Commons Petition to King Edward III of England complained about a newly introduced fishing gear, the 'wondyrechoun', a "three fathoms long and ten of men's feet wide" state-of-the-art device

> "made in the manner of an oyster dredge… upon which instrument is attached a net so close meshed that no fish be it ever so small which enters therein can escape… the great and long iron of the wondyrechoun runs so heavily and hardly over the ground when fishing that it destroys the flowers of the land below water there… the fishermen take such quantity of small fish that they do not know what to do with them; and that they feed and fat their pigs with them, to the great damage of the commons of the realm and the destruction of the fisheries, and they pray for a remedy" (Alward, 1932: xx).

These proto-ecologists were already aware of the 'wondyrechoun's' negative impact on the marine environment; historically the invention of the beam trawler in the 14th century was greeted with hostility from the outset. In 1583 the Netherlands banned its use for shrimping in estuaries and the French made its use a capital offense the following year.

The large-scale, intensive 'ploughing' of the seabed, however, is a relatively modern phenomenon. In Britain the fisheries of the North Sea opened up to beam trawlers in the early 19th century, when 'West End Fish' were sold to the upper classes of London. Once the steam railway engine was developed in the late 1820s, seafood could be distributed and sold across great distances while fresh on an unprecedented basis. By the early 1860s, over 100,000 tons of fish were being transported by Britain's railways each year (Roberts, 2007: 141-2).

By 1820 a nucleus of Devonshire fishermen had settled in Dover and Ramsgate to fish the Channel and joined Belgian, French and Dutch fishermen in the North Sea and off the French and Belgian coasts (Alward, 1932: 11-12). By 1877, the principal ports for some 1700 deep-sea trawlers in the Atlas survey catchment area of the English Channel were Plymouth and Brixham (the birth places of the trawling industry in the UK), and Dover and Ramsgate to the east (Young, 1877: 21. 46). Otter boards were introduced in 1880, enabling vessels to deploy larger nets (Jennings *et al.*, 2001: table 5.1). The introduction of the steam trawler in Britain in 1882 expanded the geographic scope of the fishing industry and the temporal capability of trawlers to operate offshore (Alward, 1932: 9). At this time steam trawlers were working up to 48km from land (Duke of Edinburgh, 1883: 36).

Immediately after World War II and the boom in human demography, fisheries development intensified dramatically, with production rising from 17.7 to 28.4 million tons globally. Between 1959 and 1972 rapid geographic fishing expansion led to annual world catches rising further from 30 to 60 million tons. The introduction of technological developments such as synthetic fibers, chain mats to protect the belly of nets and more powerful ship engines facilitated substantial increases in the size and weight of fishing gear and, in turn, fishing systems that could cover huge areas of ocean efficiently.

From 1972 to 1982 fisheries production rose again from 60 to 68 million tons worldwide as some coastal states extended the commercial parameters of fished waters. In the early 1980s the weight of many fishing boat beam trawls increased from 3.5 tons to 10 tons and formerly unexploited fishing grounds were penetrated for the first time. This period witnessed the final expansion of distant water fleets into the Indian Ocean, South Pacific and southwest Atlantic in search of high-value species such as tuna, shrimp and cephalopods. Between 1983 and 1992 annual catches increased from 68 to about 85 million tons globally, and issues of sustainability and the environmental implications of fisheries finally became a subject of widespread concern and environmental debate (Hall, 1999: 3, 4, 49).

The unsustainable scale of trawling on global fishing communities in the wake of the widespread overexploitation of resources has been acknowledged and examined scientifically for over 60 years. Severe overfishing in many developing countries resulted in a series of dramatic fishery collapses. Within 15 years of World War II the otter trawl fishery industry in the southeastern North Sea caused marked declines in elasmobranchs and larger-bodied invertebrate species. In the early 1950s the Hokkaido sardine, the North Sea and Atlanto-Scandinavian herring and the Californian pilchard decreased or collapsed. In Port Phillip Bay, southeastern Australia, the scallop fishery started in 1963 collapsed in 1968. The anchoveta of Peru dwindled from 12 million to 2 million tons in the early 1970s. In the Gulf of Thailand, the North Sea and West Africa, over-hunted long-lived species started to be replaced within the food chain by more adaptable short-lived ones (Hall, 1999: 4, 5, 59, 75). Research in the northern Irish Sea, where commercial scallop fishing has been active since the late 1930s, has concluded that this industry "may have already altered the community structure sufficiently that a return to its pre-dredging state is impossible, possibly owing to permanent changes in the substratum…" (Bradshaw *et al.*, 2000: 94, 101).

As a consequence of the threat of this uncontrolled expansion, the International Council for the Exploration of the Sea (ICES) initiated an inquest in 1970 into the effects of trawls and dredges on seabeds (Council Resolution 1970/5/1). This was followed in 1988 by the ICES Study Group on Effects of Bottom Trawling, convened

Fig 4. The wreck of a 1930s steel cargo vessel (Site T34n43d-1; Target 366) with fishing nets across the bows and anchors. Atlas shipwreck survey zone, depth 156.5m.

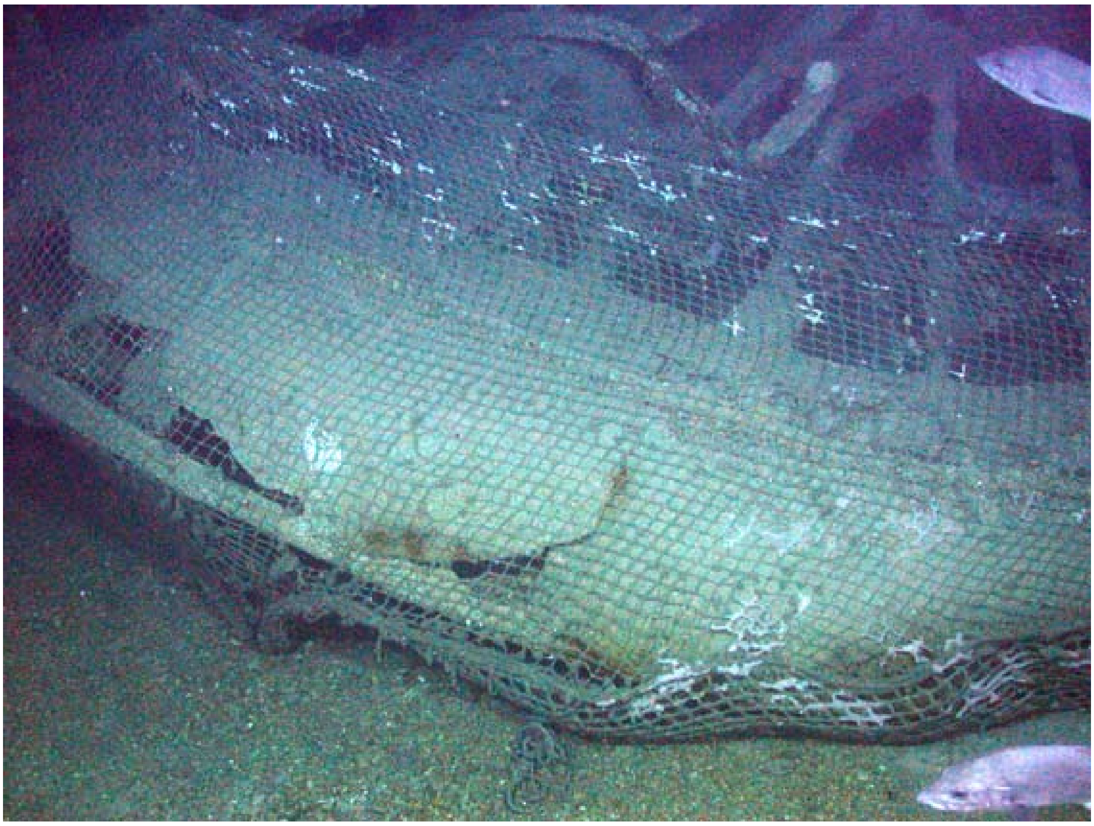


Fig. 5. Snagged fishing net on a 20th-century steel wreck (Site T34n37d-1; Target 494). Atlas shipwreck survey zone, depth 144.8m.

Fig. 6. Dense fishing net snagged on the inside of a heavily impacted 20th-century steel wreck (Site T3a61g-1; Target 183). Atlas shipwreck survey zone, depth 105.8m.

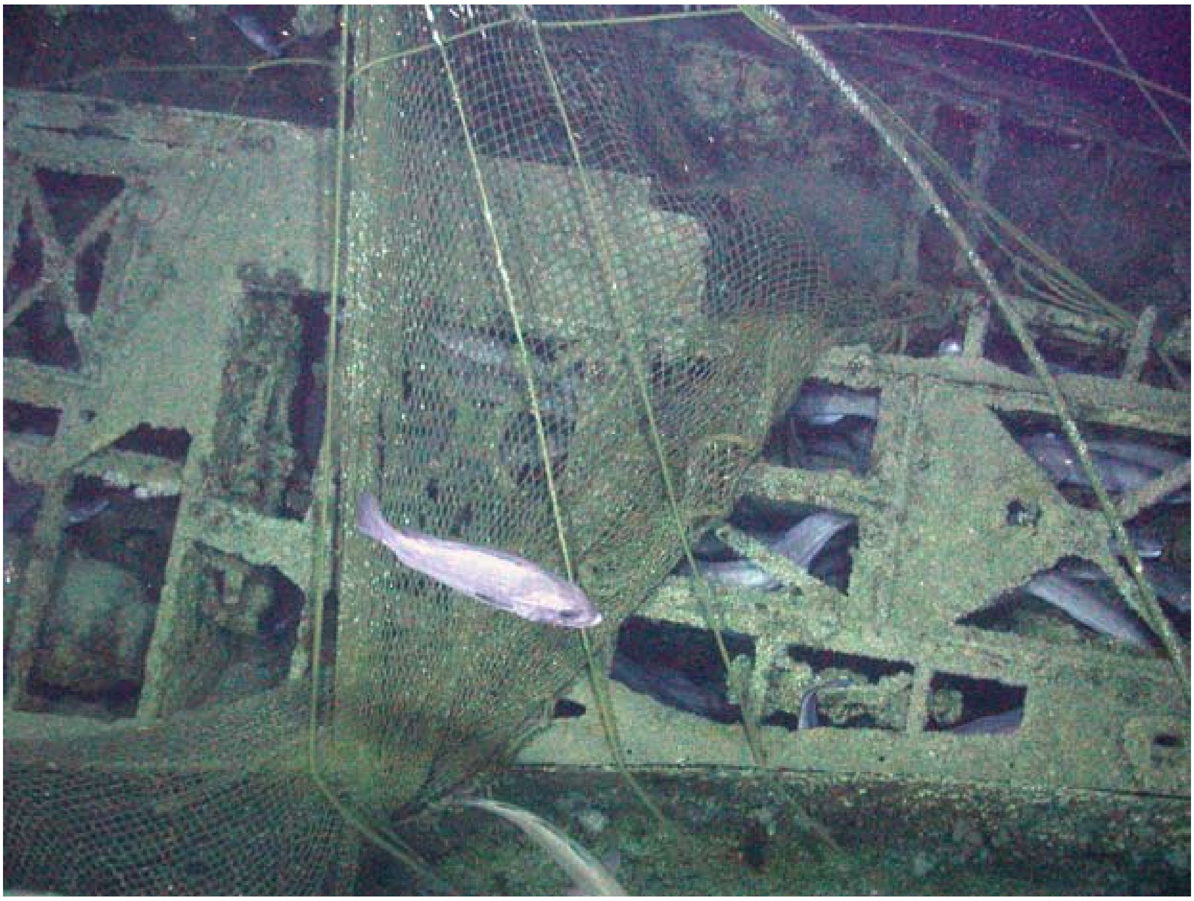


Fig. 7. Fishing nets snagged across the sides and deteriorated interior of German submarine U-326, sunk in 1945 (Site T12n9e-1; Target 373). Note the abundance of conger eels resident within its hull. Atlas shipwreck survey zone, depth 164.4m.

in response to Council Resolution 1987/2/7 to collect information available since 1972 and to report on the development of bottom trawling gear, existing literature, national research and proposals for coordinated research (Fonteyne, 2000: 16). As a consequence of this ongoing monitoring, manifold issues of zoning, fish quotas and trawler decommission have been heavily debated and in some cases implemented.

B. Trawler Equipment & Channel Fishing Ports

Fishing within the English Channel is, of course, an extensive and significant economic pursuit. In 2006, 95,138 tons of fish were landed by UK vessels alone in England and Wales with a sale value of £137,623,000 (Walmsley and Pawson, 2007: 8, table 2.2). Within the territorial and offshore waters of southern England, a variety of methods are employed by commercial fishermen. The four main types of trawl/dredge systems are defined according to methods adopted to keep the nets open (based on Gray, 1995: 7-13, 66):[1]

i. Otter Trawl

The mouth of the net is held open by weighted ground rope, floats on the headline and the lateral paravaning effect of the otter boards or 'doors'. The bridles, warps and otter boards help to drive the fish towards the net. Trawl gear is either dragged along the seabed when targeting demersal fish or through the water column to catch pelagic fish. 'Tickler' chains attached along the front of the demersal nets dig into the seabed, disturbing flatfish, which then swim up into the path of the net. The use of large rubber discs or steel bobbins on the ground rope enables the trawl to be towed over rocky ground (rock hopper gear).

More than one otter trawl net can be towed by a single boat (multi-rig trawl gear). Otter trawls are used to catch demersal roundfish (cod, whiting and haddock), flatfish (Dover sole, plaice and turbot), pelagic fish (herring, sprat and bass) and crustacea and molluscs (cuttlefish and squid).

ii. Pair Trawl

This configuration is towed by two boats, each attached to the trawl by a single warp. The dredge to which it is held open varies with the distance between the two boats and there is no need for otter boards. This method is used for both demersal and pelagic fish, mainly by inshore trawlers.

iii. Beam Trawl

This net is designed to exploit demersal fish. Modern beam trawlers usually have two beams, one towed on either side to give stability. A chain matrix is often attached to the bottom of the net to prevent damage caused by boulders when used over rocky ground, and tickler chains are attached between the steel runners when targeting flatfish on sandy ground.

iv. Dredges

Dragged along the seabed, these are used for digging or scraping up molluscs such as scallops, oysters, mussels, clams and cockles. Scallop dredges are attached to a beam, and two beams are usually towed either side of a boat (the number of dredges depends on engine power). A dredge consists of a bar bearing metal teeth that rake up the molluscs and collects them in a reinforced net or bag (Fig. 38). Heavy dredges with longer teeth dig deeper into the seabed and are required to extract scallops (recessed in the seabed), whereas lighter dredge gear scrapes queen scallops from the surface of the seabed. There are various types of scallop dredges, the most common design being the 'Newhaven' dredge, which is between 0.5 and 1m wide with a spring-loaded tooth bar that helps prevent the dredge becoming snagged on rocky and stony areas. The 'French' dredge, up to 2m in width, is heavier than the Newhaven dredge and utilizes a diving plate to force the dredge into the seabed.

In addition to trawlers and dredges, offshore impacts include fishing with gill nets on wrecks and the laying of lobster/crab pots. In the case of wreck fishing with gill nets, single sheets of netting (either fixed or drift) are set vertically taut to enmesh demersal or pelagic roundfish. Gill nets set for demersal roundfish are fixed to the seabed by a weighted ground rope and anchors or other weights at intervals and kept taut by a series of floats attached to the head rope. Gill nets with mesh size of between 120 and 160mm are set over rough ground and wrecks for cod, pollack, ling, conger eels, rays and dogfish. Small-meshed (<120mm) tangle nets are set for sole and plaice on smooth grounds, whereas larger ones (>200mm) are set for rays, turbot and brill. Boats of 6-8m can set over 5,000m of net, although the average is in the region of 1,500-3,000m.

Lobster/crab potting is an extensive activity in the English Channel. A pot used to catch crustacea is generally comprised of a steel frame (sometimes plastic coated) covered in netting forming the trap, which is then anchored by a weighted base. The two main types are the 'inkwell' and 'parlor' pot. The inkwell pot is dome-shaped, commonly used for brown crabs and crawfish, which enter from the top of the pot. The parlor pot, used for lobsters, crabs and sometimes prawns, is rectangular-shaped, comprising two chambers. Crustacea enter a baited chamber and, when trying to escape, enter the second chamber where they remain trapped. The continual development of more powerful hydraulic capstans has given the fleets the ability to haul more pots. A two-man crew may work up to 600-700 pots. Boats nearing 10m in length and crewed by three fishermen can work in excess of 1,000 pots and are capable of hauling around 500 pots in one day.

Since the 1980s, large pot boats, some over 20m in length and capable of working in excess of 2,000 pots, have been constructed with live storage facilities on board to exploit offshore stocks of brown crab. Fresh bait is used to entice crabs into pots, whereas partly decomposed food is more successful for attracting lobsters. Fish offal (heads and back bones), non-commercial and low value species (dogfish, conger eel, gurnard, sprat, herring and mackerel) are favored bait. Potting activity is highest during the warmer months, with pots set out to 48km from shore for crabs, lobsters and crawfish.

Information pertaining to the coastal fisheries of England and Wales for 2005-2006 (Walmsley and Pawson, 2007: 45, 47-49, 51-54, 56, 58, 82, 83) demonstrates that within the catchment area of the Atlas shipwreck survey zone the majority of the offshore fleet is based in Devon and Cornwall. A major queen scallop fishery exists off southern Cornwall and south of the Western Approaches, while rich grounds for brown crab occur far offshore in southern Cornwall. South Devon's total landings in 2006 were 24,225 tons with a value of £33.7 million.

Major deep-sea fishing fleets are based in South Devon at Brixham, Kingswear, Salcombe and Plymouth. This area supports one of the largest brown crab potting fleets in the UK, comprising vivier-equipped offshore boats each setting up to 2,000 pots out to the middle of the Channel and often landing their catches into France. The fishery peaks during the warmer months. Devon SFC bylaws set a close season from July to September for scallops and also limit the type, size and number of dredges allowed (the use of French dredges is now prohibited).

At Brixham, one of the largest ports in southwest England, 13 of the 25 beam trawlers are between 15-35m long. Kingswear is mainly a brown crab port with around 30 boats setting pots. Together with the potting fleet in Salcombe, this area is one of the main brown crab fisheries in the UK. Around seven boats of >10m set between 800 and 1,500 pots each in the mid-Channel area. Some of these boats are equipped with live storage facilities and often land directly to the Continent. In addition to brown crabs, spider and velvet crabs are also retained, and the smaller boats set pots for lobsters.

Salcombe supports a fleet of around 12 potting boats, six of which are more than 10m long. Some of the larger boats land in France, whilst the rest of the fleet lands to live storage facilities in the port. The numbers of pots fished vary greatly depending on the size and capability of each vessel, but the larger boats usually set over 1,200 each. The traditional inkwell pot is most commonly used offshore.

Plymouth's offshore fleet consists of up of 25 boats using otter trawls, beam trawls, scallop dredges and mid-water trawls, and includes two mid-water freezer trawlers. In winter and spring Scottish vessels target bass using pair trawls, and fishermen from other locales occasionally target anchovy, pilchard and herring. In summer a number of the local trawlers change to scalloping and are joined by visiting scallopers from around the UK. Around 10-15 boats set pots for crabs and lobsters from April to the end of December.

Off Cornwall, beam trawlers fish for monkfish, megrim, lemon sole and sole. Otter trawlers exploit more seasonal fisheries, with cod and whiting landed in autumn and winter and flatfish and rays landed all year round. Some of the larger netting boats work as far as 112km offshore, fishing gill nets in the deep-water grounds to the southwest and south of Ireland for hake. Some fishing vessels based in Looe operate up to 64km offshore. Total landings in Cornwall accounted for 11,173 tons in 2006 valued at £28.3 million.

Newlyn is one of the largest fishing ports in England and Wales and where the majority of offshore boats are based in Cornwall. A regular fleet of around 40 trawlers and 50 static gear boats land their catches into the daily fish market, along with visiting boats from Brixham, Looe, Mevagissey, Ireland and the Channel Islands. Most of the 23 local beam trawlers are 25-29m in length and operate exclusively offshore for monkfish, megrim, lemon sole and sole. Up to 60 boats, between 5-25m, set enmeshing nets from this port, the larger boats fishing hake and setting gill nets and tangle nets for monkfish, turbot and rays well offshore and often taking an important bycatch of lobsters and crawfish. About 18 boats, six of which are over 12m, set pots for brown crabs both inshore and offshore.

Of 30 vessels operating from the important port of Padstow, the majority use static gear such as nets or pots. Some of these boats were originally built for trawling, but dwindling catches of sole, cod, hake and mackerel have resulted in fishermen switching to netting. The

Fig. 8. Dense fishing net caught on the side of a post mid-20th century wooden shipwreck (Site T3a19c-1; Target 152). Atlas shipwreck survey zone, depth 91.6m.

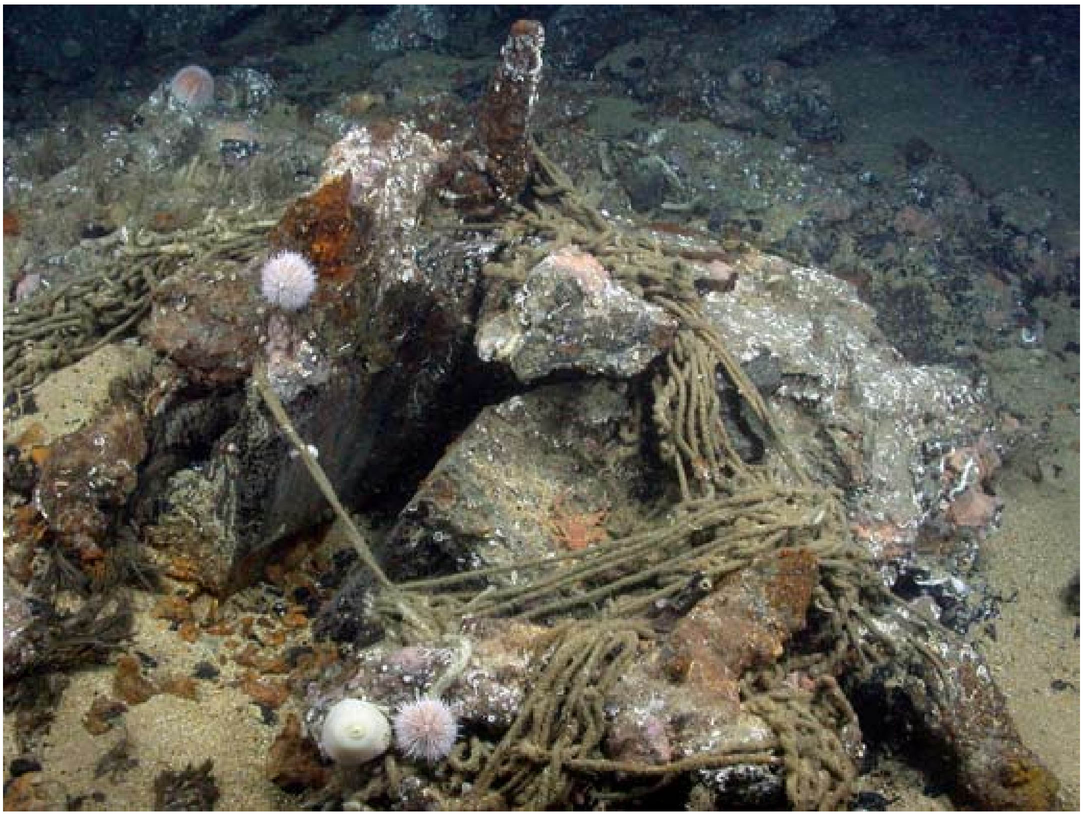


Fig. 9. Fishing net cable snagged on a mid to late 19th-century wooden shipwreck (Site 2T3a6a-2; Target 648). Atlas shipwreck survey zone, depth 83.6m.

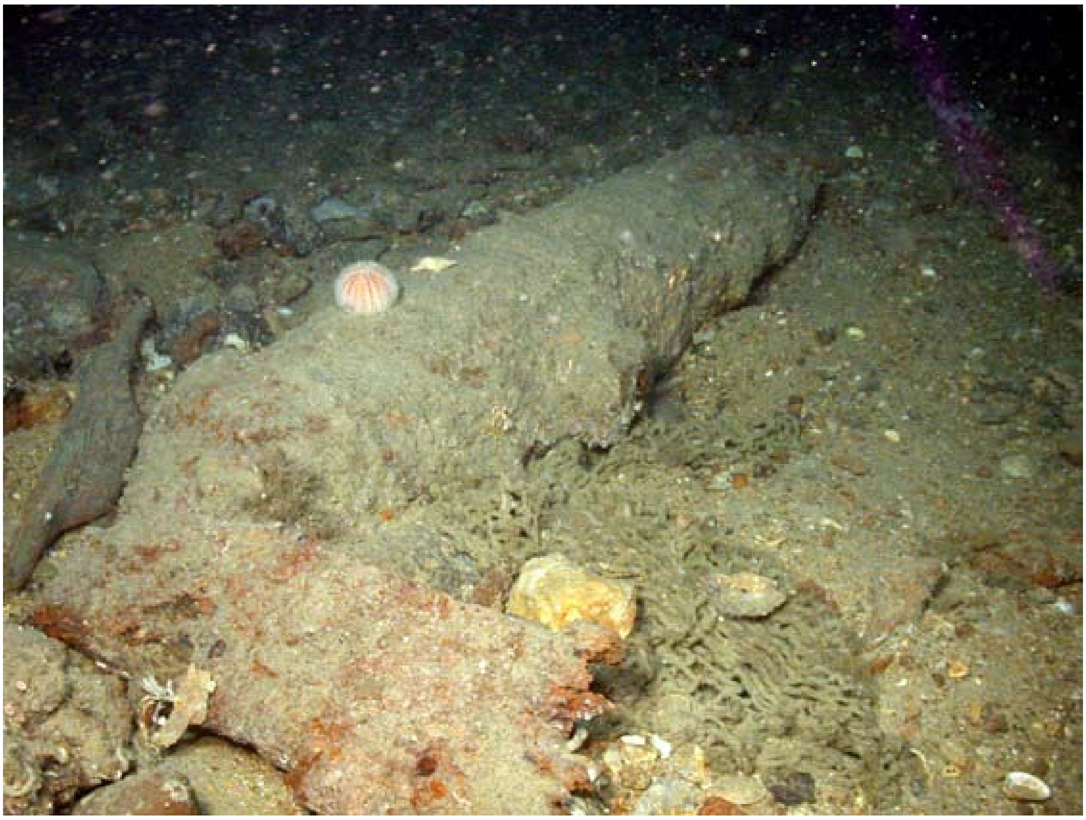


Fig. 10. Fishing net caught on a concreted iron cannon on a 19th-century wooden shipwreck (Site 2T7a64f-2; Target 624). Atlas shipwreck survey zone, depth 108m.

Fig. 11. Fishing net snagged on an iron concretion on a mid to late 19th-century wooden shipwreck (Site 2T11a4a-1; Target 587). Copper hull spikes and heavily deteriorated planking in the foreground. Atlas shipwreck survey zone, depth 96.2m.

netters take turbot, monkfish, cod and pollack, and the larger boats fish offshore for hake. Between late December and the end of March, up to 20 non-local beam trawlers participate in the local sole fishery. Fourteen boats are involved in the pot fishery during the summer, the larger and faster vessels working anything up to 1,000 pots each as far away as Lundy Island. Nearly all the boats bring their pots ashore between late December and March to avoid the worst of the weather and also to prevent damage from the visiting beam-trawl fleet. Most of the shellfish are exported weekly by vivier truck to Europe direct from the quay.

Due to strong tides within the Severn Estuary and the lack of sheltered bays, fishing within south and north Wales is largely restricted to within 9.6km of shore.

C. Quantifying Trawler Disturbance on Marine Ecosystems

Marine ecologists have no illusions about the destructive nature of bottom trawling. In a seminal paper, Watling and Norse (1998) drew an analogy between the effects of mobile fishing gear on the seabed and the clearcutting of a forest on land (Table 1). They identified one major difference, however, in the scale of the relative disturbance. Whereas forest clearcutting is estimated to fell a vast 100,000km^2 of woodlands per year worldwide, the area trawled annually is about 150 times greater. Each year trawling disturbs an area of seabed as large as Brazil, the Congo and India combined and results in local and global impacts on the structure, species composition and biogeochemistry of benthic communities (Watling and Norse, 1998: 1190-92).

All forms of deep-sea fishing from wreck fishing to trawling result in differing impacts on the seabed. Understanding the environmental effects of this industry demonstrates both how undeveloped the management of deep-sea marine archaeology remains in comparison to other areas of marine science and, simultaneously, provides key insights into impacts on the sea bottoms with which shipwrecks interact. These studies have focused on short- and long-term changes to benthic organisms and fish populations. The results of the current archaeological study within the Atlas survey zone now concludes that shipwrecks need to be considered an integral component of the marine environment and managed accordingly.

As sources of rich nutrients and sanctuaries for the shelter and nesting of myriad sea life, shipwrecks are key cogs in the food chain for fish and human consumption needs alike. When trawls or nets snag on shipwrecks, their impact is likely to be more devastating long-term

Impact	Clearcutting	Bottom Trawling
Effects on substratum	Exposes soils to erosion & compress them	Overturns, moves, and buries boulders and cobbles, homogenizes sediments, eliminates existing microtopography, leaves long-lasting grooves
Effects on roots or infauna	Stimulates, then eliminates saprotrophs that decay roots	Crushes & buries some infauna; exposes others, thus stimulating scavenger populations
Effects on emergent biogenic structures & structure formers	Removes or burns snags, down logs, and most structure-forming species above ground	Removes, damages or displaces most structure-forming species above sediment-water interface
Effects on associated species	Eliminates most late-successional species & encourages pioneer species in early years to decades	Eliminates most late-successional species & encourages pioneer species in early years to decades
Effects on biogeochemistry	Releases large pulse of carbon to atmosphere by removing & oxidizing accumulated organic material; eliminates nitrogen fixation by arboreal lichens	Releases large pulse of carbon to water column & atmosphere by removing & oxidizing accumulated organic material; increases oxygen demand
Recovery to original structure	Decades to centuries	Years to centuries
Typical return time	40-200 years	40 days to 10 years
Area covered per year globally	~0.1 million km^2 (net forest & woodland loss)	~14.8 million km^2
Latitudinal range	Subpolar to tropical	Subpolar to tropical
Ownership of areas where it occurs	Private & public	Public
Published scientific studies	Many	Few
Public consciousness	Substantial	Very Little
Legal status	Activity increasingly modified to lessen impacts or not allowed in favor of alternative logging methods & preservation	Activity not allowed in a few areas

Table 1. A comparison of the impacts of forest clearcutting and trawling on the seabed (from Watling and Norse, 1998: 1192, table 4).

on cultural remains than on the seabed or marine life. While biological oases can regenerate over wreckage of any kind, whether scattered or coherent, once wooden hulls and artifacts are dragged, smashed or snapped, their fate and the loss of scientific data is irreversible.

Bottom fishing is one of the most widespread sources of anthropogenic disturbance of seabed communities in the North, Irish and Celtic Seas and within the English Channel (Kaiser *et al.*, 1998: 354). The ecosystem effects of trawling are well known to affect species diversity, community structure and size composition (Kaiser *et al.*, 2002: 116), primarily:

A. Changes in predator-prey relationships leading to shifts in food-web structures that are not necessarily reversed by reduction of fishing pressure.
B. Effects on abundance and body-size distributions that can result in fauna dominated by small body-sized individuals.
C. Genetic selection for different physical characteristics and reproductive traits.
D. Effects on populations of non-target species (cetaceans, birds, reptiles and elasmobranch fishes) as a result of by-catches or ghost fishing.[2]
E. Reduction of habitat complexity.
F. Re-suspension of surficial sediments.
G. Alteration of benthic community structure.

Trawling and dredges physically disturb the upper layer of sea bottom sediments as they pass, flattening the seabed, exposing shell debris at the surface and buried nutrients to the water column (Tables 1-2). Beam trawlers are typically fitted with tickler chains or a chain matrix attached between the beam and foot rope. Chains are designed to exclude rocks from the gear as they penetrate the upper centimeters of substratum to disturb and fluidize the top layers of sediment and drive flatfish from the seabed and into the net (Duplisea *et al.*, 2001: 1). These inevitably

Type of Gear	Gear in Contact with Seabottom	Typical Width of Major Disturbing Parts (m ship^{-1})	Towing Speed (knots)	Penetration Depth (cm)
Beam trawl (flatfish)	Trawl shoes, tickler chains, chain mats			
A). Offshore (>12 miles)		12.0 x 2	6	>6
B). Inshore (<12 miles)		4.0 x 2	5	?
Shrimp beam trawl	Trawl shoes, ground rope with rollers	0.2 x 4	4-5	?
Otter trawl	Otter doors	1.5 x 2	3-4	8
	Ground rope	30	3-4	8-10
Industrial trawl				
A). Single	Otter doors	1.5 x 2	3.5	8-10
	Ground rope	25	3.5	?
B). Pair	Ground rope	25	3.5	?
Demersal pair trawling	Ground rope	40	3	?
Mussel dredge	Blade & belly	1.75 x 4	2	5-25
Cockle dredge	Suction head	1.0 x 2	2	≥5
Scallop dredge	Tooth bar & belly			
A). English		0.76 x 16	3	3-4
B). French		2 x 5	3-4	<10
French clam dredge	Blade & belly	0.7 x 2	3-4	<15

Table 2. Summary of the effects for different fishing gears used in the North Sea (from Hall, 1999: 50, table 3.1).

damage the infauna and epifauna. Estimates suggest that some preferred areas of fishing may be visited up to 400 times a year (Kaiser *et al.*, 1998: 354). A typical beam trawler towing two 12m-wide nets at 6 knots can impact about 535 km^2 of substratum in 2,000 hours in the North Sea (Duplisea *et al.*, 2001: 1, 5).

Shellfish dredges, rock-hopper otter trawls and heavy flatfish beam trawls cause the most extensive disturbance because they are in direct contact with the seabed (Kaiser *et al.*, 2002: 118). The scale of impact is not regular, but is determined by various conditions: the speed of towing, the physical dimensions and weight of the fishing gear, the type of substratum deposits and the strength of currents and tides. Effects on sea bottoms may persist for anywhere between a few hours in shallow waters with strong tides to decades in deeper areas subject to less natural disturbance (Jennings *et al.*, 2000: 4).

The most dynamic change caused by such fishing gear is to the surface topography. Trawler doors increase the sea bottom roughness through furrowing. Flattening results in the removal of unattached weed, seagrass and coral. Trawling over time can be expected to gradually lower the physical relief of the habitat with potentially deadly consequences for some fish species. The impact of the re-suspension of sediments and fragmentation of rock and biogenic substrata causes a release of nutrients held in the sediment, exposure of anoxic layers and the release of contaminants, which increases biological oxygen demand. Sediment community function, carbon mineralization and biogeochemical fluxes are strongly affected by trawling disturbance (Kaiser *et al.*, 2002: 119-20).

Two food sources are generated for benthic scavenging species by towed fishing gear: dead disarticulated material and exposed and damaged fauna. Interestingly, it is common practice for fishermen to re-trawl an area shortly after being fished due to the exposure of nutrients during the first pass, which attracts a frenzy of fish to the freshly 'plowed' area (Hall, 1999: 60). This has obvious destructive repercussions for newly impacted shipwrecks.

Studies reveal that seabottom form is a major influence on seabed disturbance. The longevity of furrows' vertical disturbance and visibility is dependent on sea bottom sediment profiles. Experiments have demonstrated that on a seabed consisting of mainly coarse sand, such as prevails in some parts of the catchment area of the shipwrecks of HMS *Victory* and the *Marquise de Tournay* (Figs. 43-44), a Bordeaux armed privateer lost in 1757 (Williams and Eltis, 2004: 128) and discovered by Odyssey in 2008, beam trawler tracks may only remain visible for up to 52 hours after a vessel has fished over the site. On sediments with mainly finer particles, tracks completely fade after 37 hours (Fonteyne, 2000: 15).

Absence of fishing furrows on side-scan sonar records from the Atlas shipwreck survey zone can thus in no way be considered to represent an absence of extensive fishing activities. Thus, in a well-known trawl area off southern Portugal, currents contribute to rapid furrow erosion: no marks were detectable across 86.1% of the area examined by a manned submersible down to depths of 300m

(Morais *et al.*, 2007: 116). By contrast, scallop dredge tracks can remain visible for up to 2.5 years in maerl habitats (Hall-Spencer and Moore, 2000: 105) and in more compact environments, notably gravels. This may explain the vivid set of scallop dredge furrows graphically registered on side-scan sonars across the center of Odyssey's mid-17th century site with its cargo of elephant tusks, located in a dense shell and gravel environment (Target 580, site T7a35f-5; Figs. 40, 45-47).

Studies indicate that beam trawls will penetrate bottom sediments by depths of 1-8cm, depending on the speed of towing and sedimentological matrix. However, this is highly dependent on seabottom forms. Some tickler chains with an array of 15 chains (weighing around 1.5 tons) only penetrate less than 3cm at speeds of 2.2 knots. Elsewhere, 9.5m-wide beam trawls fitted with 17 tickler chains have disturbed seabeds to depths of 10-20cm. In the case of 12m beam trawls fishing on hard sandy bottoms, tickler chain penetrated to at least 6cm (Fonteyne, 2000: 16-17, 34).

In the northern Irish Sea area of the Isle of Man, gravel sediments are found down to depths of 70m and vary from extremely stony to fine gravel substrata. As with the Western English Channel and Western Approaches, this is an important fishery for great scallops (*Pecten maximus*) and queen scallops (*Aequipecten opercularis*). The annual scallop fishing season lasts from 1 November to 31 May, although queens may be fished all year round. Scallops live in (or are partly buried in) surface sediments and are fished with toothed, Newhaven-type dredges. Toothed dredges scrape through the top 10cm or so of seabed with every pass (Bradshaw *et al.*, 2000: 84).

A single pass of a beam trawl can kill 5-65% of the resident fauna on the seabed for larger invertebrate species, which equates to annual fishing mortality rates of 5-39% in heavily trawled areas (Duplisea *et al.*, 2001: 1). Erect foliose fauna, which build reef-like structures, are destroyed by towed gear (such as tube worms or the corraline algae, maerl). Studies of mortality rates in the Netherlands by beam trawling for flatfish show that while whelk and hermit crabs are largely unaffected, starfish suffer a 10-30% mortality rate and up to 90% of bivalve *Artica islandica* are killed (Hall, 1999: 53).

Other research into invertebrate species (gastropods, starfish, crustaceans and annelids) detected direct mortality due to a single passage of a trawl varying from about 5% to 40% (Bergman, 2000: 49). Trawling can reduce anthozoa (anemones, soft corals, sea ferns) by 68% and asteroid starfishes by 21%. Repeated chronic dredging is predicted to lead to 93% reductions for anthozea, malacostraca (shrimps and prawns), ophiuroidea (brittlestars) and polychaeta (bristle worms). Single acute dredge events can even lead to 76% population reductions (Kaiser *et al.*, 2002: 123).

Scallop dredges cause mortality rates ranging from 8% on sandy substratas to 25% on gravel (Hall, 1999: 53). One-hour dredge tows by commercial boats equipped with queen scallop fishing gear can kill 27.3-57.0 animals per meter hour of dredging, compared to 4.6-8.9 animals per meter per hour for scallop dredges. This is mainly because more closely spaced teeth collect more animals.

The comprehensive study of trawling and dredges has illustrated that bottom fishing can profoundly disturb the seabed and all organisms – natural and biological – overlying and underlying it. Continuous fishing results in prolonged erosion of the sea bottom. Shipwrecks 'ploughed' by the same fishing equipment should be expected to be similarly impacted, dependant on the nature of deposits (durable or delicate).

The few documented examples of trawlers and gill net fishermen disturbing archaeological deposits at sea include the discovery of the *El Cazador* in the Gulf of Mexico in 1993, lost at a depth of 83-92m in 1784 with a cargo of 450,000 *pesos*.[3] In 1934 the trawler *Muroto,* working out of Cardiff, dredged up a 2nd-century AD Roman pot while fishing on the Porcupine Bank 250km off the west coast of Ireland (Cunliffe, 2002). The Studland Bay protected historic wreck site located off Poole harbor, southern England, a lightly armed Spanish merchant vessel of *c.* 1520-30, was found by a local fisherman whose gear snagged on the site (Gutierrez, 2003; Thomsen, 2000: 69).

The Alderney Elizabethan wreck similarly came to light after a fisherman found a long concreted object tangled in the back-line of one of his lobster pots, which proved to be a musket and the site to be a very rare armed English vessel of the 1590s.[4] The torso and arm of a 2nd century BC bronze statue has recently been recovered from a fisherman's net between the islands of Kos and Kalymnos in the Aegean Sea.

In the Mediterranean, 79 different types of amphoras dating between *c.* 1600 BC and the Crusader period, snagged in fishermen's nets from wrecks located in depths of up to 64m between Ashkelon to the south and Achziv to the north, are on display in the National Maritime Museum, Haifa (Zemer, 1977). Similarly, 70 different amphoras of the 7th century BC to 13th century AD have been caught by fishermen off Turkey and are now in the Alanya Museum (Sibella, 2002).

This paucity of officially documented artifacts snagged in fishing nets most likely stems from fishermen's reluctance to report finds, especially where disturbance or destruction of underwater cultural heritage can carry civil or criminal penalties. Reporting these finds officially requires that the locations be declared, which is something that fishermen avoid whenever possible. Traditionally, they tend to be very protective and secretive about their 'hang lists' featuring the locations of shipwrecks, which are often handed down from generation to generation as a treasured asset.

D. Wreck Fishing

The first public reports of deliberate targeting shipwrecks for fishing with nets emerged in the late 1960s. In the UK the largest offshore wreck fishing fleets are mainly situated along the English Channel between Rye and Falmouth due to the huge concentration of wartime wrecks and the variety of fish that migrate into the Channel's waters from the Atlantic and Biscay region. The size or preservation level of an individual wreck is not considered important: huge catches of various species are equally probable on both small and large sites. Smaller wrecks are considered better fishing grounds for ling and conger eel, while some sites with surviving superstructure are preferred for pollack, cod and coalfish (Arnold, 1996: 11).

Shipwrecks are attractive to deep-sea commercial fishermen because of the high volume of fish populations drawn to nutrient-rich shipwrecks as biological oases. Single catches on the *Lusitania* in the 1970s, for instance, today strewn with snagged and tangled fishing nets, are reported at 477kg (Gammon, 1975: 46). Wrecks are also renowned for unusually large fish seeking shelter, typified by the largest cod caught in British waters (23.8kg), which came from a Devon wreck in 1972. Conger eels caught 40km southwest of Plymouth have weighed up to 46 kg. Until wreck fishing was established, catches of large coalfish were a rarity. Since fishing for these species evolved from angling to commercial wreck fishing, the record for an individual example shot up from 10.3kg to 13.5kg (Gammon, 1975: 15, 16, 19, 23). Some species like whiting and dogfish are almost exclusively found on wreck sites.

The most common types of fish caught on shipwrecks (Arnold, 1996: 20-28; Gammon, 1975: 11, 15) are:

- Black bream.
- Brill: like the banks and scours around wrecks to lie in ambush, well camouflaged on the seabed.
- Seabass: the ultimate predator; loves broken up wrecks for ambushing prey.
- Coalfish: now becoming a rarity as commercial pressure from gill netting hits the population in Channel waters very hard.
- Cod: the main reason why wreck fishing took off; huge cod were very common, but are rapidly dwindling.
- Conger eel: one of most popular predators hunted on offshore wrecks. By far the biggest fish caught on wrecks.
- Ling: the scavenger of wrecks, a powerful eel-like fish. Abundant on deep wrecks from Rye to Falmouth. Grow to extremely large sizes very quickly. Most ling on Channel wrecks weigh an average of 11kg, but exceptional fish over 13.5kg are frequently caught. Extremes of 26.5kg have been landed.
- Pollack: examples in excess of 22.5kg have been taken in gill nets.
- Red sea bream.
- Sharks: use wrecks as a ready-made larder, mostly 48-72km offshore in the Channel during June to September. Lurk in the lee of wrecks.
- Turbot: a flatfish, normally in excess of 9kg when taken on a wreck. Lie on banks around wrecks, especially within large scours made by the tide run.

As fish yields diminish both in the open seas and over shipwrecks in the English Channel, new pressures are being exerted on lost ships. Even in 1996, when Stuart Arnold published *The Art of Wreck Fishing*, wrecks originally visited for deep-sea fishing in the 1960s only held an estimated 5% of the volume of fish harvested in former years. Inshore wrecks located 19-22km from land at depths of up to 40m had been so heavily exploited that "There are very few inshore wrecks that are unknown, and have not been hammered over the years…" (Arnold, 1996: 12).

Consequently, offshore wrecks provide the main area of operation for serious deep-water wreck fishing, with a wider choice of not only numbers of wrecks but also more fish to concentrate on. The optimum time to fish the Channel wrecks has traditionally been between January and October in the Western Approaches, when the gulf stream warms the water, and from March to December in the eastern end of the Channel. Ongoing sea temperature rises, possibly linked to global warming, are changing this traditional timetable.

The locations of many deep-sea shipwrecks are known from UKHO records or can be accessed from the French handbook *Repertoire des Croches et Epaves*. However, as abundant tangled nets of durable synthetic fibers choke sites and make them inaccessible to fishermen without the further risk of losing expensive gear, undiscovered wrecks are being actively sought.

Fishing gill nets can become lost or abandoned for a number of reasons, including the severing of the anchor or surface marker lines by underwater snags during retrieval and conflicts with towed fishing gear. Experiments with gill nets on 11 shipwrecks located along a 100km stretch of coastline in northeast Scotland (Sunderland to Farne Isles) documented that over a two-year period most of the nets remained stretched out throughout the duration of the study, even though their capacity for active fishing was zero due to degradation (broken mesh and bundling) (Revill and Dunlin, 2003).

Although the study concluded that lost nets are an insignificant source of unaccounted fishing mortality, the impact of deep-sea gill net fishing on the archaeological integrity of historical wooden shipwreck is an entirely different matter, with the potential to result in:

A. The decontextualization, inadvertent recovery, loss and probable destruction of artifacts.
B. Snagging and breaking of hull structure, leaving it susceptible to relocation off-site by bottom currents.
C. Dragging of artifacts out of context and off site, leaving them susceptible to loss by current motion.
D. Threats to undiscovered wrecks, actively sought out as former sites become impractical for fishing due to over-exploitation and dense net cover.

3. Fishing Impacts & HMS *Victory* (Site MUN-T1M25c-1)

The shipwreck of HMS *Victory* is one of the three most archaeologically significant sites recorded by Odyssey during the Atlas survey. (The second is a *c.* mid-17th century merchant vessel with a cargo of ivory tusks, iron cannon and manilla bracelet currency; Figs. 45-47. The third is the armed French privateer *Marquise de Tournay*, captured by the British and lost in 1757; Figs. 43-44.) *Victory* was lost at a depth of around 100m some 100km west of the Casquets (Cunningham Dobson and Kingsley, 2009). The visible wreck site covers an area of 61 x 22m and is characterized by loose scatters of eroded small finds (galley hearth brick, crushed copper vessels), rigging and disarticulated planking scattered between 41 bronze cannon.

Human skeletal material and a skull were discovered below sediments, concentrated adjacent to cannon C10, while further possible remains were identified on the site's surface in association with cannon C22 and C39 (Cunningham Dobson and Tolson, 2009). Modern contamination in the form of discarded rubbish is common and includes plastic (Figs. 28, 29), a plastic video cassette tape (Fig. 30), glass bottles (Figs. 19, 27), canvas sheet and a man's black-spotted pink tie (Fig. 19). Although seemingly cosmetic in nature, these finds indicate that *Victory* is far from undisturbed by human impact. For many years bottom currents have and continue to mix such rubbish into the archaeological matrix of the wreckage and to disturb *in situ* remains, adversely affecting the site's coherence.

HMS *Victory* foundered in the Western English Channel, where a fairly smooth sea bottom with a gentle gradient slopes toward the west-southwest into the Western Approaches. In the area of site 25C, coarse sands (0.25-1.0mm diameter) form into large sandwaves intercut by mobile sand ripples (Hillis *et al.*, 1990: 79, fig. 49), from which fresh wreckage is covered, exposed and scoured on an ongoing basis. Beneath the sediment coverage of varying depth is intermittently exposed a sea bottom composed of dense, well-sorted shell fragments and angular flint nodules.

As the sea deepened during the last Holocene transgression (about 10,000 to 7,000 BP), bottom currents deposited a thin and discontinuous veneer of gravelly sand and sandy gravel (generally less than 0.5m thick) over solid formations and channel-fill sediments in the Western Channel. This lag deposit is generally too coarse to be moved by currents (Grochowski *et al.*, 1993: 684). The seabed substrata matrix is dominated by Cretaceous chert flint resulting from seabed or cliff erosion during the transgression and by further cliff erosion during the Holocene adding to the deposit nearshore or fluvial transport during Pleistocene regressions (Hamblin *et al.*, 1992: 82).

Offshore fishing activities are particularly high in the vicinity of the wreck of HMS *Victory* (Table 3). The 4,725 square nautical mile Atlas shipwreck survey covers 34 ICES sub-squares, each measuring about 76.4 x 55.5km. The site is located within a sub-square that contains the highest volume of deep-sea fishing traffic detected anywhere in the survey zone by VMS satellite sightings procured every two hours by the UK Marine and Fisheries Agency between 2000 and 2008: 147,460 sightings, 17.6% of the total. Activities are dominated by beam trawlers (66.85%), scallop dredges (10.93%) and lobster/crab potters (7.4%).

The second highest ratios of fishing within the Atlas survey zone are located in two adjacent sub-squares, accounting for 12.6% and 11% of all fishing activities. These data suggest that 41.2% of all fishing activities are focused in three adjacent sub-squares of the survey region. The wreck of HMS *Victory* lies at the epicenter of this activity. The current analysis is based on total fishing traffic and does not distinguish between steaming and vessels actively fishing. The sample can thus only be considered a generalized indication of net/dredge towing and setting scales within the zones discussed. The filtering of VMS data to focus on fishing hotspots is ongoing.

Twelve separate examples of trawler/wreck fishing impacts have been verified visually on the surface of HMS *Victory*:

1. A series of four distinct sets of fresh beam trawler furrows between 500m and 1000m east-northeast of the wreck site (Figs. 15-16).
2. VMS satellite evidence for the sub-square in which HMS *Victory* lies, covering the period 2000-2008, displays widespread evidence of intensive fishing operations in this area and in the catchment zone

Vessel Type	Number	% of Total
Beam Trawler	98,580	66.85%
Demersal Side Trawler	190	0.13%
Demersal Stern Trawler	5	0%
Freezer Trawler	420	0.28%
Gill Netter	482	0.33%
Lobster/Crab Potter	10,906	7.4%
Long Liner	114	0.08%
Pair Trawler	2,894	1.96%
Pelagic Stern Trawler	2	0%
Scallop Dredger	16,117	10.93%
Trawler (General)	1,569	1.06%
Unknown	16,051	10.88%

Table 3. Various fishing forms practiced in the ICES sub-square in which site 25C (HMS Victory*) is located, based on VMS satellite data 2000-2008.*

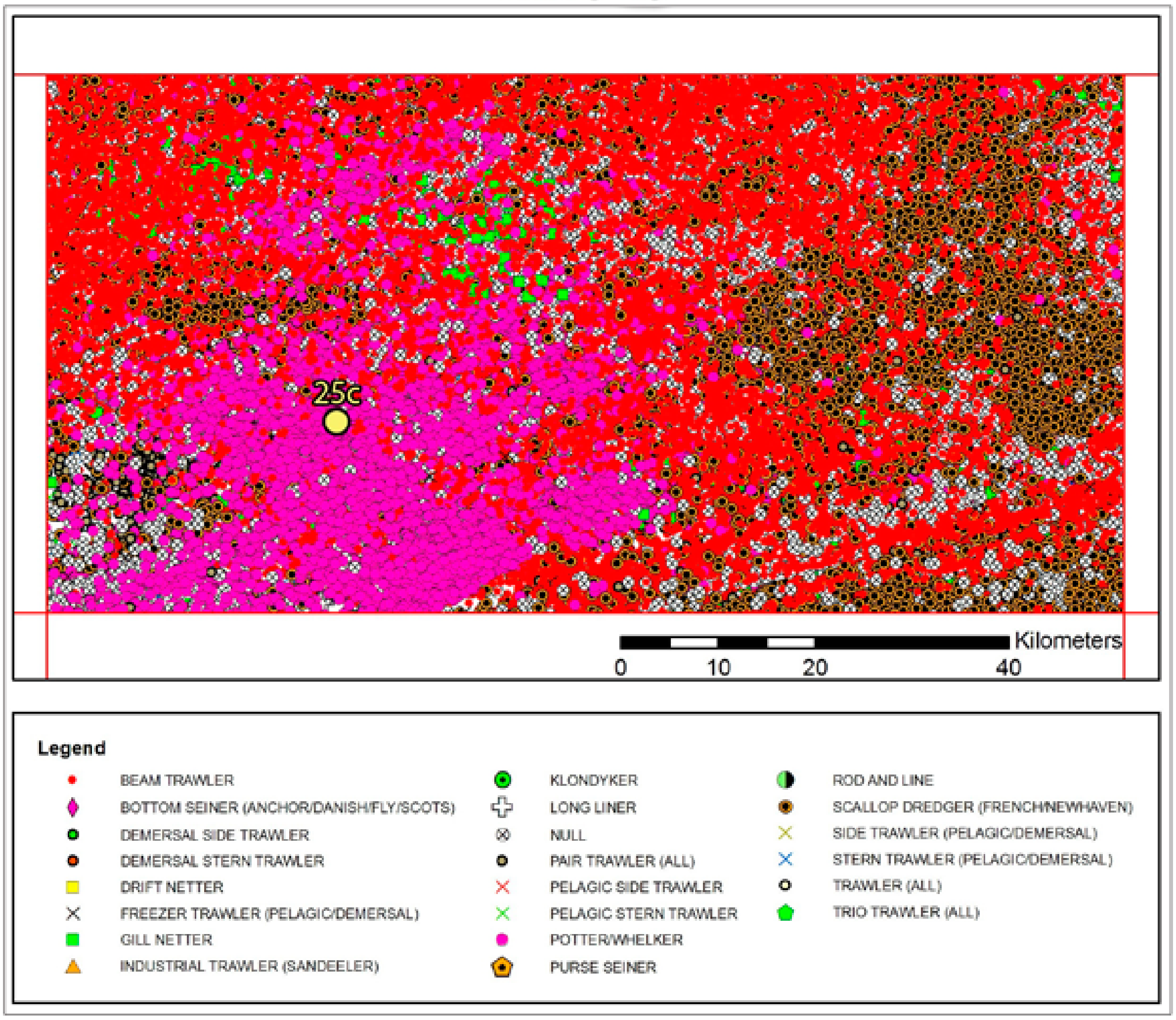


Fig. 12. The wreck of HMS Victory *(site 25C) in relation to VMS satellite sightings of fishing vessels (2000-2008) within its specific ICES sub-square, Atlas shipwreck survey zone.*

of the wreck site (Table 3, Fig. 12). Some 72 fishing vessels have been documented within 1km of site 25C in the same timeframe (65% lobster/crab potters, 29% beam trawlers, 3% scallop dredgers). Statistically, these sightings only represent a very small fraction of the actual fishing activity occurring in and across the wreck site of HMS *Victory*. Average-sized scallop dredges operate at 2.5-3 knots (4.63-5.5km per hour) in the Western English Channel (Dare *et al*., 1994: 5), while beam trawlers tow at speeds of 4-6 knots (7.4-11.1km per hour) (Duplisea *et al*., 2001: 1; Fonteyne, 2000: 15). This indicates that positions of VMS records are only potentially accurate to within a maximum geographical area of 11km for dredges and 22.2km for beam trawlers, which are the distances that either form of fishing craft could steam away from a direct shipwreck hit in the two-hour window between satellite detection. Deep-sea trawling has also been active in the study region since at least 1960, far longer than the 2000-2008 sample data available from satellite surveillance.

3. Fishing net mesh snagged between iron concretions towards the southwest flank of the wreck (Fig. 17).
4. Plastic rubbish and fishing cable snagged around the end of a bronze cannon (Fig. 18).
5. Fishing cable snagged on a rectangular iron ballast block towards the southwest of the site (Fig. 19).
6. Thick fishing rope cable snagged on a stone boulder alongside dragged hull remains to the southeast of the wreck (Figs. 21-22).
7. A possible shoe from one end of a beam trawl snagged on a boulder at the southeast of the wreck (Fig. 20).
8. Rope cable snagged between cannon C7 and C8 (Fig. 23).
9. Modern canvas and fishing cable snagged on a deposit of brick, copper and wood on site 25C (Fig. 31).
10. Bronze cannon dragged off-site by trawlers, including C38, C33 and C32, which has been displaced 55m southwest of the wreck (Fig. 14). The marine growth on C32 is notably visible on the underside of the cannon, while the upper side is entirely devoid of any biological material. This indicates that this 4-ton, 42-pounder cannon has been flipped upside down during its recent displacement: until very recently the clean upper side had clearly been embedded long-term in an anaerobic environment, which prevented the growth of marine concretions (Figs. 25-26). The surfaces of all other cannon on the wreck exposed to the water column bear marine growth.
11. A parlor lobster/crab trap on the northeast flank of the wreck (Fig. 24).
12. Scratched parallel scars along both recovered cannon C33 (42-pounder, King George I, 1726) and C28 (12-pounder, King George II, 1734) caused by trawl cable and net friction (Figs. 32-34). These marks are located all along each cannon. Georgian damage, evident as deep gouges along the muzzle of 12 pounder gun C28 and as markings located beneath concretion or the patina of marine growth, are easily distinguished from modern impacts. Trawl scratches visible on cannon C28 includes evidence along the cascable (Fig. 32). Evidence on C33 includes scratches at the foot of one dolphin, right of the royal arms crown and down the middle and lower sides (Figs. 33-34).

4. The Atlas Shipwreck Survey Project: Fishing Impact Overview

The deep-sea fishing impacts evident in the area of HMS *Victory* are far from an isolated case. Between May 2005 and October 2008 Odyssey Marine Exploration's Atlas shipwreck survey visually documented 147 anomalies displaying evidence of mild to extreme trawling/dredging and wreck fishing impacts, ranging from steel wrecks (70; 47%) to wooden wrecks (25; 17%), submarines (7; 5%), geological outcrops (13; 9%), isolated fishing gear on the seabed (19; 13%) and snagged ships' anchors (3; 2%) (Figs. 1-3). This excludes data obtained from side-scan sonar. The wreck sites range from depths of 40-190m, with the majority (58%) concentrated between 90m and 120m.

The character of the fishing industry's impact varies widely. Most conspicuous are extensive sections of commercial gill nets draped across standing steel ships' structures and torn sections of gill and trawl net snagged on wooden wrecks and cannon. Snagged nets have been recorded on 108 wreck sites, from the mid-17th century merchant vessel carrying a cargo of ivory (Figs. 45-47) to World War II submarines (Fig. 7) and steel ships (Figs. 4-6).

This phenomenon results largely from offshore wreck fishing. The scale of the industry has left many sites so densely covered with nets that they have become dangerous to fish without the risk of losing equipment. The over-exploitation of resources on known wrecks has also stripped these biological oases of fish stock in the short-term life cycle, forcing fishermen to seek out virgin wreck sites.

Rock hopper gear identified on 17 wrecks in the Atlas survey zone signifies the omnipresence of a different form of fishing, trawling, denoting the accidental snag-

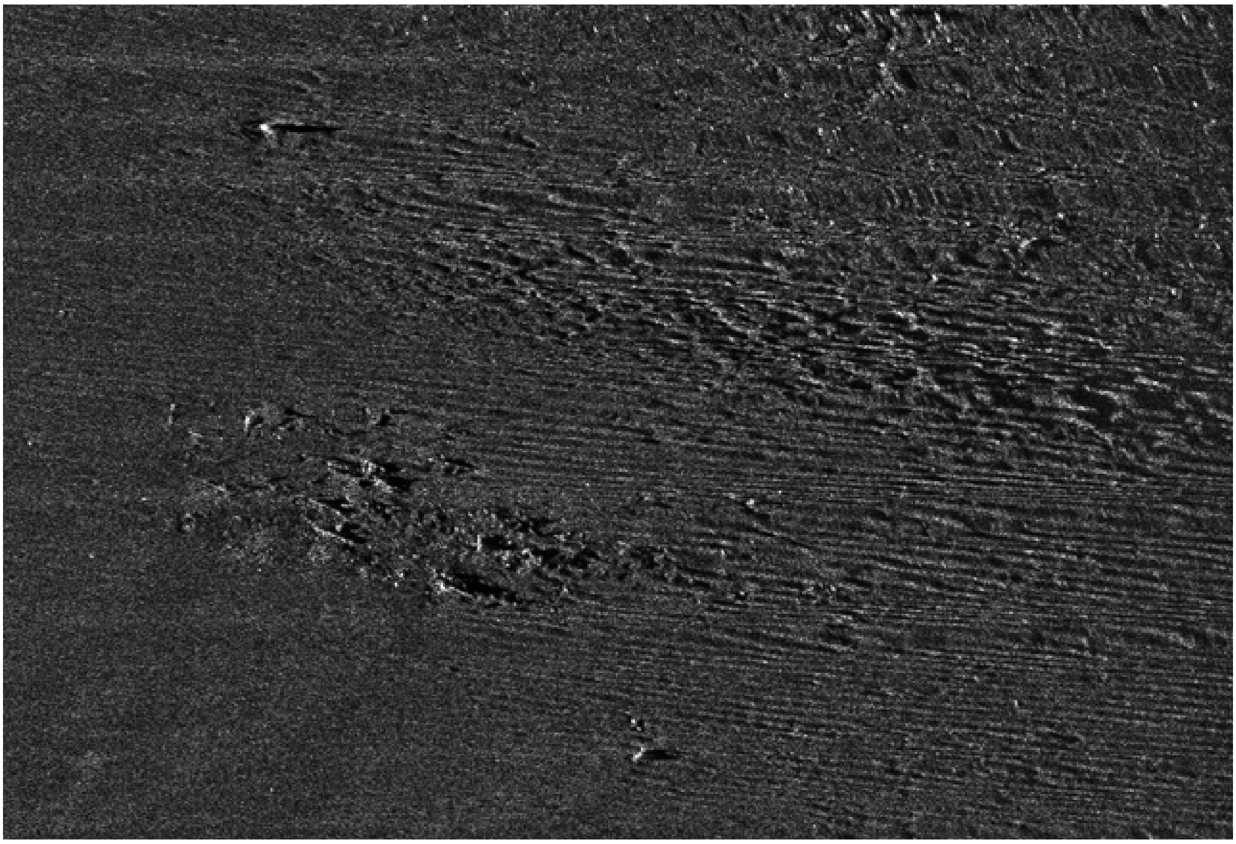


Fig. 13. Side-scan image of shipwreck 25C, with apparent parallel-sided sand ripples running across the site.

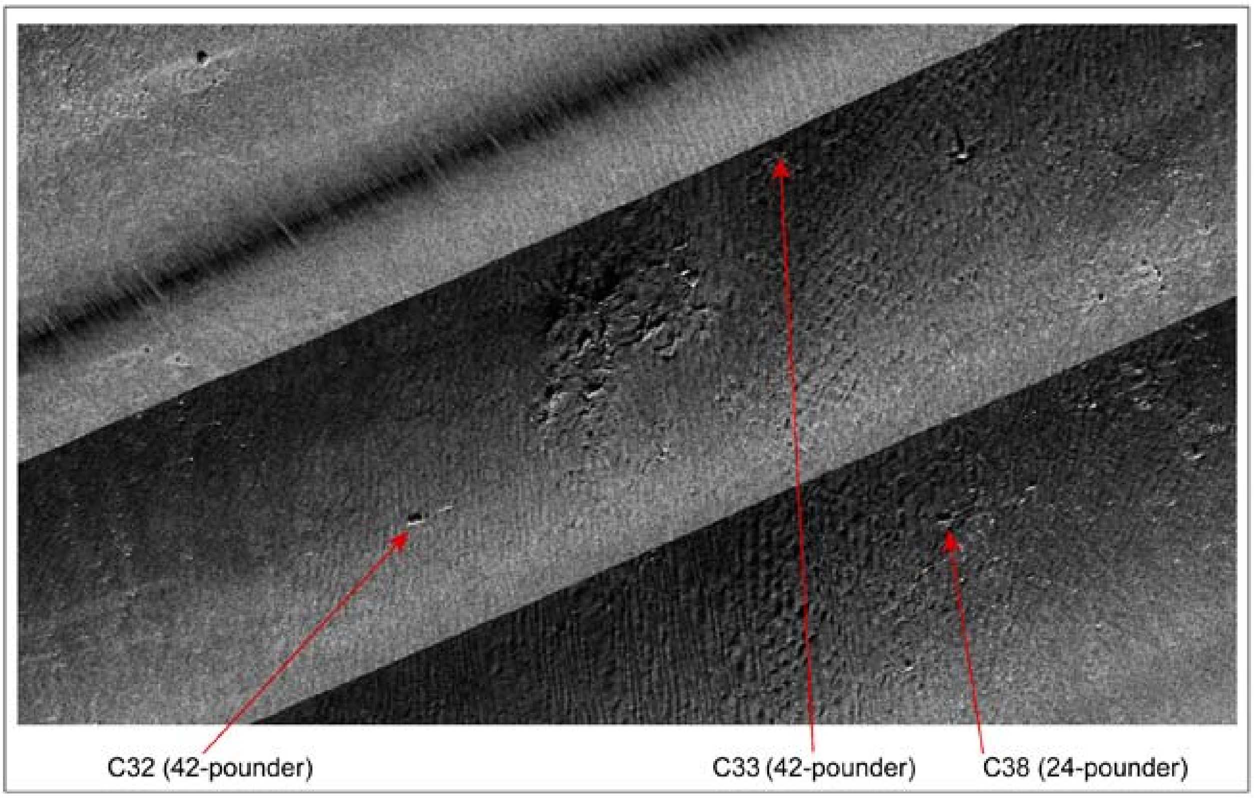
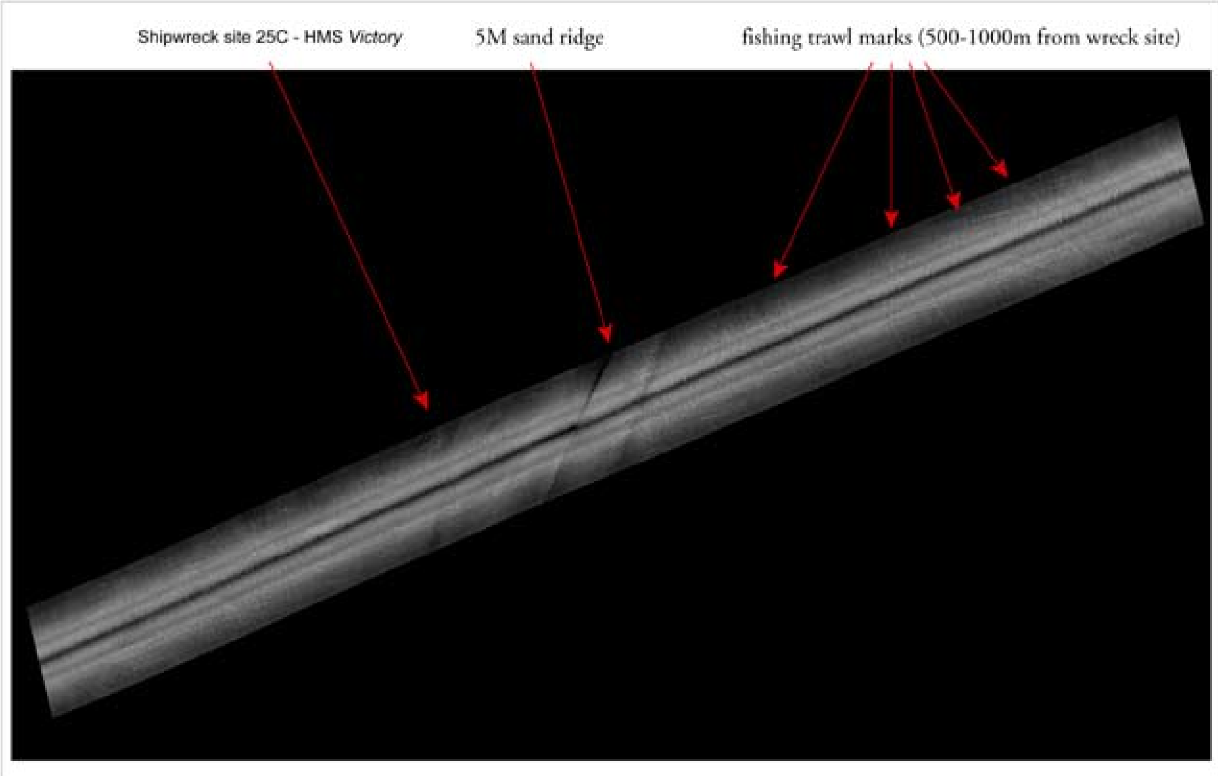
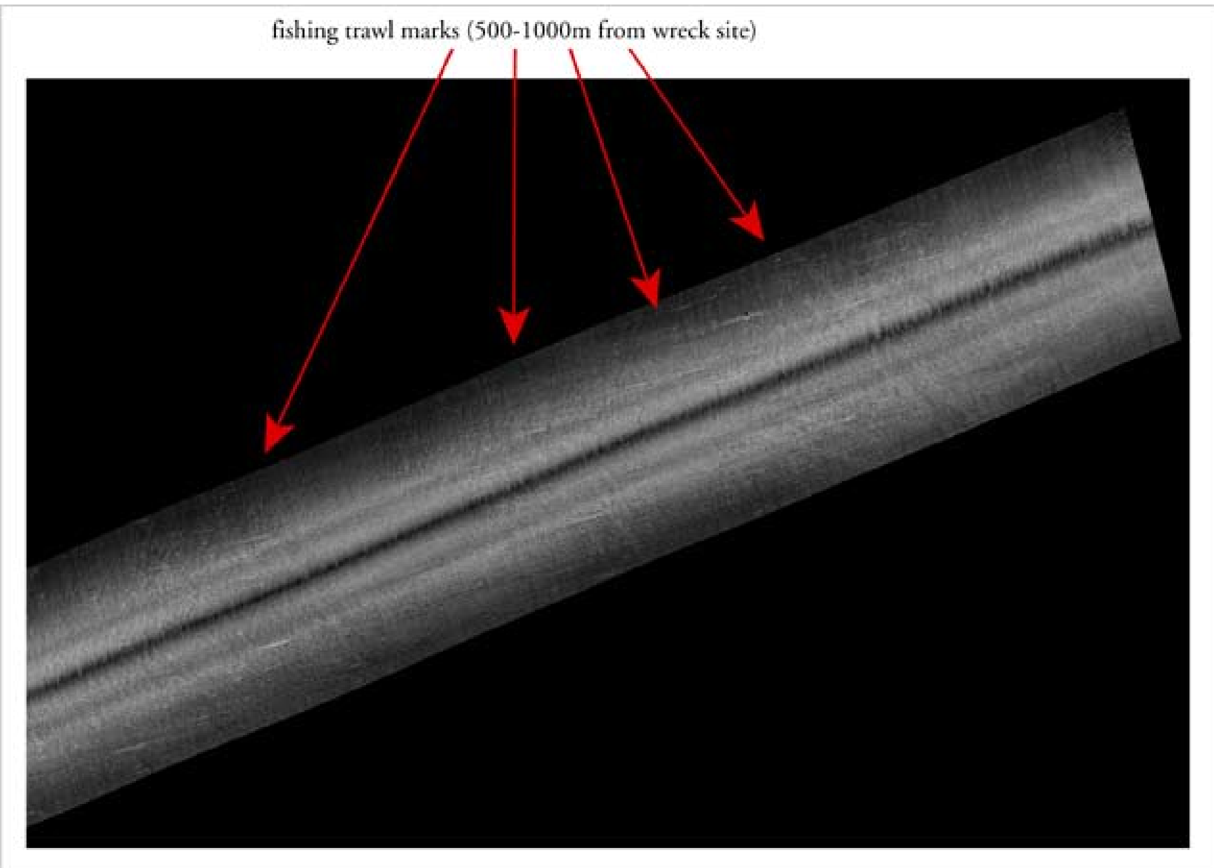


Fig. 14. Side-scan image of site 25C (February 2009) showing the locations of bronze cannon dragged off site by trawler impacts, identified by visual ROV inspections.





Figs. 15-16. Beam trawler furrows in direct proximity to site 25C, evident on side-scan imagery.

Fig. 17. Green fishing net snagged on wreckage on site 25C.

Fig. 18. Partly buried trawler cable on site 25C.

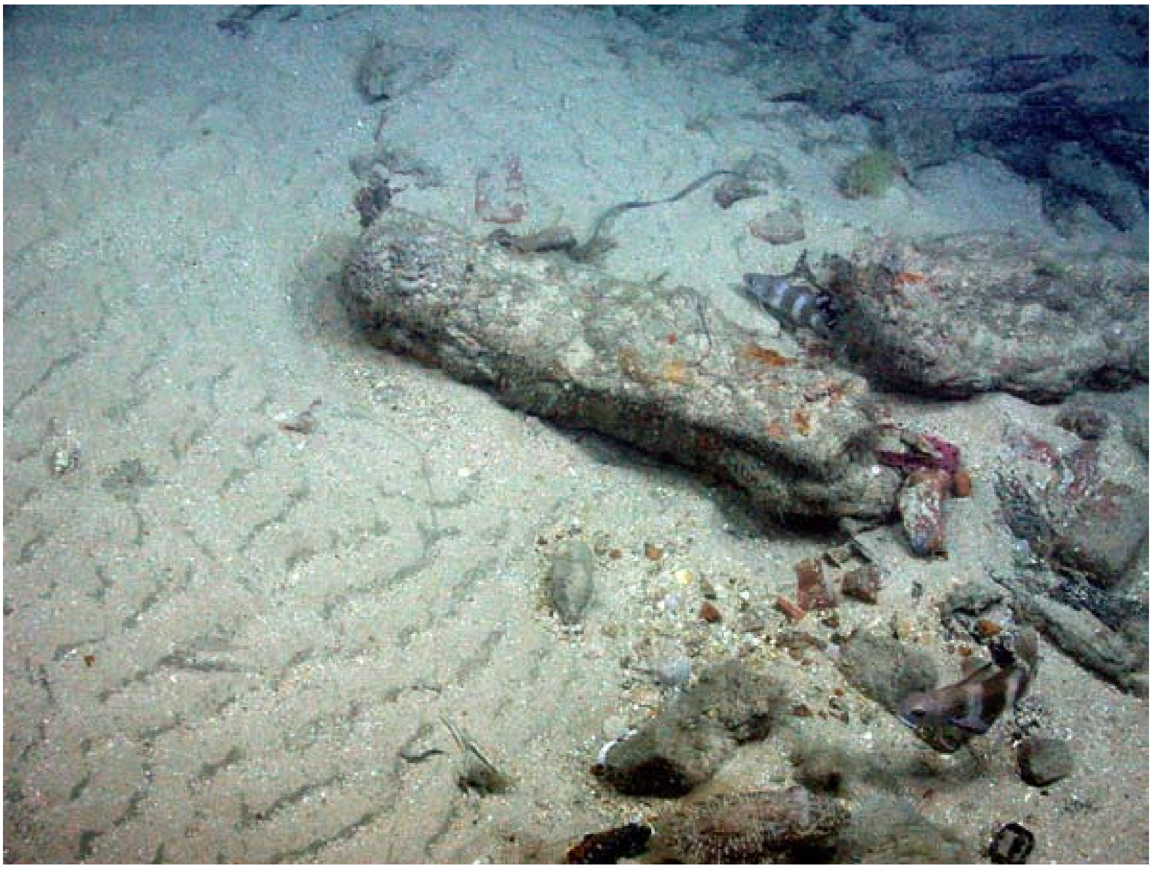


Fig. 19. Snagged fishing net rope, a pink tie and glass milk bottle (in the foreground) on site 25C.

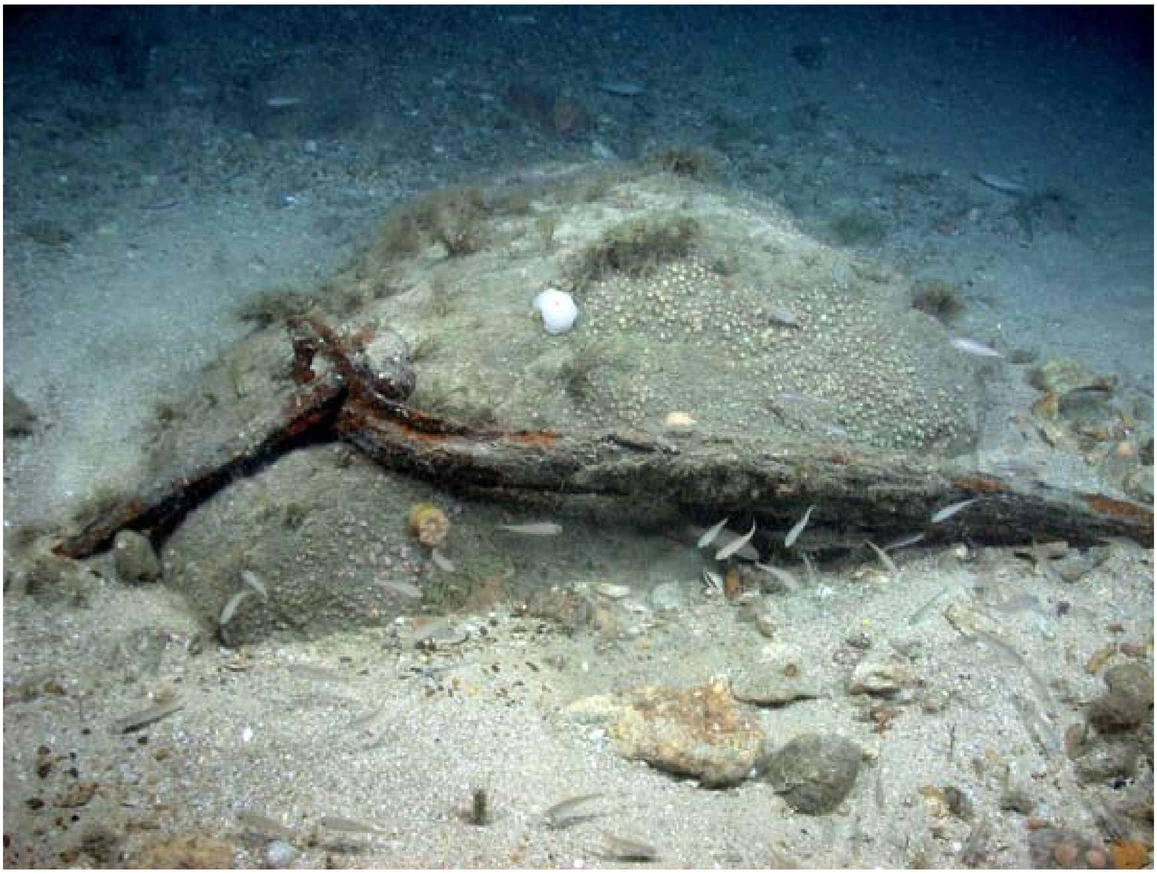


Fig. 20. A possible shoe from one end of a beam trawl snagged on a stone boulder on site 25C.

Figs. 21-22. Fishing cable snagged on a stone boulder on site 25C, with dragged hull remains alongside.

Fig. 23. Fishing cable snagged between cannon C7 and C8 on site 25C.

Fig. 24. A lobster/crab pot on site 25C, evidence of wreck fishing.

Figs. 25-26. The 4-ton 42-pounder bronze cannon C32 with marine growth on the underside, dragged 55m off site and flipped upside down by a trawler or scallop dredge.

Fig. 27. A modern beer bottle under the trunnion of cannon C13 on site 25C and probable trawler scratches along the reinforce.

Fig. 28. Plastic rubbish and sacking in the foreground on site 25C.

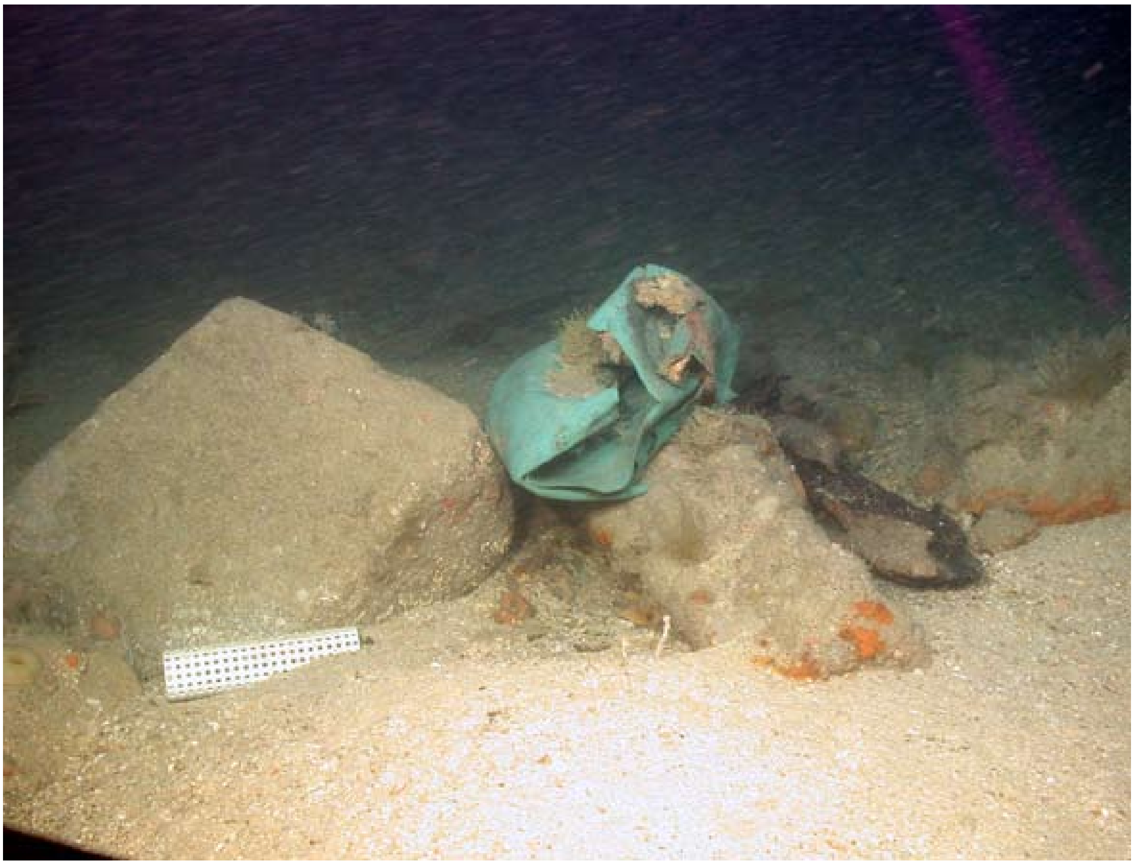


Fig. 29. Plastic rubbish on the southern flank of site 25C.

Fig. 30. A plastic video tape cassette on site 25C with iron ballast blocks in the background.

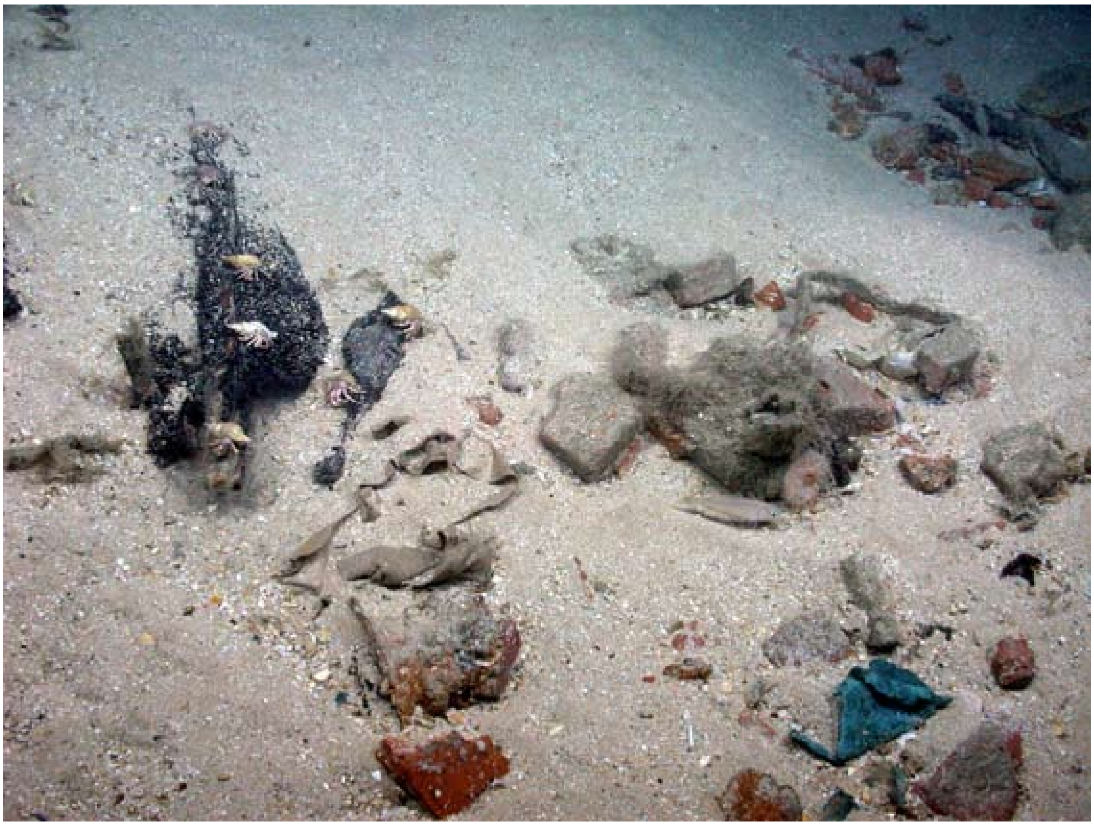


Fig. 31. Modern canvas (left) and fishing cable (right), snagged on a deposit of brick, copper and wood on site 25C.

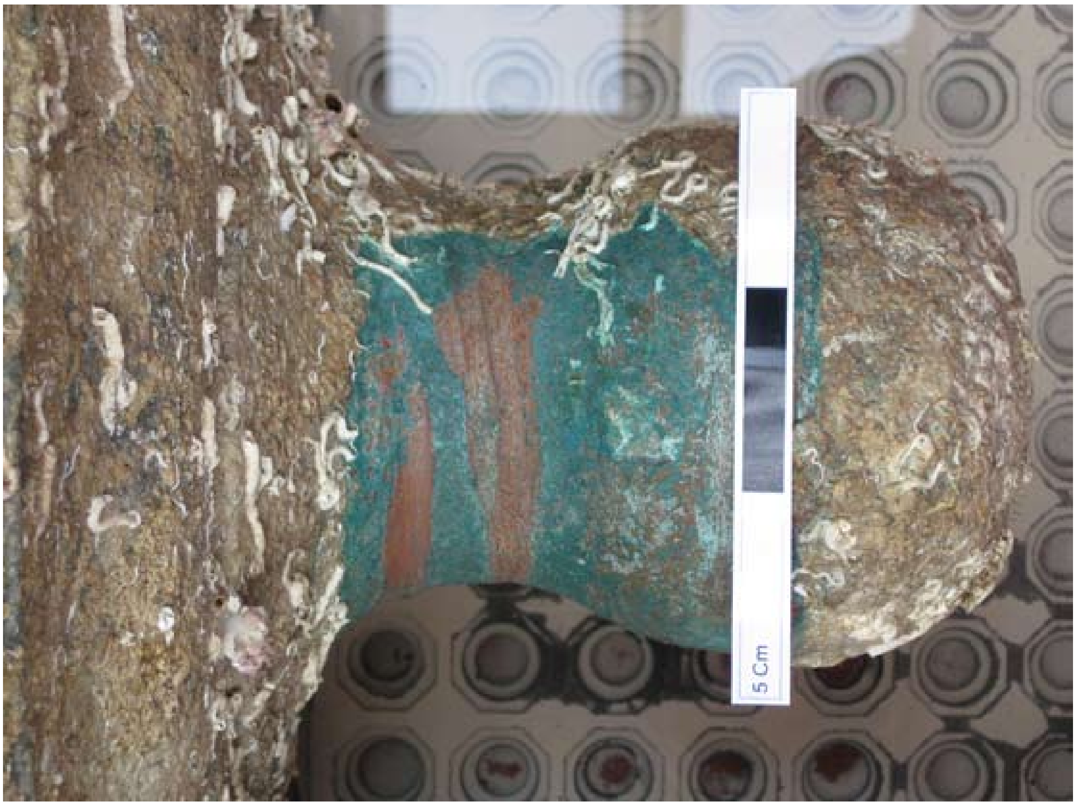


Fig. 32. Fishing net cable friction damage on the cascable of 12-pounder cannon C28 from the wreck of HMS Victory *(site 25C). The impact has broken off concretion and exposed a patch of the original bronze surface.*

Fig. 33. Diagonal fishing cable scratches beneath the crown of the royal arms from bronze 42-pounder cannon C33, recovered from the wreck of HMS Victory *(site 25C).*

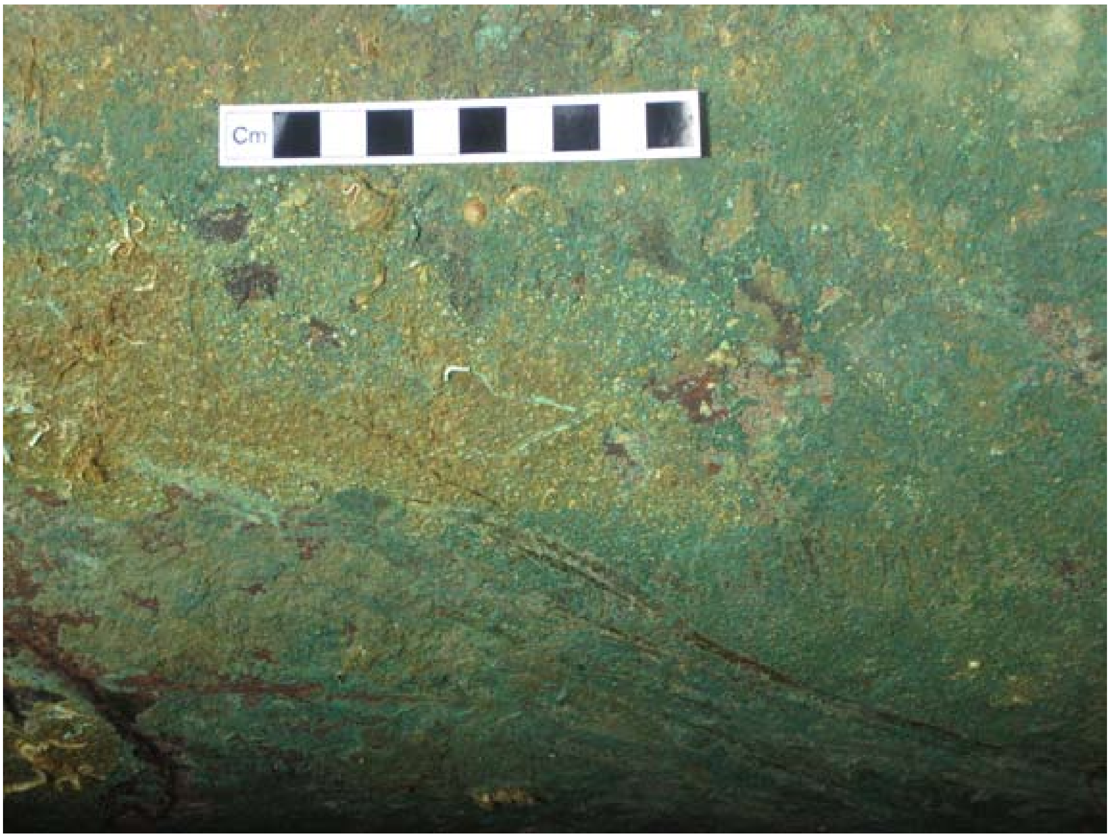


Fig. 34. Diagonal and horizontal fishing cable scratches on the underside of bronze 42-pounder cannon C33, recovered from the wreck of HMS Victory *(site 25C).*

ging and loss of expensive gear on wreck obstacles. While relatively unproblematic culturally on modern steel vessels, the speed and power exerted by all trawlers (and dredges) is extremely detrimental to delicate wooden wreckage and cultural assemblages. The passage of a beam trawler, for instance, will dislocate articulated and interconnected hull remains and smash and drag – possibly for kilometers – anything *in situ* on the seabed. The relocation 55m offsite and flipping upside-down of a 4-ton bronze cannon on the wreck of HMS *Victory* exemplifies the severe impact of fishing gear. If this is the end-result for such a durable and heavy artifact, little imagination is required to acknowledge the high risk to hulls, small finds and human remains.

As a second example of the threat posed by trawlers, site 2T11w24b-1 (Target 581), is a mid to late 19th century wooden wreck lying at a depth of 124.0m on a shell-rich coarse sand matrix intermixed with scallop shells across a banked seabed. A cargo of white ironstone pottery bowls and plates, some with blue feathering on the rim, lies still partly stacked on its side, having fallen over, on top of a sand ripple. The upper edges have been 'shaved' by a passing trawler/dredge, with vessels partly smashed and dragged out of context. Pottery is scattered across the site alongside an orange rock hopper from the bottom of a trawl net (Figs. 36-37).

This cargo seems to have been relatively recently exposed from beneath its protective sand blanket, but demonstrates the damage to which older ceramic or other delicate cargoes are susceptible. Whether caused by beam trawlers or more destructively by dredges, this process may explain why virtually no pottery other than large bricks is encountered on the surface of any wooden wreck in the survey zone. The interplay of bottom currents on the scattering of pots smashed into sherds in this process remains to be modeled, but is considered to be a core effect of dispersal.

With teeth digging into sea bottoms to extract scallops, dredges are especially destructive to wreck sites. A dredge head snagged and lost on the mid -20th century steel wreck TRI-13a-19Wg-1 (Target 717) at a depth of 72.6m demonstrates the functionality of this form of fishing gear (Fig. 38), designed to literally plough the seabed to extract scallop shells.

Trawler/dredge furrows are common across the Atlas survey zone (Fig. 39). Scallop dredge furrows have been recorded on five side-scan sonar records taken above mid-17th to 19th-century wooden wrecks, and a set of beam trawl furrows was identified adjacent to HMS *Victory* in February 2009. The extensive impacts on site T7a35f-5 (Fig. 40) are manifested on side-scan sonar as parallel-sided furrows produced by a scallop fishing vessel towing 18 dredges per side (pers. comm. Michel Kaiser, May 2009), as well as scratched scars on iron cannon and ballast stones as well as net and cable on-site.

Lobster/crab pots have been identified on four wreck sites within the Atlas survey zone, including HMS *Victory* (Fig. 24). Such pots are strung out across the seabed in lines of up to 100 traps. When being pulled in from the surface of wooden wrecks they may snag on and snap hull remains or drag artifacts out of context, leaving them susceptible to being dislocated by bottom currents, scoured and destroyed.

Other distinct signs of fishing activities recorded on the Atlas shipwreck sites include a trawler beam bar (1 site), trawl floats (6 sites), gill floats (33 sites), foot rope (13 sites), trawl rope (8 sites), trawl door (1 site) and steel cable (4 sites), including T7a35f-5, where a length has been caught beneath iron cannon in direct proximity to elephant tusks (Fig. 47). The broken ends of several otherwise intact tusks may be due to snagging.

5. Atlas Shipwrecks: Deep-Sea Fishing Quantification

A total of 838,048 fishing vessels were sighted by VMS (Vessel Monitoring Systems) satellite reconnaissance within the offshore Atlas survey zone between 2000 and 2008. Bearing in mind that the data currently remain unfiltered for steaming versus active fishing actions, this enormous sample currently provides a solid reflection of what types of fishing vessels operate in this part of the English Channel.

Deep-sea fishing is dominated by trawlers, which comprise 58.4% of all activities (490,663 sightings). Of these, beam trawlers are definitively the most active (440,731 sightings; 52.6%), with stern trawlers (27,112 sightings; 3.2%), pair trawlers (10,454; 1.2%), freezer trawlers (4,875 sightings; 0.6%) and side trawlers (5,289 sightings; 0.5%) far less numerous (Figs. 41-42).

Scallop dredges account for a high 15.8% (132,126 sightings) of all activities and gill netters (which focus on wreck fishing) for 7.3% (60,892 sightings). Lobster/crab potters comprise 3.9% of all fishing activities and long liners 2.5% (33,122 sightings). The function of 11.6% of all fishing vessels is undocumented.

VMS observations only monitor the movements of UK boats. An analysis of relative numbers and percentages of fishing activities conducted by different nationalities thus has to rely on the smaller sample of aerial sightings. An examination of fishing vessels operating within the Atlas shipwrecks survey zone identified 73,385 sightings between 1985 and 2008. Of 18 nationalities recognized, the majority of vessels are French (45.5%) and from the United Kingdom (40.5%). Spain represents 9% of activities and Belgium, Denmark, Ireland and the Netherlands 1% each. More obscure vessel registers include Estonia, the Faroes, Lithuania and Russia.

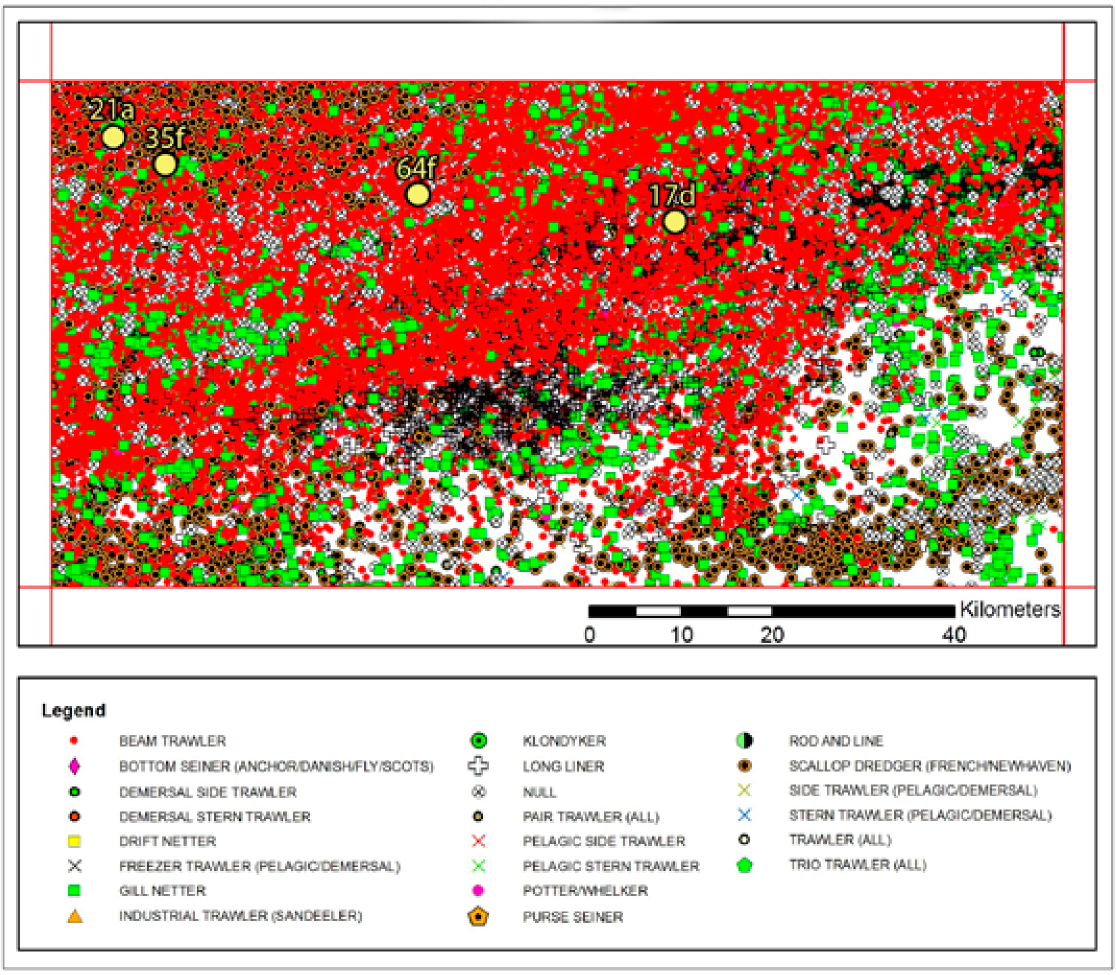


Fig. 35. Distribution of four of the ten most archaeologically significant shipwrecks, including wreck site 35F with its ivory cargo, in relation to total VMS satellite sightings of fishing vessels operating in the Atlas shipwreck survey zone (2000-2008).

Fig. 36. A ceramic cargo fallen on one side on a mid to late 19th-century wooden shipwreck (Site 2T11w24b-1; Target 581). The top edges of the plates have been 'shaved' by a trawler/dredge. Atlas shipwreck survey zone, depth 124.0m.

Fig. 37. Parts of the ceramic cargo on site 2T11w24b-1 dragged and smashed by a trawler/dredge.

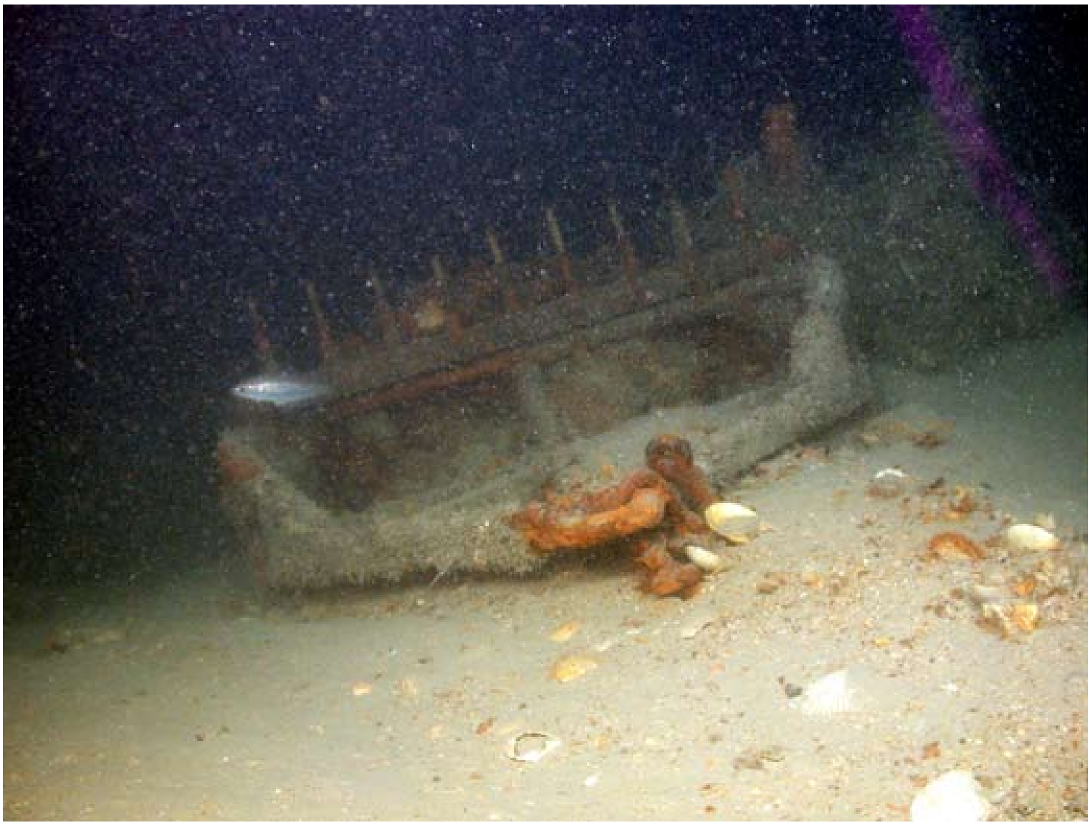


Fig. 38. A scallop dredge beam bar snagged on an early to mid-20th century steel wreck (Site TRI-13a-19Wg-1; Target 717). This type of fishing gear 'ploughs' the seabed to extract scallop shells and is highly detrimental to wooden hulls and other archaeological remains. Atlas shipwreck survey zone, depth 72.6m.

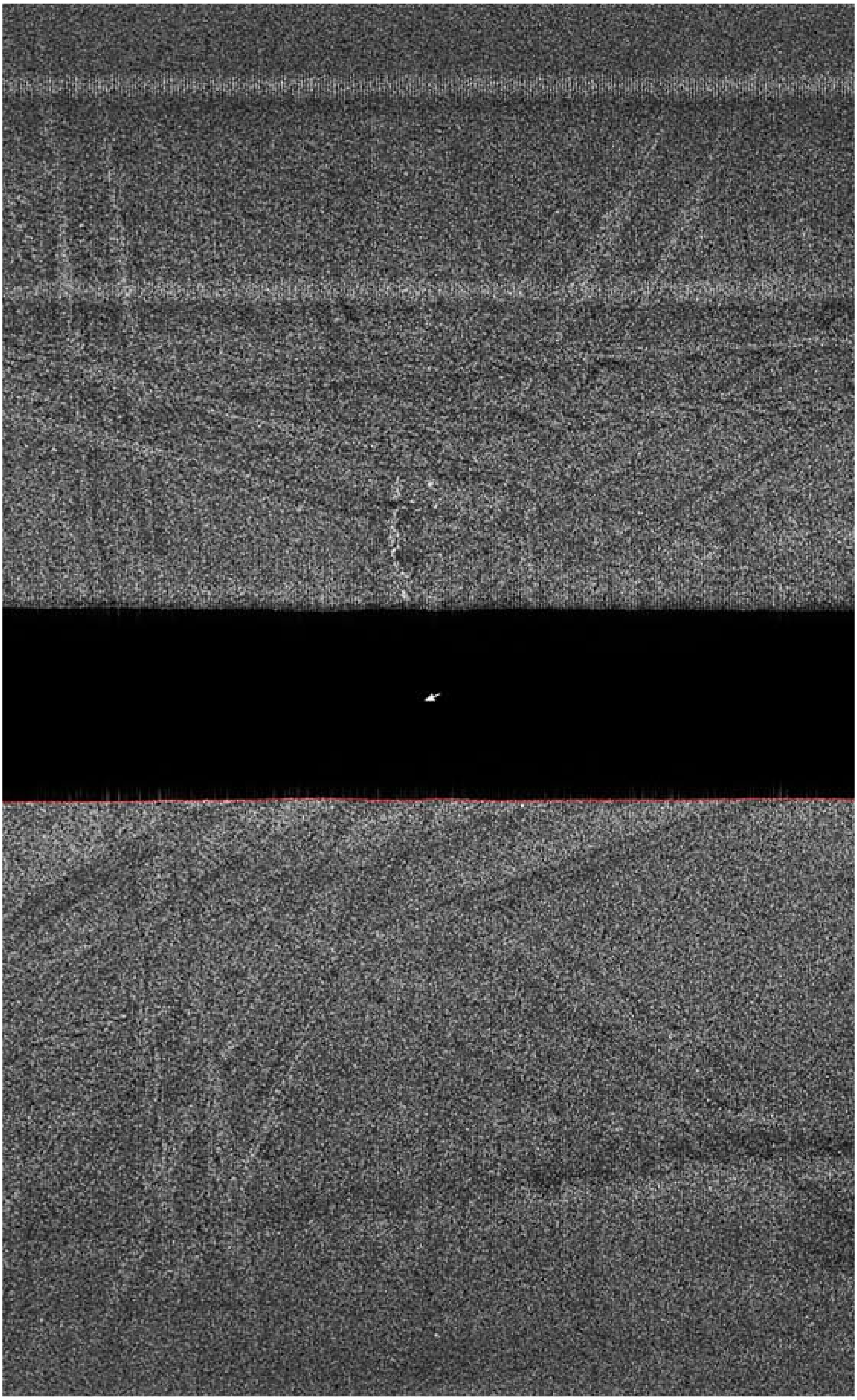


Fig. 39. Trawler furrows criss-crossing a flat seabed in the Atlas shipwreck survey zone.

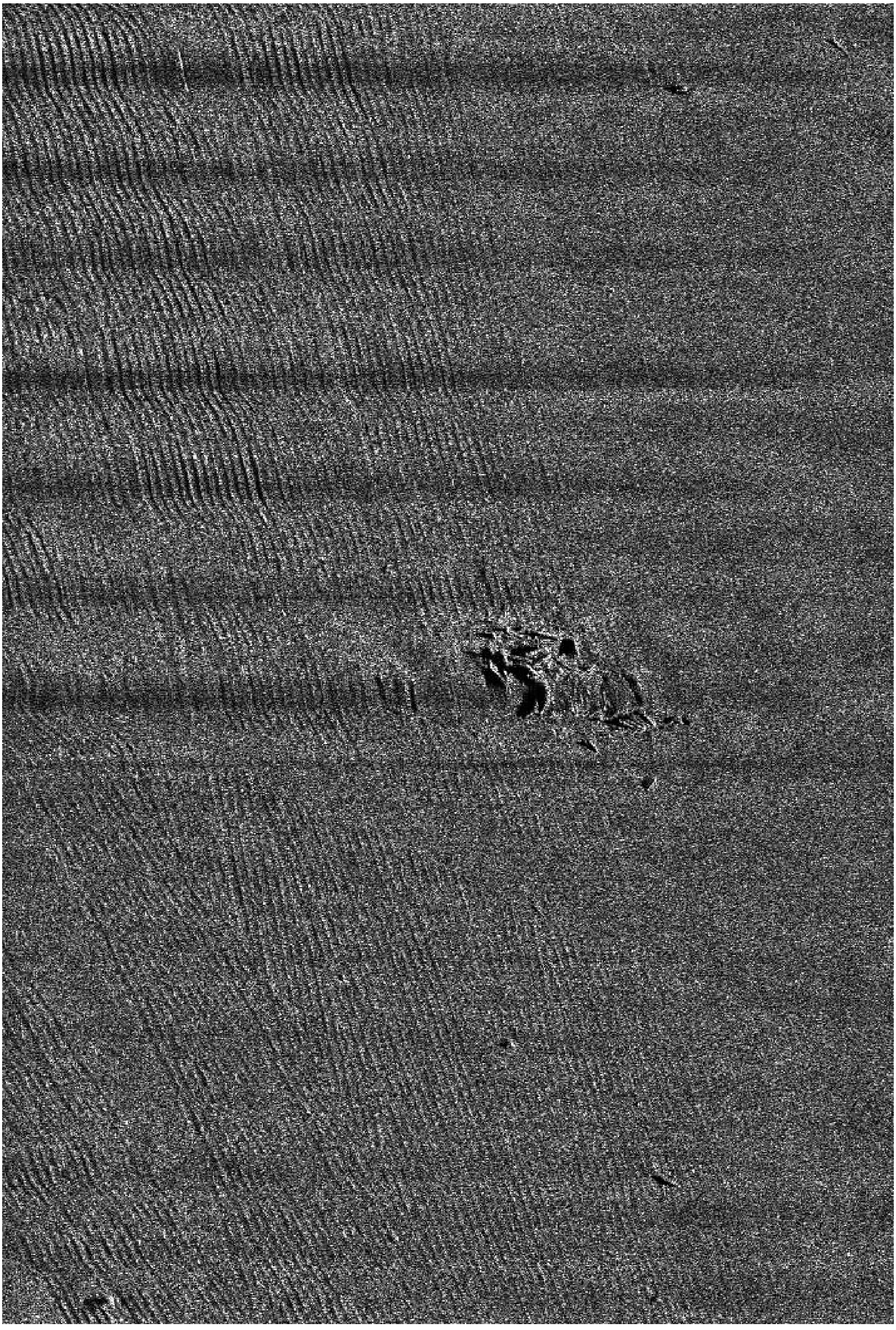


Fig. 40. Scallop dredge furrows running directly through ivory cargo site T7a35f-5 (Target 580), with cannon visibly dragged off-site.

A breakdown of each distinct fishing type by nationality follows:

A. Stern trawling: France (86%), UK (8.7%), Spain (3.4%), Netherlands (0.9%).
B. Beam trawling: UK (89%), followed by Ireland (5.7%), Belgium (3.6%), the Netherlands (0.8%) and France (0.4%).
C. Side trawlers: UK (40.9%), Spain (30.6%), France (23.9%), Denmark (3%), Ireland (1.6%).
D. Pair trawlers: France (56.9%), UK (30.7%), Spain 6.8%, Denmark: 4.9%.
E. Freezer trawlers: the Netherlands (54.6%), Denmark (12.8%), France (11.4%), UK (10.1%), Germany (7.5%) and Ireland (2.2%).
F. Lobster/crab potting: UK (76.5%), followed by France (22.9%).
G. Long liners: Spain (82.4%), UK (10%), France (5.8%), Ireland (0.8%) and Norway (0.4%).
H. Gill netters: UK (90%) followed by France (8.6%).
I. Scallop dredges: UK (89%), Netherlands, (4.4%), Ireland (3.2%), France (2.4%).

This data leave little doubt that the majority of impacts documented by Odyssey across the Atlas survey zone have been caused predominantly by UK fishing vessels. The stern trawling figure apparently dominated by France is a skewed statistic. This category contains 22,205 sightings from aerial reconnaissance. However, within the far larger satellite database, beam trawling massively exceeds stern trawling by 52.6% compared to 3.2%. Since the aerial evidence points to a dominance of beam trawling by the UK (89%), this is a more accurate reflection of this nationality's overall dominance of this industry within the English Channel. France is only highly represented in stern and pair trawling, although this specialty only accounts for 3.2% and 1.2% respectively of the total activities.

UK vessels are also most conspicuous within the scallop dredge industry (89% of all sightings), lobster/crab potting (76.5%) and gill netting (90%). With 2,902 sightings (82.4%), Spain seems to dominate the use of long liners within the survey zone.

6. Conclusion: an End of Innocence

This report has examined a form of shipwreck impact, which, until now, has been almost completely neglected as a major cause of underwater shipwreck destabilization, potential destruction and knowledge loss. Based on the evidence reviewed, the image of pristine deep-sea wrecks displaying superior levels of preservation in contrast to shallow water sites is invalid within the Narrow Seas. In fact it is clear that the opposite is true.

Of 267 shipwrecks recorded in the 4,725 square nautical mile Atlas survey zone by Odyssey Marine Exploration, a total of 115 wrecks have been catalogued with evidence of fishing disturbance on the basis of visual reconnaissance using the Remotely-Operated Vehicle Zeus. A total of 838,048 fishing vessel sightings – both steaming and actively fishing – have been recorded by satellite within the research area for the period 2000 to 2008. Some 73,385 sightings by airplane spotters enable the nationalities exploiting the area – predominantly the UK and France, and less so Spain – to be assessed. To reiterate the observed pattern derived from unfiltered satellite vessel monitoring, deep-sea fishing is dominated by beam trawlers (52.6%), scallop dredges (15.8%) gill netters (7.3%) lobster/crab potters (3.9%) and long liners (2.5%).

Wreck Watch Int. has identified ten sites discovered by Odyssey that warrant further archaeological survey and/or excavation. These shipwrecks would extensively expand our knowledge of the maritime history of the English Channel – in the case of sites MUN-T1M25c-1 (HMS *Victory*) and T7a35f-5 (ivory cargo) uniquely so. All of these sites lie in heavily fished waters (Fig. 35). The wrecks of HMS *Victory* and the *Marquise de Tournay* (site MUN-T1M33c-1) within the same ICES sub-square are located at the epicenter of the deep-sea fishing industry within the Western Channel (147,460 sightings).

A variety of sources demonstrate that both sites have been heavily ground down, with trawlers and dredges clearly an active cog in that process. Site MUN-T1M33c-1 has stabilized to some extent due to the profound level of deterioration and dominance of thick concretions on site (Fig. 43), a combination of iron cannon and apparent cargo-related storage units. Unfortunately, on the surface of site MUN-T1M25c-1 delicate organic remains, including human skeletal bones and wooden planking, are currently contextualized and comprise just the latest stratum of archaeology to be exposed and scoured. Consequently, damage to the site will certainly continue.

Attempting to record and recover assemblages from the majority of shipwrecks within the Atlas zone would be a difficult task that is currently beyond the budget or interests of any organization. In this regard the ten most important sites, which constitute 3.7% of all wrecks documented by Odyssey, are archaeological microcosms for the Channel in its totality. If just the wreck of HMS *Victory* and the 17th-century merchant vessel site T7a35f-5 are subjected to further formal archaeological fieldwork, then 0.7% of the rich maritime heritage discovered so far within the Atlas survey zone could be saved for future generations. Intensive fieldwork on HMS *Victory* would cover a mere 0.4% of all discovered sites, although it is clear that from a heritage and historical perspective its

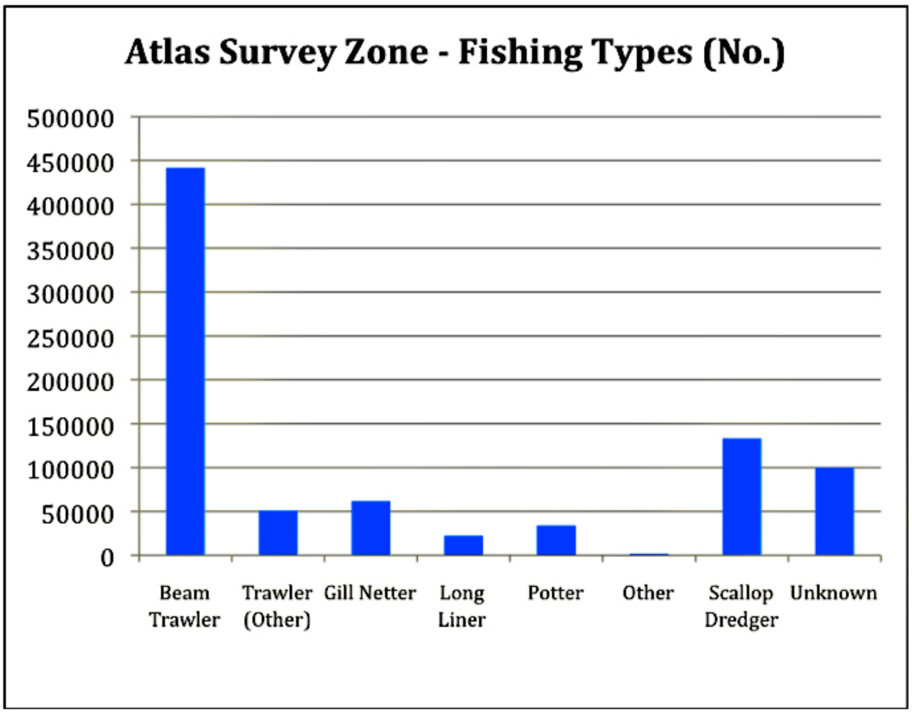


Fig. 41. Fishing activities in the Atlas shipwreck survey zone recorded by VMS satellite, 2000-2008 (nos. of sightings).

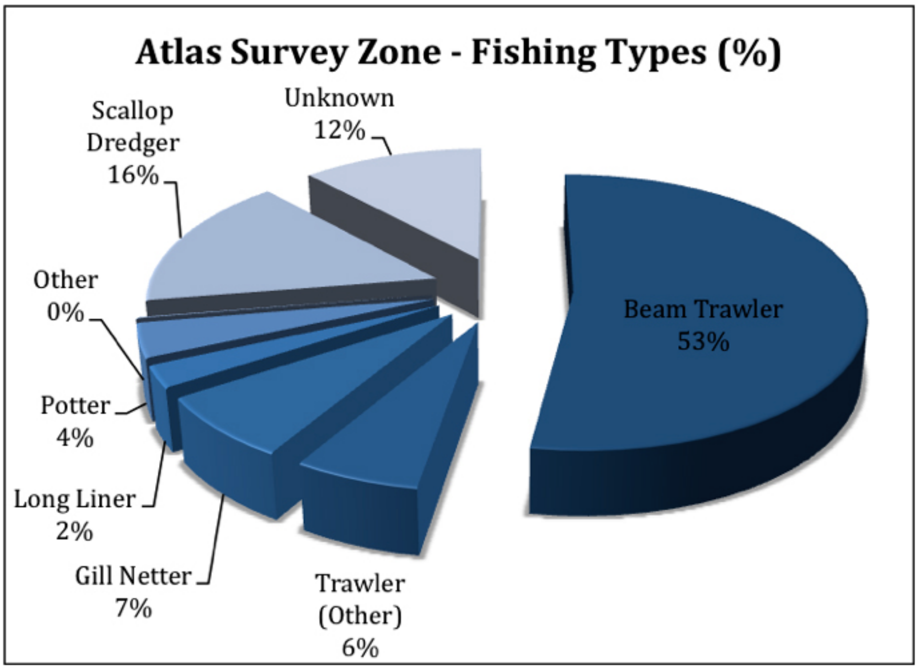


Fig. 42. Fishing activities in the Atlas shipwreck survey zone recorded by VMS satellite, 2000-2008 (%).

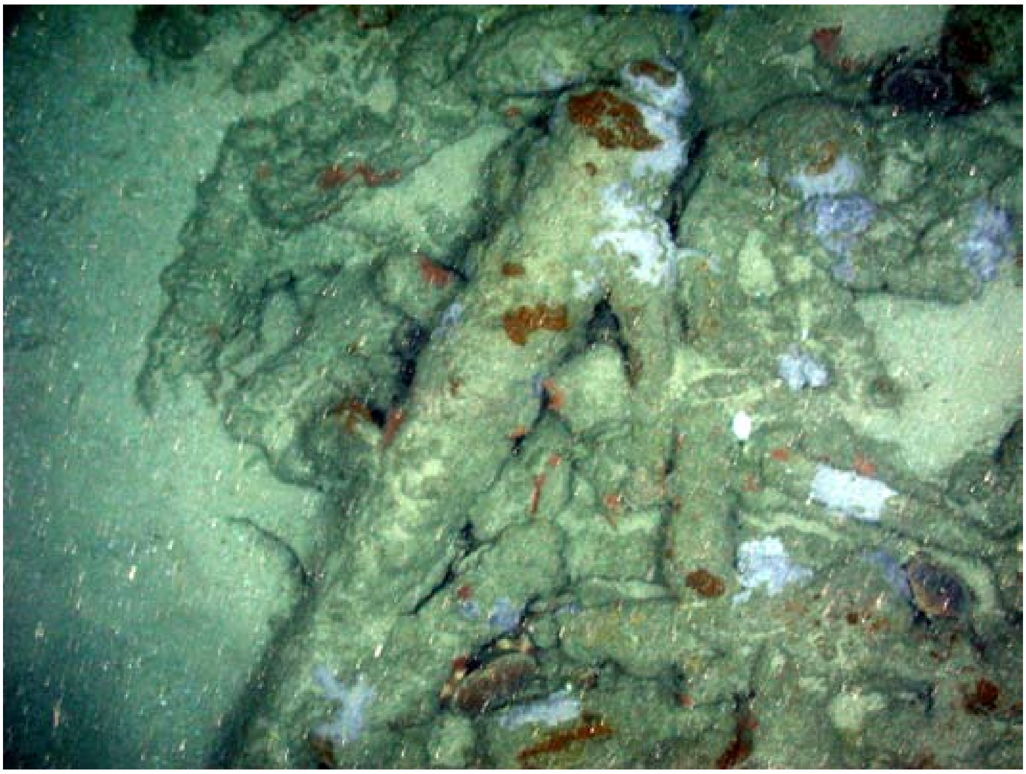


Fig. 43. Dense concretions characterize the surface of the wreck of the French privateer the Marquise de Tournay*, lost in 1757 (Site MUN-T1M33c-1; Target 676). Atlas shipwreck survey zone.*

significance warrants exceptional intervention.

Due to the past and ongoing threat from the deep-sea fishing industry, such a managerial position is already a case of damage limitation. The rarity of identified shipwrecks predating 1800 is a serious anomaly and concern. Within the geographical catchment area of the English Channel a 3rd century AD wooden Roman hull is preserved off Guernsey (Rule and Monaghan, 1993). The St. Peter's Port sites include hull sections of nine medieval ships dating from pre-1350 to 1450 (Adams and Black, 2004). The *St. Anthony*, an armed merchant carrack belonging to King John III of Portugal, lost in 1527, has been identified in Gunwalloe Cove, Cornwall.[5] The former Dutch fluit in the East India service, the *Schiedam*, lost on 4 April 1684, lies in the same cove. The currents of Alderney are notoriously dangerous and destructive – amongst the most extreme in the entire English Channel – but nevertheless have preserved remains of an Elizabethan armed dispatch carrier of the 1590s (Davenport and Burns, 1995).

An early 17th century wreck is preserved in Rill Cove, Cornwall (Simpson *et al.*, 1977) and a mid-17th century site at Salcombe off Devon.[6] The wreck of the English East Indiaman *President*, which foundered in 1684, has been identified near Loe Bar.[7] Lost off Penlee Point, Plymouth, in 1691, the second-rate, 90-gun warship the *Coronation* is another protected UK wreck site.[8] The probable remains of the 70-gun, third-rate *Eagle*, lost on 22 October 1707, are known off Tearing Ledge in the Isles of Scilly (McBride and Larn, 1999). The hull of the 74-gun HMS *Colossus,* wrecked off the Scilly Isles in 1798, is exceptionally intact (Camidge, 2007).

As the coherent hulls of two 19th-century wooden merchant vessels (T7a21a-8 and 2T7a64f-2) within the study region demonstrate, the environment of the Atlas region certainly has the potential to facilitate reasonable preservation. All sites display some level of coarse sands, either mixed with well-sorted gravel or fragmented shell, capable of sustaining anaerobic conditions on wreck sites. Although lost in a similar environment of deep sand to HMS *Colossus* (although coarser), the wreck of HMS *Victory* has apparently suffered far more and appears to have been ground down to the keel line in some areas. Clearly, other scrambling forces are at work in the Atlas zone beyond the typical actions of time and tide.

The chronological pattern of Odyssey's deep-sea wrecks, with an evident rarity of pre-1800 sites, is a distorted archaeological reflection of commercial and military reality. By stark contrast, historical records describe the existence of 1,275 pre-1800 shipwrecks in shallow waters (out to the 30 mile boundary) off Cornwall, Devon, Dorset and the Scilly Isles (this statistic and the below are tabulated from Larn and Larn, 1995). Of these 35 pre-date 1600 (2.7%), 170 date between 1600 and 1700 (13.3%) and 1,070 cluster between 1700 and 1800 (83.9%).[9] This loss timeline is currently the most accurate guide available for appraising the chronological range of wrecks that might be anticipated in the offshore Atlas survey zone, where the rarity of pre-1800 sites is striking.

The paucity of such early wrecks cannot be dismissed as a consequence of selective sealane exploitation by diverse ship types or nationalities (eg. offshore versus inshore sea routes, lighters compared to international merchant vessels). Figures for Dorset's inshore wrecks, for instance, reveal that of 125 mercantile ships lost before 1800 the greater majority (88; 70.4%) were long-distance ships exploiting such far-flung sea lanes as Bordeaux-London, Canary Islands-Hamburg, Genoa-Hamburg, Jamaica-Amsterdam, Le Havre-Baltimore, Leghorn-Amsterdam, Lisbon-London, London-India, Newfoundland-Poole, New York-Liverpool, Sweden-Nantes and Virginia-London. The ships that made these pre-1800 voyages obviously traversed open waters.

This report concludes that arguably the principal reason for the current low level of preservation on the wreck of HMS *Victory* and the rarity of wrecks pre-dating 1800 is a result of fishing impacts in the form of:

1. Direct physical disturbance by beam trawlers and scallop dredges that cut furrows into the seabed and into shipwreck sites. Although wholly or largely inadvertent, this causes:
   • The loosening of archaeological strata.
   • The exposure of wrecks to oxygen, leading to direct deterioration of organic remains.
   • The decontextualization, inadvertent recovery, loss and destruction of artifacts.
   • The snagging and breaking of hull structure, leaving planking susceptible to being washed off-site by bottom currents.
   • The dragging of artifacts out of context and off site, leaving them susceptible to loss by current motion.
2. Wreck fishing using gill nets, intentionally or inadvertently on shipwreck sites, which causes the same sets of impact as no. 1 above.
3. Lobster/crab potting intentionally or inadvertently on shipwreck sites, which causes the same sets of impact as no. 1 above (although inadvertent artifact recovery is rare).

The ten shipwrecks that Odyssey considers most archaeologically significant in the survey zone are currently unstable and cannot be left *in situ* without further deterioration and destruction, severe in some cases. If a trawler/dredge can lift, drag and flip a 42-pounder, 4-ton bronze cannon 55m off-site, then the rest of the artifacts on the wreck of HMS *Victory* have to be considered at high risk, as are the iron cannon on site T7a35f-5 along with the remaining artifacts, including ivory tusks. As Odyssey's experiences on both HMS *Victory* and T7a35f-5 demonstrate, fishermen continue to run lines near and across wrecks of major archaeological significance: for the most part, they are most likely uneducated about the nuances of site formation and the potential for damage.

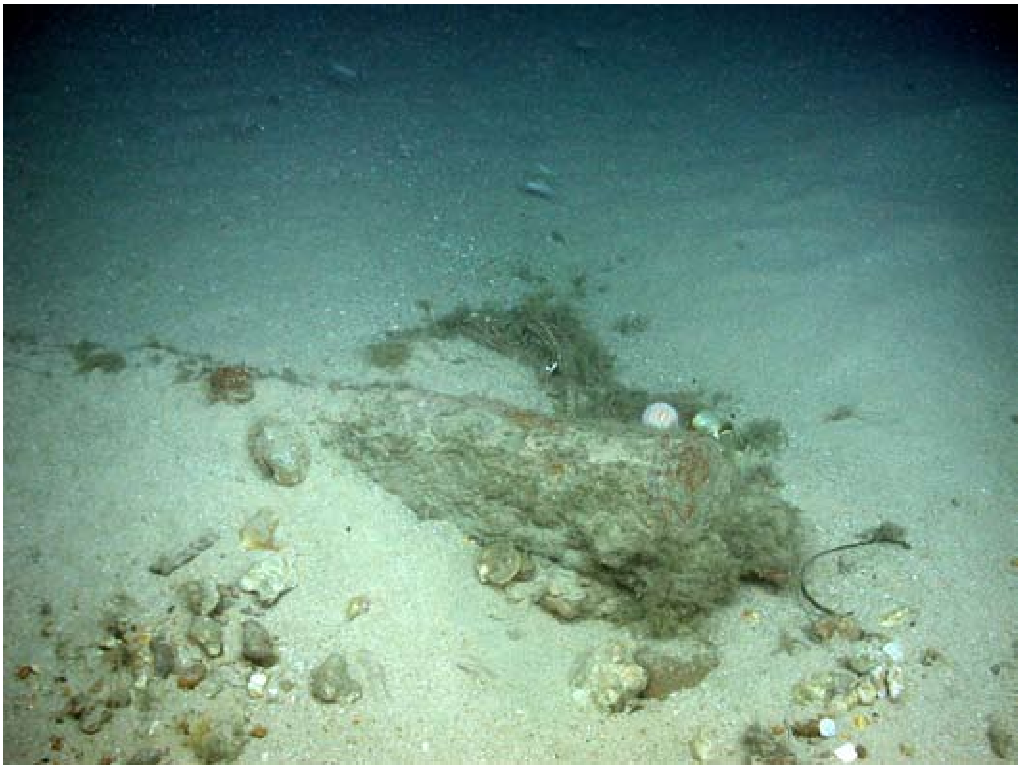


Fig. 44. Fishing net and plastic next to a concreted iron cannon on the wreck of the Marquise de Tournay.

In addition to the evidence presented by deep scallop dredge furrow scars visible on the side-scan sonar images of site T7a35f-5 (Fig. 40), confirmed by physical scars on some cannon surfaces and ballast stones, Odyssey has observed first-hand evidence of trawling through the site. While the company was surveying the wreck on 25 September 2006, a passing trawler warned the *Odyssey Explorer* to move off station so it could trawl the area. The trawler captain emphatically stated that he had been fishing this seabed for years and had detected no obstructions. This incident demonstrates that the commonly cited argument that fishermen are fully knowledgeable of wreck locations and actively avoid them to protect their gear is incorrect.

Moreover, a very real threat exists to currently undetected wrecks because such sites are being actively sought out as fish-rich biological oases as known sites become non-viable due to the over-exploitation of fish resources and dangerous net cover makes access problematic.

Odyssey's results in the Western English Channel and Western Approaches are not isolated. Geophysical research in the Eastern Channel by CEFAS has confirmed that the physical impact of trawlers and scallops feature across a large parts of the area, including the region where aggregate extraction licenses have been granted since 2005 (Vanstaen *et al.*, 2007). The main difference between these two areas of the Channel is the presence of extremely deep sandbanks in the east, 10-30m thick, 3-5km wide and extending across lengths of 30-70km (Reynaud *et al.*, 2003: 364). As the massive scale of offshore aggregate quarrying continues, the impact of newly exposed wreck sites within a large-scale fishing zone will certainly become an extremely complex and expensive underwater cultural heritage managerial issue.

Legislation exists, and is consistently being refined, to protect fishing stocks and commercial interests of fishermen alike, who have their own rich and highly respected maritime traditions within the Narrow Seas. Economically unexploitable by-catch is a major problem within the English Channel, Western Approaches, Celtic and Irish Sea, where one study has demonstrated that an estimated 186 million (72,000 tons) of fish and cephalopods are caught every year, of which 117 million (24,500 tons) is discarded. Beam trawlers and otter trawlers are together responsible for more than 90% of these discards (Enever *et al.*, 2007).[10]

This inefficiency and damage to the marine environment has been tackled by the imposition of government fishing quotas, the decommissioning of ships and by zoning regulations. Some 17% of the Western Channel's fleet is scheduled for decommission as part of a long-term plan to protect sole stocks.[11] Zoning is largely designed to protect unique and endangered biological formations, such as on Darwin Mounds, an area for the deep-water

Fig. 45. On the badly preserved wreck of a c. mid-17th century merchant vessel, site T7a35f-5 (Target 580), hull remains are only preserved where they are pinned down by iron cannon.

coral *Lophelia pertusa*, and other deep-water coral sites off the Azores, Madeira and the Canary Islands.[12]

As a discipline, for the most part marine archaeology and cultural heritage managers appear to be unaware of these developments or the threat that deep-sea fishing poses to unique maritime heritage, even though leading scientists have warned that "The seas are undergoing ecological meltdown" (Roberts, 2007: 373). However, it is not necessarily too late for sea life because zoning and marine reserves may allow plant-life and fish species to regenerate and repopulate. Shipwrecks lost at the bottom of the sea do not share that opportunity. Just a single pass from a trawler or dredge can irretrievably destroy unique maritime heritage; unlike fish and plants, substantial knowledge is permanently lost. Simultaneously, expensive fishing gear can be snagged and lost.

The vast signature of deep-sea fishing registered by Odyssey within the Atlas survey zone makes it clear that the shipwrecks of the Narrow Seas have been subjected to destructive hammer blows on a continuous and extreme basis in some cases. The scale and scope of the impacts to the most archaeologically significant shipwrecks – at the very least – need to be quantified in the near future.

In the absence of any effective political legislation to protect such sites, where does marine archaeology go from here? No viable legal instruments exist to safeguard the world's deep-sea shipwrecks beyond the territorial seas of nations. Even in the case of sovereign immune vessels, no government is likely to willingly monitor and protect an historic ship dozens of miles offshore, even if it was legally possible. Realistically, the protection of shipwrecks stands at the bottom of the food chain in issues of marine studies and conservation. For economic reasons alone, regular satellite or spotter plain supervision of potentially hundreds or even thousands of historical shipwrecks short- or long-term is impractical. Due to such sites' locations far offshore, there is no practical way to prevent the accidental snagging and recovery of wreck structure and artifacts, much less illicit salvage, which AIS (Automatic Identification System) makes a realistic threat.[13] Zoning is entirely unenforceable so far offshore.

This leaves two alternatives. Abandon shipwrecks to the wild natural rhythms of the sea and fisheries in hope rather than intelligent managerial design. Or, alternatively, the fishing industry, other users groups, governments and/or the private sector should endeavor to pool resources to rescue those shipwrecks of national and international significance. This pattern is most likely to prevail in the future as increasing evidence for comparable scales of fishing impacts to the English Channel and Western Approaches emerges from other oceans. A similar model already exists in the Aggregates Levy Sustainable Fund,

Fig. 46. Snagged fishing net on an iron cannon on the c. mid-17th century site T7a35f-5.

which is being put to good effect in the Eastern English Channel to model possible wreck impacts and the erosion of submerged prehistoric landscapes (Dix and Lambkin, 2005; Firth, 2006). Legislation is also in existence for shipwrecks threatened by offshore oil pipelines at Ormen Lange in the Norwegian Sea (Bryn *et al*., 2007), Nord Stream (Greifswalder Bodden coastal lagoon, Germany) and Mardi Gras, Gulf of Mexico (Ford *et al*., 2008).

Future research will likely demonstrate that the case of the Atlas survey region is far from unique and in deep seas is actually the rule rather than the exception. The Woods Hole Oceanographic Institution (WHOI) has detected at least two trawl nets and one gill net wrapped around the windlass of the wreck of the schooner *Paul Palmer*, lost in 1913 off Maine.[14] In the Mediterranean Sea, Brendan Foley of WHOI has recalled how "we optically surveyed the sea floor off the island of Malta, for centuries a center of maritime commerce. At depths of 500+ meters, we expected to encounter marine life and hoped to discover ancient shipwrecks. Instead, we found only furrows in the sediments, indicating intensive trawling… occasionally we have seen evidence of dragging at depths approaching 1000 meters. It is unlikely that many ancient archaeologically significant sites will survive in areas subjected to trawl fishing."[15] Ballard (2008: 136) has also observed trawl marks in deep waters in depths of 1,000m off Malta, as well as off the Gulf of Naples, Egypt and in the Black Sea. Odyssey has recorded a heavily trawler-impacted mid-19th century merchant vessel 370m beneath the Atlantic Ocean off Jacksonville, carrying a cargo of largely British blue china (Tolson, 2009).

Following Odyssey's three-year non-intrusive shipwreck survey project in the English Channel and Western Approaches, in this sea *in situ* preservation emerges as an inappropriate all-encompassing managerial policy for the protection of maritime heritage, either in the short- or long-term. Incalculable wreck destruction has already occurred and is ongoing. Statistical information indicates that deep-sea fishing and wreck disturbance in the Narrow Seas are predominantly an English problem. Certainly one realistic, responsible policy is to recover elements of the threatened heritage for both the education and enjoyment of future generations.

The comprehensive mapping and planning of sites will help differentiate between heritage-rich shipwrecks with high evidential, historical and communal value (Dunkley, 2008: 24-25), which require the recovery of select archaeological assemblages, those that need to be avoided by fishermen and the greater majority of modern wrecks that are devoid of historical significance and can be exploited by the fishing community (relatively flat wreck sites for beam trawlers and scallop dredges and standing superstructure for netting). The relationship between all user groups (fishermen, ecologists, archaeologists, historians, salvors, sport divers, heritage managers and the marine construction industry alike) is, and needs to remain, respectfully symbiotic.

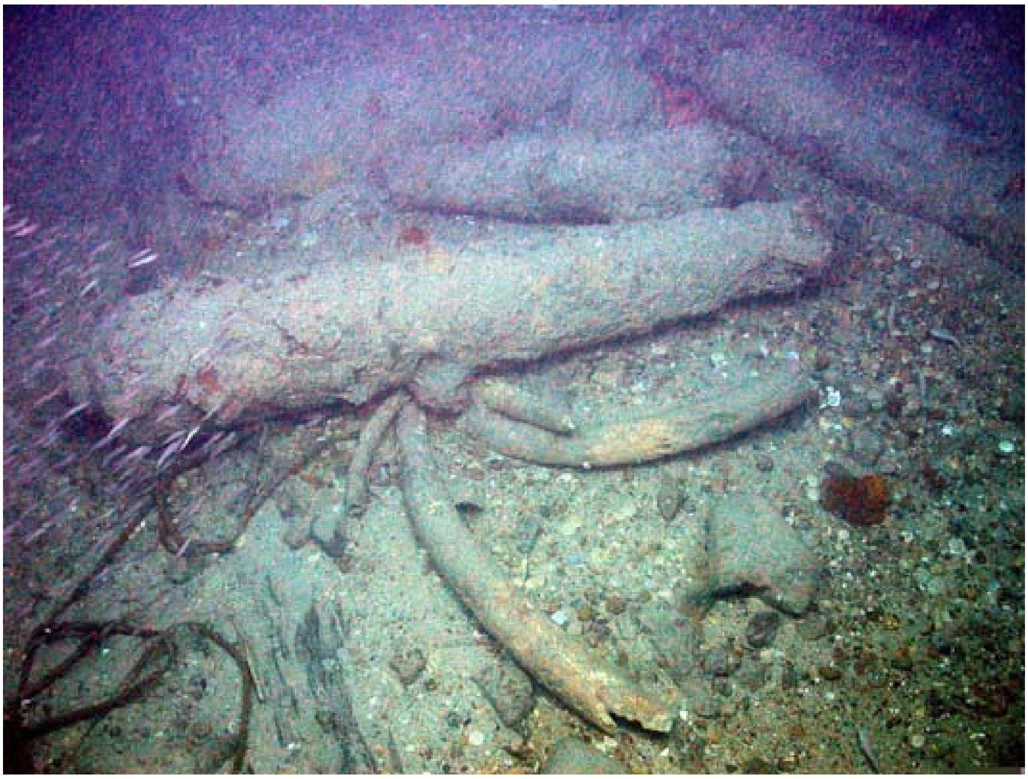


Fig. 47. Snagged steel trawler cable on iron cannon on the c. mid-17th century site T7a35f-5, adjacent to elephant tusks with their ends snapped off.

Acknowledgements

This report owes a vast debt of gratitude to the whole Odyssey team, which has conducted the first comprehensive deep-sea shipwreck survey in the English Channel and Western Approaches: to Greg Stemm for initiating and managing the project and encouraging and facilitating swift publication for our fellow scientists; to Mark Gordon, Laura Barton and John Oppermann for their ongoing support and energetic encouragement; to on-site project managers Tom Dettweiler, Andrew Craig, Ernie Tapanes and Mark Martin.

The primary underwater ROV photographic record on which this report is based was taken under the direction of Directors of Field Archaeology Neil Cunningham Dobson and Hawk Tolson. Neil Cunningham Dobson diligently accumulated the images displaying fishing damage by site from the Atlas survey area, dated the wrecks, identified fishing gear and has strongly facilitated the production of the primary data utilized in this report.

GIS wreck distribution maps were produced with great patience by Gerhard Seiffert. John Griffith processed the hard data obtained by the UK Marine and Fisheries Agency into statistical form and produced the GIS maps in this report. Chief Conservator Fred Van de Walle advised on the bronze cannon lifted from the wreck of HMS *Victory*.

Both Prof. Michel Kaiser (School of Ocean Sciences, Bangor University) and Prof. Andrew Price (Department of Biological Sciences, University of Warwick) generously commented on the current project and report. For various further support and advice, I am also most grateful to Sir Robert Balchin, Jason Williams, Peter Goodwin and Nick Hall. All errors are of course my own.

Notes

1. These fishing forms are also characterized by the Food & Agriculture Organization of the United Nations: http://www.fao.org/fi/website/FISearchAction.do?dslist=geartype&lixsl=webapps/figis/shared/xsl/search_result.xsl&kw[0]=name&kv[0]=trawl&refxml=true.
2. Fishing gear tends to be constructed from modern synthetic fibers that are non-biodegradable. This means that snagged or lost gear and torn fragments of net may continue to catch fish indefinitely. This is termed ghost fishing (http://www.jncc.gov.uk/page-1567). Largely relevant to diveable water depths, this issue is not pertinent to deep-sea shipwrecks, although the ongoing effects of snagged nets of durable nature on site deterioration are in theory a continuous problem.
3. In the absence of published reports, see: http://www.deepimage.co.uk/expeditions/expeditions.htm.
4. See: http://www.alderneywreck.com/node/7.
5. *St Anthony, off Gunwalloe, Kerrier, Cornwall. Designated Site Assessment: Archaeological Report* (Wessex Archaeology, 2007).
6. See:http://www.english-heritage.org.uk/server show/ConWebDoc.6610.
7. *Loe Bar, Penwith (District), Cornwall. Designated Site Assessment. Full Report* (Wessex Archaeology, 2005).
8. *Archaeological Services in Relation to the Protection of Wrecks Act (1973). Coronation Offshore, Penlee Point Plymouth. Designated Site assessment: Full Report* (Wessex Archaeology, 2004).
9. These statistics exclude the 120 Danish galleys lost off Swanage in AD 877, according to the *Anglo-Saxon Chronicles*.
10. Research based on 3,643 hauls from 306 trips aboard commercial fishing vessels (142 different boats) between 2002 and 2005 (Enever *et al*., 2007).
11. See: http://www.defra.gov.uk/marine/fisheries/fishman/eufleet.htm.
12. See: http://www.jncc.gov.uk/page-1568.
13. By law, all international and passenger ships and vessels in excess of 300 tons are compelled to be equipped with AIS principally for purposes of identifying and locating craft.
14. See: http://www.whoi.edu/sbl/image.do?id=10977&litesiteid=2740&articleId=4958 and http://stellwagen.noaa.gov/maritime/paulpalmer.html.
15. Foley, B., *Impact of Fishing on Shipwrecks*: http://www.whoi.edu/sbl/liteSite.do?litesiteid=2740&articleId=4965.

Bibliography

Adams J. and Black, J., 'From Rescue to Research: Medieval Ship Finds in St. Peter Port, Guernsey', *IJNA* 33.2 (2004), 230-52.

Alward, G.L., *The Sea Fisheries of Great Britain and Ireland* (Grimsby, 1932).

Arnold, S., *The Art of Wreck Fishing* (Seaford, 1996).

Ballard, R., 'Searching for Ancient Shipwrecks in the Deep Sea'. In R.D. Ballard (ed.), *Archaeological Oceanography* (Princeton University Press, 2008), 132-47.

Bergman, M.J.N. and Van Santbrink, J.W., 'Fishing Mortality of Populations of Megafauna in Sandy Environments'. In M.J. Kaiser and S.J. de Groot (eds.), *Effects of Fishing on Non-Target Species and Habitats* (Oxford, 2000), 49-68.

Bradshaw, C., Veale, L.O., Hill, A.S. and Brand, A.R., 'The Effects of Scallop Dredging on Gravelly Seabed Communities'. In M.J. Kaiser and S.J. de Groot (eds.), *Effects of Fishing on Non-Target Species and Habitats* (Oxford, 2000), 83-104.

Bryn, P., Jasinski, M.E. and Soreide, F., *Ormen Lange. Pipelines and Shipwrecks* (Oslo, 2007).

Camidge, K., *HMS Colossus. Survey Report 2007* (2007).

Cunliffe, B., 'People of the Sea', *British Archaeology* 63 (2002).

Cunningham Dobson, N. and Kingsley, S. *HMS Victory, a First-Rate Royal Navy Warship Wrecked in the English Channel, 1744. Preliminary Survey and Identification* (OME Papers 2, 2009).

Cunningham Dobson, N. and Tolson, H., *A Note on Human Remains from the Shipwreck of HMS Victory, 1744* (OME Papers, forthcoming).

Dare, P.J., Palmer, D.W., Howell, M.L. and Darby, C.D., *Experiments to Assess the Relative Dredging Performance of Research and Commercial Vessels for Estimating the Abundance of Scallops (Pectens Maximus) in the Western English Channel Fishery* (Fisheries Research Technical Report No. 96, Lowestoft, 1994).

Davenport T.G. and Burns, R., 1995, 'A Sixteenth Century Wreck off the Island of Alderney'. In M. Bound (ed.), *The Archaeology of Ships of War* (Int. Maritime Archaeology Series, Volume 1, Oxford), 30-40.

Dix, J. and Lambkin. D., 'Modelling Exclusion Zones for Marine Aggregate Dredging'. In *Technical Conference. Marine Aggregate Levy Sustainability Fund. Marine Aggregate Extraction. Helping to Determine Good Practice, July 6 2005, SOAS, London*.

Duke of Edinburgh, H.R.H., *Notes on the Sea Fisheries and Fishing Populations of the United Kingdom* (International Fisheries Exhibition, London, 1883).

Dunkley, M., 'The Value of Historic Shipwrecks'. In I. Radic Rossi, A. Gaspari and A. Pydyn (eds.), *Proceedings of the 13th Annual Meeting of the European Association of Archaeologists (Zadar, Croatia, 18-23 September 2007*) (Zagreb, 2008), 18-28.

Duplisea, D.E., Jennings, S., Malcolm, S.J., Parker, R. and Sivyer, D.B., 'Modelling Potential Impacts of Bottom Trawl Fisheries on Soft Sediment Biogechemistry in the North Sea', *Geochemical Transactions* 14 (2001), 1-6.

Enever, R., Revill, A., and Grant, A., 'Discarding in the English Channel, Western approaches, Celtic and Irish seas (ICES subarea VII)', *Fisheries Research* 86 (2007), 143-52.

Firth, A., 'Marine Aggregates and Prehistory'. In *Underwater Cultural Heritage at Risk. Managing Natural and Human Impacts* (ICOMOS, 2006), 8-10.

Fonteyne, R., 'Physical Impact of Beam Trawls on Seabed Sediments'. In M.J. Kaiser and S.J. de Groot (eds.), *Effects of Fishing on Non-Target Species and Habitats* (Oxford, 2000), 15-36.

Ford, B., Borgens, A., Bryant, W., Marshall, D., Hitchcock, P., Arias, C. and Hamilton D., *Archaeological Excavation of the Mardi Gras Shipwreck (16GM01), Gulf of Mexico Continental Shelf* (New Orleans, 2008).

Gammon, C., *Wreck Fishing* (Reading, 1975).

Gray, M.J., *The Coastal Fisheries of England and Wales, Part III: A Review of their Status 1992-1994* (Fisheries Research Technical Report No. 11, Lowestoft, 1995).

Grochowski, N.T.L., Collins, M.B., Boxall, S.R. and Salomon, J.C., 'Sediment Transport Predictions for the English Channel, Using Numerical Models', *Journal of the Geological Society* 150 (1993), 683-95.

Gutierrez, A., 'A Shipwreck Cargo of Sevillian Pottery from the Studland Wreck, Dorset, UK', *IJNA* 32.1 (2003), 24-41.

Hall, S.J., *The Effects of Fishing on Marine Ecosystems and Communities* (Oxford, 1999).

Hall-Spencer, J.M. and Moore, P.G., 'Scallop Dredging has Profound, Long-Term Impacts on Maerl Habitats', *ICES Journal of Marine Science* 57 (2000), 1407-15.

Hamblin, R.J.O., Crosby, A., Balson, P.S., Jones, S.M., Chadwick, R.A., Penn, I.E. and Arthur, M.J., *The Geology of the English Channel* (HMSO, London, 1992).

Hillis, R.R., Gatliff, R.W., Day, G.A. and Edwards, J.W.F., *The Geology of the Western English Channel and its Western Approaches* (HMSO, London, 1990).

Jennings, S., Kaiser, M.J. and Reynolds, J.D., *Marine Fisheries Ecology* (Oxford, 2001).

Jennings, S., Warr, K.J., Greenstreet, S.P.R. and Cotter, A.J.R., 'Spatial and Temporal Patterns in North Sea Fishing Effort'. In M.J. Kaiser and S.J. de Groot (eds.), *Effects of Fishing on Non-Target Species and Habitats* (Oxford, 2000), 3-14.

Kaiser, M.J., Collie, J.S., Hall, S.J., Jennings, S. and Poiner, I.R., 'Modification of Marine Habitats by Trawling Activities: Prognosis and Solutions', *Fish and Fisheries* 3.2 (2002), 114-36.

Kaiser, M.J., Edwards, D.B., Armstrong, P.J., Radford, K., Lough, N.E.L., Flatt, R.P and Jones, H.D., 'Changes in Megafaunal Benthic Communities in Different Habitats after Trawling Disturbance', *ICES Journal of Marine Science* 55 (1998), 353-61.

Larn, R. and Larn, B., *Shipwreck Index of the British Isles. Volume 1: Isles of Scilly, Cornwall, Devon and Dorset* (London, 1995).

McBride, P. and Larn, R., *Admiral Shovell's Treasure and Shipwreck in the Isles of Scilly* (Penryn, 1999).

Morais, P., Borges, T.C., Carnall, V., Terrinha, P., Cooper, C. and Cooper, R., 'Trawl-Induced Bottom Disturbance off the South Coast of Portugal: Direct Observations by the "Delta" Manned-Submersible on the Submarine Canyon of Portimao', *Marine Ecology* 28 (2007), 112-22.

Revill, A.S. and Dunlin, G., 'The Fishing Capacity of Gillnets Lost on Wrecks and on Open Ground in UK Coastal Waters', *Marine Fisheries* 64 (2003), 107-113.

Reynaud, J.-Y., Tessier, B., Auffret, J.-P., Berné, S., De Batist, M., Marsset, T. and Walker, P., 'The Offshore Quaternary Sediment Bodies of the English Channel and its Western Approaches', *Journal of Quaternary Science* 18 (2003), 361-71.

Roberts, C., *The Unnatural History of the Sea. The Past and Future of Humanity and Fishing* (London, 2007).

Rule, M. and Monaghan, J., *A Gallo-Roman Trading Vessel from Guernsey. The Excavation and Recovery of a Third Century Shipwreck* (Guernsey Museum Monograph, 1993).

Sibella, P., *The George McGhee Amphora Collection at the Alanya Museum, Turkey* (INA Quarterly 19, Suppl. 1, 2002).

Simpson, K., Hall, H., Davis, R. and Lam, R., 'An Early 17th Century Wreck Near Rill Cove, Kynance, Cornwall. An Interim Report', *IJNA* 6.2 (1977), 163-66.

Thomsen, M.H., 'The Studland Bay Wreck, Dorset, UK: Hull Analysis', *IJNA* 29.1 (2000), 69-85.

Tolson, H., *The Jacksonville 'Blue China' Shipwreck & the Myth of Deep-Sea Preservation* (OME Papers 3, 2009).

Vanstaen, K., Limpenny, D., Lee, J., Eggleton, J., Brown, A. and Stelzenmuller, V., *The Scale and Impact of Fishing Activities in the Eastern English Channel: an Initial Assessment Based on Existing Geophysical Survey Data* (CEFAS, Lowestoft, 2007).

Walmsley, S.A. and Pawson, M.G., *The Coastal Fisheries of England and Wales, Part V: A Review of their Status 2005-6* (Science Series Technical Report 140, CEFAS, Lowestoft, 2007).

Watling, L. and Norse, E.A., 'Disturbance of the Seabed by Mobile Fishing Gear: a Comparison to Forest Clearcutting', *Conservation Biology* 12.6 (1998), 1180-97.

Williams, G. and Eltis, D., *History of the Liverpool Privateers and Letters of Marque: with an Account of the Liverpool Slave Trade, 1744-1812* (McGill-Queen's University Press, 2004).

Young, A., *Sea Fisheries* (London, 1877).

Zemer, A., *Storage Jars in Ancient Sea Trade* (Haifa, 1977).

