August 2012

Out of Sight, Out of Mind?
Fishing & Shipwrecked Heritage

Sean A. Kingsley

Wreck Watch Int., London, UK www.wreckwatch.com

Out of Sight, Out of Mind?
Fishing & Shipwrecked Heritage

SEAN A. KINGSLEY
Wreck Watch Int., London, UK

Amongst the detrimental man-made impacts to which shipwrecks are susceptible – such as sand and gravel dredging, pipeline cutting and looting – the pressures of the global fishing industry are understated. Recent research has led to a growing concern that trawling and scallop dredging are high on the list of the most aggressive forms of anthropogenic impact on the resource. The classes of artefacts inadvertently snagged in nets reveal a geographically and typologically wide set of data. The damaging reality may be compared to the effects of ploughing on terrestrial archaeological sites. Underwater, however, no policies have been formulated to manage and mitigate offshore fishing politically or to recommend best-practice guidance. This report presents global evidence for the history of bottom fishing impacts on underwater cultural heritage and examines the diversity of impacted finds and sites through 68 examples and case studies. Potential forms of mitigation and management are discussed.

KEYWORDS shipwrecks, underwater cultural heritage, fishing, trawlers, sustainability.

1. Introduction

In theory, the inadvertent recovery of artefacts and ships' timbers in fishing nets should be an obvious high-visibility means of wreck sourcing. Although underwater cultural heritage has been brought to the attention of antiquarians and archaeologists through these channels since the 18th century in some countries, and with rapid escalation since the 1950s linked to the development of fishing fleets with more powerful engines (causing world catches to double from 30 to 60 million tonnes between 1959 and 1970: Hall, 1999: 3), this highly intrusive form of impact is poorly understood. The neglect is at odds with the scientific value of much of the resource.

Like ramblers stumbling across potsherds popped out of a molehill or scattered across a newly ploughed farmer's field, fished up finds have tended to be treated as curious and unexpected gifts. This positive valuation flies in the face of archaeology's holiest cow: provenance and contextual recording. Detecting a target, however, is not simple. Since trawlers run 10-30km-long lines or more before pulling in their nets, pinning an artefact to a specific site for future mitigation or research is often impossible without remote sensing technology, which is almost never applied. Site and artefact typically remain divorced. Displaced oddities most frequently end up thrown back into the sea or dumped unseen and crumbling in storerooms, contributing nothing to public knowledge.

Out of sight and out of mind defines the current lack of consciousness about the effects of fishing impacts on underwater cultural heritage today. The subject has recently received a wake up call following Odyssey Marine Exploration's deep-sea survey of the western English Channel and Western Approaches. Conducted between

2005 and 2008 in international waters, the 'Atlas' Shipwreck Survey Project recorded 267 wooden and steel shipwrecks and submarines dating between the mid-17th century and modern day, of which 112 (42%) displayed varied fishing impacts. These ranged from seemingly innocuous snagged nets to more disturbing beam trawler and scallop dredge furrows cut by towed bottom gear directly through sites (Fig. 18). Some bronze and iron cannon on the most important 17th and 18th-century wrecks had been broken, flipped and dragged offsite (Kingsley, 2010; Cunningham Dobson and Kingsley, 2011).

Fig. 1. A pair trawler lifting its nets.

The time is long overdue for marine archaeology to 'whistleblow' this complex management problem, to question the scale and scope of fishing impacts and to discuss means of sustainable mitigation and cooperation with fishermen for optimum protection. Due to the enormity and extreme pressures of seabed trawling, there is a growing realization that fishing impacts may be the greatest anthropomorphic threat to underwater cultural heritage today in terms of data loss. While taking a global perspective, this article draws extensively on UK data and models to define and debate the issue.

2. Fishing impacts theory

No legal frameworks or best practice policies have been formulated to guide the fishing industry how to avoid or declare snagged underwater cultural heritage. This black hole stands in stark contrast to the public obligation for industries to mitigate the imprint of offshore sand and gravel dredging and oil and gas pipeline cutting on archaeology through the 'polluter pays' principle (Irion *et al.*, 2008).[1]

Marine archaeology has also not mirrored the progressive track of marine ecology, where bottom trawling has spawned public and academic outcry and debate, popular books, television documentaries and practical counter-measures (cf. Clover, 2005). The short and long-term impacts of trawlers, scallop dredges and other gear on marine flora and fauna have been the subject of extensive research since ICES (International Council for the Exploration of the Sea) initiated a 1970 inquest following Council Resolution 1970/5/1 (Fonteyne, 2000: 16).

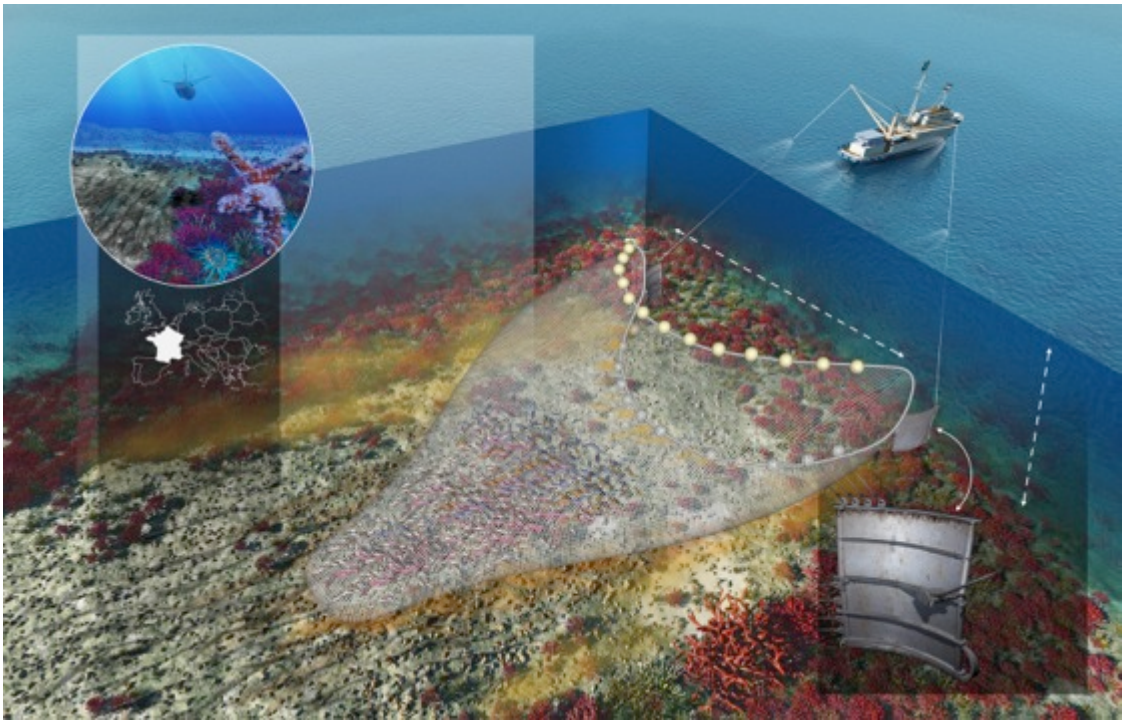

Fig. 2. Bottom trawls with enormous fishing nets dragged across the sea floor 'clear-cut' everything in their path. The mouths of the largest nets are big enough to swallow a Boeing 747 Jumbo Jet, and trawls and dredges can destroy century-old reefs in moments. Shipwrecks are an unappreciated category at high risk from destruction. Photo: courtesy of and © Don Foley.

Although contradictory views exist about the severity of bottom trawling, its reality is indisputable. At the most provocative limits of interpretation, Watling and Norse (1998: 1190-92) equated the effects of mobile fishing gear to the clearcutting of forests on land, but identified a major difference in the scale of the relative disturbance. Whereas forest clearcutting was estimated to fell 100,000km^2 of woodlands a year worldwide, the area trawled annually was calculated at some 150 times greater. Each year of trawling has been described as disturbing an area of seabed as large as Brazil, the Congo and India combined, resulting in local and global impacts on the structure, species composition and biogeochemistry of benthic communities. Current estimates suggest that trawlers sweep an area of seabed equivalent in size to half the world's continental shelves every year (Roberts, 2012: 44). Issues of seabed monitoring, zoning, fish quotas and trawler decommission are now strongly debated and mitigation measures implemented worldwide (Clover, 2005: 289-90).

Fig. 3. Bottom fishing gear and nets on the quay side at Weymouth, southeast England.

Bottom fishing is acknowledged to be one of the most widespread sources of anthropogenic disturbance to seabed communities, affecting species diversity, community structure and size composition (Kaiser *et al*., 1998: 354; Kaiser *et al*., 2002: 116). Demersal fishing trawlers using gear dragged over the seabed and dredges physically disturb the upper layer of sediments, flattening the seabed, removing seagrass, coral and exposing buried fauna. Trawling gradually lowers the physical relief of habitats. Direct contact with the substratum via ground rope, chains, bobbins, sweeps, doors, chaffing mats or parts of the net bag may result in scraping, penetration, pressure, sediment suspension, habitat destruction, burying and benthos mortality (Fonteyne, 2000: 16-17; Linnane, 2000: 1-2; Duplisea *et al*., 2001: 1).

Ferrari (1994: 74-75) has discussed the effects of trawling and dredging scraping, penetration and pressure on shipwrecks, and cites references for fishing gear penetration to depths of 10-30cm. Otter boards can penetrate 8-17cm in mud environments and up to 5cm in sand, while beam trawls can affect the upper 2-6cm of hard and sandy sea bottoms and 10-30cm in soft and muddy ground (Linnane, 2000: 3, 5-7).

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 surface impact and sediment penetration, key points for understanding wreck impacts, is not consistent but is determined by various interlocking 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 (Jennings *et al*., 2000: 4). Overall, the impact of fisheries on bottom-dwelling animals has been calculated within the North Sea, for instance, to be a thousand times higher than sand and gravel extraction and 100,000 times greater than oil or gas extraction (Clover, 2005: 59).

3. Fishing impact types

Whereas the modeling of the effects of bottom trawling on marine ecosystems is advanced (cf. Dare *et al*., 1994; Morais *et al.*, 2007; Vanstaen *et al*., 2008), no overviews of the types of sites and artefacts impacted exist within marine archaeology. At best a report may cursorily note the generic mode of discovery as resulting from fishing activity. With minor exceptions, the types of gear associated with the snag are very rarely provided. Available literature reveals a trail of evidence for sustained and extensive impacts since the 18th century, which can be divided into eight categories:

- Class 1: artefacts recovered in static gear (gillnets, longlines, lobster/crab pots).
- Class 2: artefacts recovered in trawl nets.
- Class 3: artefacts exposed and impacted by scallop/clam dredges.
- Class 4: wooden/metallic ship's structure recovered in trawl and static nets.
- Class 5: wrecks identified following the visual investigation of fasteners.
- Class 6: submerged prehistoric settlements discovered through the recovery of artefacts in nets.
- Class 7: impacts identified on wrecks through trawler/scallop dredge furrows visible on side-scan sonar imagery.
- Class 8: impacts identified visually underwater on wrecks (broken artefacts, dragged and scattered structures), often in association with snagged fishing gear.

Records of the recovery of underwater cultural heritage in fishermen's nets stretch back to the 18th century. A 16th-century Portuguese brass swivel gun, almost 2.4m-long, was caught off the Goodwin Sands in 1775 by fisherman dragging for anchors (King, 1779). Since 1755 the appearance of large numbers of "a very peculiar kind of red earthen ware found amidst the cottage furniture of the fishermen on the Kentish coast, within the mouth of the river Thames" (Pownall, 1779: 282) generated intense fascination amongst Britain's antiquarians. Snagged from a Roman wreck 6.4km north of Herne Bay, these bowls earned this fishing ground the name "Pudding-pan-sand" in honour of the functional merits of these intact wares, which made perfect recycled desert receptacles on the dinner tables of the village's fishing community (Figs. 4-5).

By 1885, two to three dozen Roman bowls were being recovered in fishermen's oyster dredge nets each year, and by the early 20th century around 250 examples stamped with 216 Latin names had been catalogued (Smith, 1907: 275; 1909: 403). Despite a fieldwork project pursued by the British Museum and Southampton University to locate this rare Roman wreck off the UK, little if anything of the site seems to survive today. Various intact Baetican amphoras and tablewares trawled up elsewhere off the UK and Scotland, including Aberdeen, the Dogger Bank and the Thames Estuary (Figs. 8, 10), suggest that further Roman wrecks exist in deeper waters. Sherds from a Roman bowl caught off Denmark reside in the Great Yarmouth Museums (inv. GRYEH:1976.67).

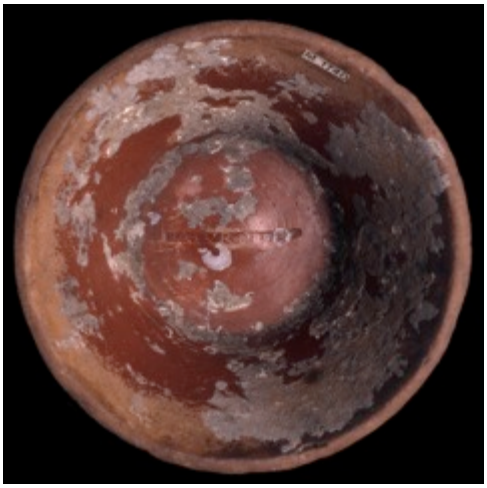

Fig. 4. A 2nd-century AD Samian ware pottery bowl made in Lezoux, central Gaul, recovered in an oyster dredge net at Pudding Pan Rock, Herne Bay, Kent, before 1805. Photo: the British Museum, Townley Collection. P&EE M 1740.

Fig. 5. An oyster dredge net in Whitstable Museum & Art Gallery of the type that snagged Roman 'pudding pans' off Herne Bay, Kent, in the 18th and 19th centuries.

Fishermen dredging for oysters in Chesapeake Bay in the early 20th century reported comparable chance finds from the Americas. On 18 November 1906, the *New York Times* described wreck impacts in the bay, a dangerous business because "The timbers catch the dredge, and the iron handles of the windlass are thrown back on the heads of the winders, and many a man has been killed by the stroke of the iron on his head. Finding a "hang" is dreaded more than anything else." More recently, in 1980 the *Decco 7* operating 72km off the mouth of the Chesapeake entangled its net on a 180kg concretion that was sold to the Mariners' Museum and proved to be a 2-pounder iron cannon associated with a wooden sabot and canvas shot bag containing 27 multi-sized iron shot (Rodgers, 1989).

Random finds derived from wrecks whose nuclei have never been located represent the most common impact form (Class 2). Their chronological range and typological variety are spectacular. The barbed Mesolithic bone point found in a large lump of

peat caught by the trawler *Colindia* working the Leman and Ower Banks off Norfolk in 1931 marked the beginning of awareness about many thousands of fossils and lithics recovered from the North Sea by trawlers running 10-13km-long track lines, whose nets penetrate between 4-8cm in a single pass (Verhart, 1995: 291; van Kolfschoten and van Essen, 2004: 70-72). The discovery of the original contexts from which these materials were netted, as was successfully tracked down in the case of Bouldnor Cliff submerged prehistoric landscape of *c*. 7,500-7,000 BP in the western Solent, first identified in 1976 after local fishermen dredged up timbers and peat (Momber, 2000: 86, 91), is the exception to the rule.

Fig. 6. Statue of a Victorious Youth before and after conservation, unknown maker, perhaps by a pupil of Lysippos, bronze with copper inlays, H. 151.5cm, 300-100 BC. Caught by a trawler off Fano in the northern Adriatic Sea in 1964. Photo: The J. Paul Getty Museum, Villa Collection, Malibu, California.

Class 2 impacts have yielded almost everything imaginable within the maritime archaeological record, including organic and metallic material culture rarely encountered on land and ranging from wooden cherub sterncastle decoration of *c*. 1700 in the North Sea (pers. comm. Ton van der Horst, 12 December 2009; Fig. 17) to 3-5 ton anchors trawled onto ships' decks off Denmark (Christoffersen, 1992: 43). Historically, the discovery of artefacts through the 20th-century exploitation of fishing grounds began off the UK with a 16th-18th century Spanish olive jar fished up in a scallop net in 1924 off Beachy Head (Curwen, 1927). Numerous elephant tusks brought up by fishermen of Potrieux in the 1930s gave rise to stories of an underwater mammoths cemetery submerged in the Saint-Brieuc region of Brittany, which

eventually proved to be a possible Dutch wreck off Saint-Quay-Portrieux dated to between 1711 and 1750 associated with a finbanker cannon, Delft domestic pottery and glass beads (Henry, 2005).

Fig. 7. The 'Dancing Satyr of Mazara del Vallo', a 4th-century BC bronze statue snagged in a fisherman trawler's net at a depth of 500 metres off Sicily.

Amphoras are the most common category of artefact netted from Mediterranean contexts, such as 'Pot Cave' off Andalusia, where since "time immemorial" fishermen have caught jars (Guasch, 1973: 113). In 1978 a trawler dredging for scallops east of the entrance to St. Peter's Port, Guernsey, brought up fragments of early 1st century AD Dressel 7-11 Roman amphoras from a depth of 50m (Keen, 1979: 87). The 200 objects in the George McGhee collection, snagged offshore by trawlers between Antalya and Alanya off southeast Turkey, and the equally extensive Ruth and Yair Kennet collection fished up 5-10km off Israel, span the entire history of amphora production and classical trade from the 16th century BC to the late Byzantine era (Zemer, 1977; Sibella, 2002). A separate study of 433 ceramics snagged off Israel between 1948 and 1963, dating from the Early Bronze I period (*c.* 3,300 BC) to the Islamic era, determined that only 20% of their find spots could be reconstructed (Barag, 1963). The largest ceramic pots caught in trawl nets are the largest forms manufactured by all past societies – Roman, Colonial period and post-medieval (Fig. 12) – typified by two stamped *dolia* of *c.* 50 BC to AD 50 landed from a site 240m deep off Ostia near Rome (Parker, 1992: 296).

Figs. 8-9. Left: a 2nd-3rd century AD Roman jug, H. 36.5cm, caught in a fisherman's net 24km off the coast of Aberdeen, Scotland. Photo: Aberdeen Maritime Museum, ABDMS084500. Right: a rare non-glazed Mamluk earthenware bottle with moulded decoration, H. 27.2cm, probably made in Syria or Palestine in the 14th century. Recovered in a trawl net in 1994 off Start Point, south Devon (Armitage and Armitage, 2005). Photo: Brixham Heritage Museum.

Fig. 10. A Roman amphora manufactured in Spain recovered in 1983 by a fishing trawler in the Thames estuary off north Kent. Found sealed and containing over 6,000 olives. Photo: © the National Maritime Museum, Greenwich, London, AOA0853.

Classical metallic finds tend to catch the public eye due to their aesthetic qualities and financial value. These include a concreted mass of Roman copper coins snagged by a trawlerman off La Ciôtat, France, in 1935 (Dumas, 1962: 52), a hoard of 4,000 4th-century AD bronze coins trawled up in a small amphora off La Meloria, Livorno, in 1965 and at least six Roman lead ingots, each weighing 70kg, brought up from 18m in a single trawl net off Le Petit Rhône, France (Parker, 1992: 275, 309). Museum quality artefacts include a colossal 0.7m-high head of the Roman emperor Augustus

sculpted in Luna marble caught in an oyster dredge in the Rhône Delta, France, a bronze statue of a 'negro boy' and a figurine of Isis-Fortuna netted in 1953 from depths of 88m and 100m off Bodrum and Marmaris, Turkey, and a 0.51m-high 1st century BC bronze satyr trawled up off Saintes-Maries-de-la-Mer in 1967 (Parker, 1992: 366, 377, 453).

The life-size Victorious Youth bronze statue is a Greek masterpiece dated between 300 and 100 BC that turned up in an Italian trawl net off Fano in the northern Adriatic Sea in 1964 (Mattusch, 1997; Fig. 6). Bought by the J. Paul Getty Museum in Malibu in 1977 for $3.95 million, in 2010 an Italian court ordered the artefact to be repatriated. The 2m-high, 4th century BC 'Dancing Satyr', netted from a depth of 500m, 80km off Mazara del Vallo, Sicily, by the *Capitan Ciccio*, is also at the centre of legal wrangling over ownership between fishermen and the State (Petriaggi, 2007; Fig. 7). The latest sensation to surface is a bronze statue delivered to the Ephorate of Underwater Antiquities in March 2005 recovered by a trawler fishing for cod 800km west of Kythnos at a depth of 500m (Sakellariou *et al*., 2007: 367). The volume of artistic masterworks lost to society is unquantifiable, but the extremely rare bronze ram of a war galley, decorated with the head of Medusa, found by a fisherman off Sanary, France, as early as 1877, and sent to a foundry to be melted down for scrap (Dumas, 1962: 52), is an unwelcome marker for the fate of many such casualties.

Fig. 11. A rare Langerewehe stone-ware jar of c. *1500 from Germany, recovered in a fisherman's net off Scotland. Photo: Scottish Fisheries Museum, Fife, ANSFM: 1990/22.*

A particularly delicate and problematic category of fishing impacts are snagged hull timbers, which in some cases have enabled wreck sites to be identified. Clear examples typifying Classes 4-5 come from UK territorial waters. The 11m-deep Dunwich Bank armed merchant vessel, dated to the second half of the 16th century, was discovered after a Southwold fisherman brought up ship's timbers and shot in a trawl net on at least three occasions between 1974 and 1993.[2]

The wreck of the *Stirling Castle* on the Goodwin Sands was first identified when a stern trawler struck a 'fastener' in 1979. More recently, inadvertent damage has been caused by gillnetters blown off course by currents and winds. Subsequent underwater inspections revealed a gill net snagged on the bow starboard with an upper frame missing and very large transom timbers measuring 56cm square by 6m, weighing approximately 2 tons, having disappeared (pers. comm. Robert Peacock, 8 and 9 March 2010). In a similar vein the wreck of HMS *Invincible* was found in 1979 when local fisherman snagged two pewter pots and large timbers (Bingeman, 2010: 21-22). In 1998, a trawler snagged and dragged up a 5m-long Anglo-Saxon dugout canoe in the vicinity of Southwold (Flemming, 2002: 35; cf.

Goodburn, 2008 for its interpretation as part of a fish trap; Fig. 13). A Neolithic wooden dugout has been reported in the Bulgarian press as similarly trawled up off Sozopol.

The damage that bottom gear can inflict on hulls is exemplified by four timbers caught in the net of the *Ho Bugt* trawler between the islands of Mando and Fano in the Wadden Sea, Denmark. The catch made in a single pass in 2006 consisted of a 37cm-wide and 4.05m-long keelson with mast step, a 2.55m-long floor timber and two planks measuring 2.05m and 2.61m in length. The timbers have been dated through dendrochronology to 1264. Fortunately the find was declared to the Fisheries and Maritime Museum in Esbjerg and the trawler even participated in subsequent surveys (Byskov, 2006; Auer *et al*., 2008).

Exactly the same classes of fishing impacts are common in American waters. Florida's royal red shrimp fishery overlies the former West Indies and American trade route of Colonial Spain. In 1954 a shrimp boat landed 450kg of wreckage – cannonballs, metal wares and ballast – from a deep-water site later identified by Seahawk Deep Ocean technology as a vessel probably associated with Spain's 1715 fleet (Vorus, 1997: 21). The 400m-deep Dry Tortugas shipwreck from the 1622 Spanish Tierra Firme fleet was first identified off the Florida Keys in 1965 when the shrimp boat *Trade Winds* snagged an obstruction that brought the vessel to a shuddering halt. The badly damaged nets contained three intact Spanish olive jars, various metallic artefacts, ship's rigging and a considerable amount of wood, including a section of ornately carved railing (Marx, 2009: 57).

Fig. 12. A 69cm-high jar fished up in nets off the Channel Isles and inscribed 'St Aubin En Bray Oise', indicative of manufacture 56km north of Paris. Photo: courtesy Shane Petit.

Following the recovery of an iron cannon in the late 1970s, a few years later a different trawler, the *Casey Jones*, dragged a 10cm-high wooden figurine, cannonballs, olive jars and ship's timbers off the Marquesas shrimp grounds, 80km off Key West, later identified by survey as a late 18th or early 19th-century wreck (Vorus, 1997: 21). Extensive impacts by shrimp trawlers on the 500m-deep Jacksonville 'Blue China'

shipwreck, a mid-19th century New York schooner excavated by Odyssey Marine Exploration, cut furrows into the site and caused the disappearance of over three-quarters of the ship's cargo (Gerth *et al*., 2011; Fig. 19).

Similarly, off southwest Louisiana the 24m-long *Lady Barbara* shrimper was stopped in its tracks in 1979 when its nets snagged on the *El Nuevo Constante*, a Spanish galleon lost in a hurricane in 1766. Its nets hauled up three copper ingots, each 50cm wide and weighing 32-36kg (Pearson and Hoffman, 1995: xv, 3). Some 80km off Louisiana another shrimp trawler landed hundreds of silver coins, which led to the infamous discovery of *El Cazador*, a Spanish warship lost in 1784 en route from Veracruz, Mexico, to New Orleans. A salvage operation recovered the ship's bell, cannon and over 12,000 silver coins in ten days. Elsewhere, off Texas a huge anchor from the 1554 fleet snagged by a shrimper, whose concretion conglomerate included chain rigging and rope fragments, has been donated to Raymondville Chamber of Commerce (Barto Arnold and Weddle, 1978: 322).

Further afield in the Far East the Portuguese 'Wanli' shipwreck of *c.* 1625 was discovered off peninsular Malaysia's east coast in 1997 and 1998 after pottery appeared in trawler nets (Sjostrand and Syed Idrus, 2007: 15). The Desaru shipwreck was located south of peninsular Malaysia in 2001 when a bottom trawler twice snagged its nets and recovered pottery sherds and a piece of ship's timber. When dived by Nanhai Marine Archaeology, the site was found to have been "shaved flat" and scattered potsherds littered a large area of seabed. Despite the subsequent placement of a hazard warning buoy over the site, by April 2002 trawlers had returned and the site was covered with broken planks and misplaced bulkhead frames, while a long steel chain and parts of a trawl net had snagged on the wreck's timbers. Three heavy longitudinal beams belonging to the mast support had vanished.[3]

4. Towards a philosophy of fishing impacts

How should society rationalize the public value of these myriad fishing-related discoveries? The 21st-century maritime *realpolitik* is most aptly comparable to archaeologists' pre-World War I perception of the effects of ploughing on terrestrial sites. In July 1870 Colonel Lane-Fox (later General Pitt-Rivers) wrote in the *Saturday Review* about plough damage to the Iron Age *oppidum* of Dyke Hills in Dorchester, where "At least a third of the dyke has already been lowered, and will gradually be utterly destroyed beneath the yearly passage of ruin's merciless plough share." His concern contributed to the creation of Britain's first Ancient Monuments Act in 1882 (Lambrick, 2004: 189). Despite the dazzling technological tools of the trade available to marine archaeologists, current political consciousness about the effects of fishing impacts on underwater cultural heritage stands where ploughing on land found itself in 1870.

The ploughing of archaeological sites on land serves as a close analogy for the current debate. Literature describing the serious effects of ploughing mushroomed in the 1970s, when discussions of technologies and vertical cutting potential led to the recognition in the UK that "Centuries of history can be destroyed for ever by one pass of the plough" (Lambrick, 1977: 32). Studies revealed that by 1970 an estimated less than 1% of the Berkshire chalk, 2% of Hampshire chalk and under 3% of Dorset

chalkland remained untouched beneath unploughed grasslands. Archaeologists slowly acknowledged that "we are facing a future that holds a completely modified rural environment; an environment in which the chances of locating and investigating well-preserved sites are rapidly diminishing… Much of the optimism of contemporary archaeology may be misplaced" (Yorston *et al*., 1990: 67-8). Cultivation was acknowledged to represent the greatest threat to archaeological sites by the early 1980s (Hinchliffe, 1980).

The 1995 Monuments at Risk Survey (MARS) sampled 5% of England in the form of 1,297 1 x 5km randomly distributed transects containing 14,591 recorded monuments. The results similarly concluded that cultivation was the single greatest hazard to the archaeology, accounting for 10% of their wholesale destruction and for 30% of their piecemeal loss (Darvill and Fulton, 1998: 3, 8).

Following 25 years of scrutiny, however, only in the last few years have practical steps been adopted through the Management of Archaeological Sites in Arable Landscapes Project undertaken by the Oxford Archaeological Unit in conjunction with the CBA, Oxford University and DEFRA. Nevertheless, major UK monuments remain under the plough. A recent condition survey of Avebury World Heritage site in Berkshire, for instance, revealed that predominantly arable farmland cultivation accounts for about 46% of the threats to the region's archaeological monuments (Lambrick, 2004: 188, 190). According to Wiltshire Council, around 50% of the 1,000 known monuments in the Avebury and Stonehenge Word Heritage Sites are still being ploughed (Young *et al*., 2008: 36). Balancing proportionate protection with essential access by farmers is a complex real-world problem.

Within marine archaeology, however, no consensus exists today about whether we face a problem requiring management, let alone agreement on management strategies. No legal, practical or proactive protocols have been proposed for mitigation. How has this mentality caught us so unawares, when marine ecologists have been tackling the matter head on for over four decades and encrusted wonders have been emerging from the world's oceans for 250 years?

One explanation is that technology-driven marine archaeology has come of age comparatively late compared to land archaeology. Due to complexities of site detection, access and thus awareness, an out of sight and out of mind mentality has prevailed as a default position. Because society cannot readily observe the full extent of the underwater resource (unlike in ploughed fields), it has not been visualized, quantified or afforded the same level of esteem as land sites. Desperately low funding and fewer practitioners are also part and parcel of the dilemma, leading to a compressed profile. Flatman (2007: 87), for instance, has calculated that the UK territorial sea zone currently has just one officer per approximately 20,150km^2 of seabed, compared to one officer per 482km^2 of land in Surrey. This disproportionate representation typifies the worldwide pattern.

5. The scale of the threat: case studies

The crux of the debate revolves around whether we should count ourselves fortunate that bottom trawling and fishing result in the discovery of the odd piece of underwater

cultural heritage or whether such finds are a microcosm of more severe damage. A major problem with understanding this impact form is the difficulty of proving a negative: once a beam trawler or scallop dredge has struck a hull and associated artefacts, within days or weeks at latest the furrows cut into the seabed will have smoothed over and subsequently currents and wave motion will wash away broken artefacts and disarticulated timbers. All that survives is a wreck site in an ever-diminishing state of preservation. In the absence of repeat site surveys, quantifying change is impossible. Absence of evidence, however, of course is not the same as evidence of absence. The above list of 'isolated' cultural catches is rarely peripherally divorced from a wreck site. The following more detailed case studies characterize the scale of impacts on the shipwreck archaeology itself.

Fig. 13. A 5m-long Anglo-Saxon dugout or industrial trough dated to AD 775-892 trawled up off Covehithe, Suffolk, in 1998. Photo: courtesy of Stuart Bacon, Suffolk Underwater Studies.

Of the 267 shipwrecks located during Odyssey Marine Exploration's 'Atlas' Shipwreck Survey Project, 112 sites (including 25 wooden, 70 steel and seven submarines) displayed evidence of fishing impacts. These ranged from abundant nets on 108 sites, gill floats snagged on 33 wrecks and trawler hopper gear caught on 17 sites. Although it is not demonstrable that all of these constitute direct impacts by bottom gear because fishermen sometimes dump broken or redundant gear on wrecks otherwise avoided as hangs (a very different problem in its own right), the pattern of damage is clear. Of particular concern are wooden wrecks that display several disturbing trends: an absence of pottery, which is omnipresent on almost all wreck forms worldwide; net fragments embedded within the sedimentological matrix down to depths of 30cm; furrows running directly through sites; and dragged cannon with scratched and broken surfaces.

Two wrecks reflect the scale of wider bottom trawling impacts. Site T7a35f-5 is an armed merchantman dated to *c.* 1670-90 found at a depth of 110m in the Western

Approaches. A poorly preserved cargo of elephant tusks and copper *manilla* bracelets characterizes the wreck, which as the sole example of this date and type off the UK is of high archaeological value. The passage of trawler gear and scallop dredges has been demonstrated by interlocking visual evidence. Side-scan sonar imagery has revealed linear, parallel-sided furrows running straight through the centre of the wreck caused by scallop fishing vessels towing 18 dredges per side (pers. comm. Michel Kaiser, 28 February 2009; Fig. 18). At least 12 of Site 35F's iron cannon have been dragged 60-300m offsite to both the north and southwest. Repeat monitoring surveys recorded one of seven cannon overlying the keel to have been dragged and flipped between 2008 and 2009. Additional guns display evidence of modern fishing cable abrasion and breakage (Cunningham Dobson and Kingsley, 2011).

Fig. 14. An iron cannon trawled up by a Lowestoft trawler off Kessingland, Suffolk, in 1975. The snagged gun carriage and decking were thrown back into the sea. The gun, possibly from the wreck of the Royal James *lost at Solebay in 1672, was not conserved and dried up and shattered. Photo: courtesy of Stuart Bacon, Suffolk Underwater Studies.*

Site MUN-T1M25c-1, the wreck of Admiral Sir John Balchin's First Rate HMS *Victory* lost on 5 October 1744 (Cunningham Dobson and Kingsley, 2010), displays further evidence of fishing impacts. The 61 x 22m visible wreck site is covered with eroded small finds (galley hearth brick, crushed copper vessels), rigging and disarticulated planking scattered between 43 bronze cannon. The surface again contains no pottery vessels or fragments. In 2008, a series of four sets of beam trawler furrows was recorded on side-scan imagery 500-1,000m east-northeast of the wreck site. A new set of furrows was documented by Wessex Archaeology just 100m from the wreck in 2009. The majority of surface cannon on the wreck display breakage of their depositional marine concretions and extensive scratches, while three 3.5-ton guns have been dragged 48-233m offsite. Between 2008 and 2011, 100% of the seven archaeological surface areas examined by monitoring on the *Victory* site were impacted by fishing activities and 2.7m-long sections of wood disappeared (Kingsley *et al*., 2012).

These observations for widespread impacts off the UK are not isolated. Prehistoric bones caught in nets have been raised since the early 20th century from the submerged area of Doggerland, 90-110km off the east coast of Britain. The

University of Birmingham's mapping of nearly 23,000km^2 of this former prehistoric land mass lost to sea rise *c*. 6000 BC concluded that some 54% of the surface area of the North Sea as a whole is affected by beam trawling today, largely conducted by Dutch vessels, and that an estimated 57 tonnes of faunal remains may be scraped off the surface of the seabed over a five-year period. Much of the associated finds are either dumped without recording or sold on eBay (Gaffney *et al.*, 2009: 153). This data has disturbing repercussions for shipwrecks within the same catchment zone.

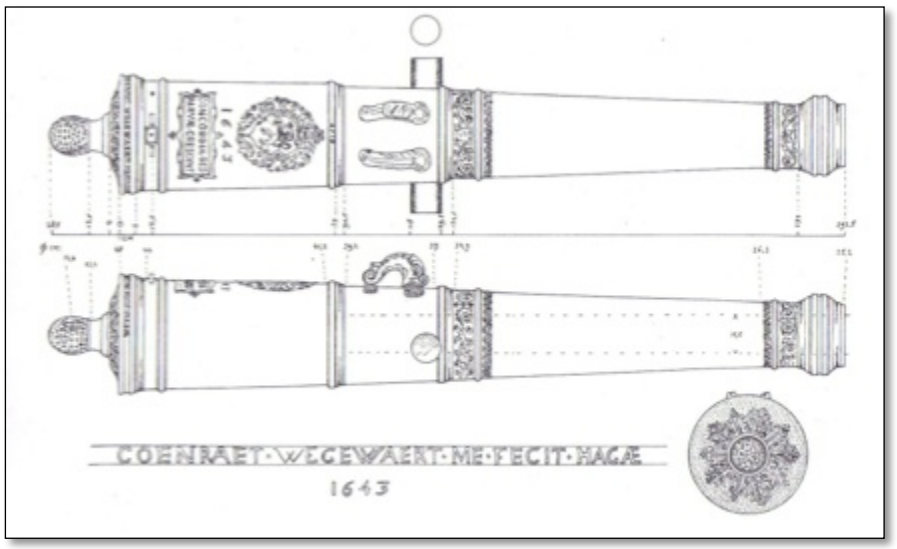

Fig. 15. A bronze 24-pounder cannon of 1643 from the wreck of the 73-gun Dutch warship Eendracht*, sunk in the Battle of Lowestoft in the North Sea in 1665. One of 20 cannon snagged from the site by Dutch fishing nets. Photo: by and courtesy of Nico Brinck.*

In addition to these publicized case of trawled (and dredged) mammal remains off the UK, in the last ten years Nico Brinck has recorded 50 cannon, weighing up to 2.3 tons, brought into the Netherlands by Dutch fishing trawlers working in the English Channel and North Sea. A further 20 snagged bronze cannon seem to be associated with the 73-gun Dutch flagship *Eendracht* (Fig. 15), sunk in the Battle of Lowestoft in the North Sea in 1665 (Brinck, 2008). These overall figures suggest that since 1970 at least 200 cannon may have been caught in the nets of fishermen based in Holland. Other finds netted by Dutch trawlers include the stern section of an English submarine, conning towers, complete cars, cargo containers, torpedoes, anchors, airplane engines and modern artillery and mines (pers. comm. Nico Brinck, 5, 11 and 15 March 2011).

Another iron cannon was snagged in 2009 by a Dutch trawler working over the Dutch East Indiaman wreck of the *Vliegenthart*, sunk off Holland in 1735. The wreck was covered with nets when first discovered, one bronze cannon had been displaced around the site and another's surface damaged by the friction of fishing cables. When fieldwork directed by Rex Cowan first commenced in 1979 the sternpost protruded 2.20m above the seabed. By 2002 uninterrupted fishing activities across the site had reduced the sternpost's height to 30cm (pers. comm. Ton van der Horst, 12 December 2009).

The total volume of cannon snagged off the UK since the 1970s by British, Dutch, French and Belgium trawlers, retained as garden attractions, sold or left to crumble, is unquantifiable. Given their status as the heaviest class of artefact recovered in trawl nets, cannon serve as 'trace elements' for abundant smaller and lighter sets of material culture and wooden hull structures lost to science.

Fig. 16. An iron cannon fished up 64km southeast of the Shetland Islands off northeast Scotland in 1994 bearing the moulded name 'Bacon' and cast at Hirwaun Furnace in Breconshire in 1780-86. Photo: Fraserburgh Heritage Centre.

Moving into the Mediterranean realm, in the mid-1980s crushed copper cauldrons, three 24-pound cannon balls, a sword blade and a sabre hilt were caught in fishing nets 11km off Punta Tagliamento, northern Italy, followed by a 1.65m-long iron cannon recovered by the motor-trawler *Albatvos* in 2001. The wreck was subsequently identified at a depth of 17-19m as the Napoleonic brick *Mercure*, lost in 1812. In common with the whole coast of the North Italian Adriatic, surveys demonstrated that the seabed displayed widespread evidence of trawler "ploughing" and side-scan sonar imagery revealed clear traces of furrows left in the seabed by *rapidi* and *turbosofianti* bottom trawls, which "have a devastating impact upon submarine archaeological deposits, causing damage and dislodging". Numerous net fragments and lines belonging to fishing equipment littered the site, ropes and cables were found under 20cm of sand and the archaeological remains were scattered across an area of 100m (Beltrame and Gaddi, 2002: 60, 62).

Within the North Adriatic as a whole every square metre of the sea bottom has been calculated to have been swept by trawlers at least three times. Eight kilometres offshore on the 15m-deep Roman wreck of Grado the necks of the upper level of amphoras were found decapitated, the "typical effect to the passage of the trawls on the cargos of amphoras".[4]

The 4th-century AD Levanzo I wreck found off northwest Sicily in 2006 by the Ufficio di Soprintendenze del Mare and the RPM Nautical Foundation adheres to this consistent pattern. Many areas were "scraped clean of virtually all biological presence

and loose stones, leaving a barren, flat landscape. The only features are long drag marks that crisscross the seafloor and flat rock outcrops…" Scattered and damaged artefacts dumped by ripped nets and associated with snagged fishing gear were only present in areas where the dragging ended due to the presence of rocky outcrops elevated about half a metre above the seabed. The surviving wreck mound stood less than 30cm high. A bronze ram and Roman bronze helmet recovered from the same area by drag-net and static-net fishermen cautions about the quality of regional heritage at risk (Royal, 2010: 9; Royal and Tusa, 2012).

The Ephorate of Underwater Antiquities of the Greek Ministry of Culture and the Hellenic Centre for Marine Research joined forces in 2004 to map the underwater cultural heritage around Chios (7km^2 survey) and Kythnos (6.6km^2) in the Aegean Sea, where down the decades amphoras and statues had surfaced in trawler nets. Two Hellenistic wrecks were identified using side-scan sonar in areas displaying significant cod trawler furrows, several tens of centimetres deep and about 1-2m wide. In one case amphoras had been displaced by trawler doors, leaving behind shallow furrows across the site (Sakellariou *et al*., 2007: 377-8).

Fig. 17. A wooden cherub from a sterncastle of c. *1700 snagged in a Dutch fisherman's net in the North Sea and brought into the port of Flushing, Holland. Photo: Ton van der Horst.*

Another survey project, conducted in Turkey's Eastern Aegean Sea in 2008 and 2009 by the Institute for Exploration and the Center for Ocean Exploration and Archaeological Oceanography at the University of Rhode Island, compared the condition of wrecks within and beyond the confines of areas excluded to trawlers by Turkey's Fisheries Law 1971. The law is not tailored to specifically protect shipwrecks, which is a fortuitous side effect of the prohibition against trawling within 2.5km of shore and within 100m to either side of submarine communications cables. The survey recorded 11 ancient wrecks around the Bodrum and Datcha peninsula, all within the areas restricted to bottom fishing. Away from these zones the seabed

displayed a "brushed metal appearance" and no shipwrecks were found, raising the question of whether they survive today at all beyond the relative security of the exclusions zone.

Type	Fishing Impacts on Wrecks
Type 1	Broken artefact assemblages (pottery/glass).
Type 2	Broken hull structure.
Type 3	Loosening of archaeological strata. Exposure of wrecks to oxygen, leading to ongoing deterioration of organic remains.
Type 4	Decontextualization, inadvertent recovery, loss and destruction of artefacts.
Type 5	Snagging and breaking of hull structure, leaving planking susceptible to being washed off-site by bottom currents.
Type 6	Dragging of artefacts out of context and off site, leading to loss by current motion.

Table 1. A classification of fishing impacts on wreck sites.

Within the no-trawl zones the shipwreck formations showed differing levels of disarticulation. Sites in naturally sheltered areas avoided by trawls as hazards pre-1971 consisted of high mounds of intact amphoras. At the opposite extreme, on severely impacted wrecks trawled before the imposition of the 1971 legislation all that remained were half a dozen amphoras and small piles of ballast stones. The damage to these wrecks is considered "inevitable" and the "extent of trawling in the region suggests that there may be a greater loss of cultural sites to modern fishing activities in the Aegean than we can physically document" (Brennan, 2010: 4-5).

Off the waters of America's Stellwagen Bank National Marine Sanctuary, an 842 square-mile protected marine zone at the mouth of Massachusetts Bay managed by the National Oceanic and Atmospheric Administration (NOAA), fishing gear has impacted nearly all historic shipwrecks. Underwater surveys initiated in 2008 revealed the "severe impact" that fishing has inflicted because on an annual basis "virtually every square kilometer of the sanctuary is physically disturbed by fishing activities, including bottom trawling and dredging. Some wrecks are covered in nets while others have been stripped of all upper structure and metal hardware" (Marx, 2010: 8).

These more detailed case studies confirm the worldwide picture, for instance as noted in the Gulf of Naples and off Egypt and the Black Sea (Ballard, 2008: 136). Woods Hole Oceanographic Institute surveys off Malta beyond depths of 500m once more encountered furrows in the sediments, indicative of intensive trawling, leading to the conclusion that "It is unlikely that many ancient archaeologically significant sites will survive in areas subjected to trawl fishing."[5]

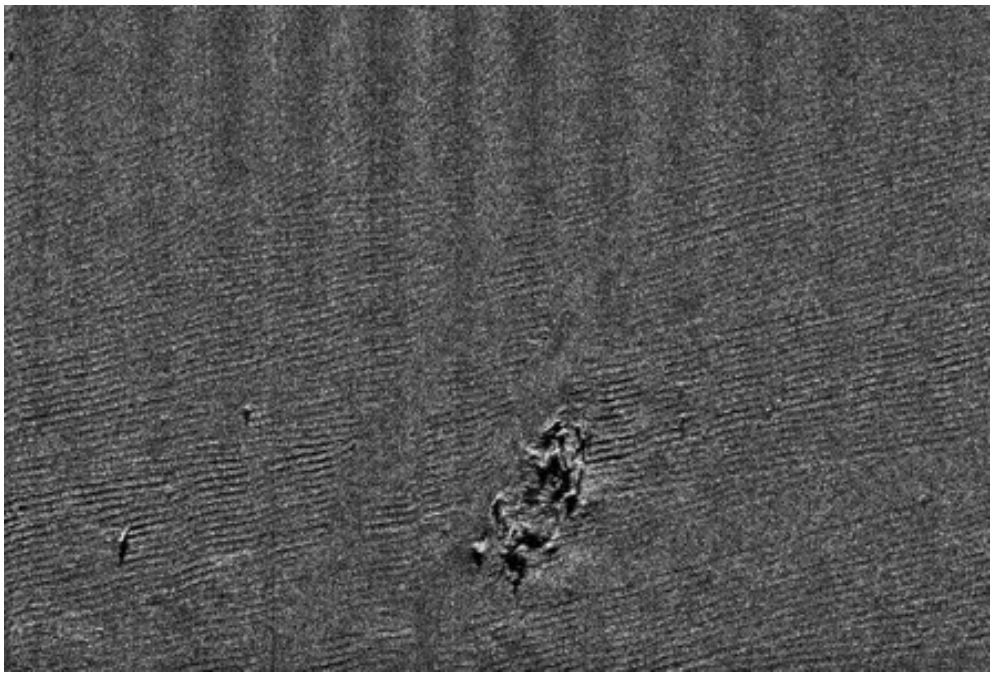

Fig. 18. A side-scan sonar image in the Western Approaches to the English Channel showing furrow lines cut by a scallop dredge boat through a rare shipwreck of c. *1670-90 (Odyssey site 35F). At a depth of 110m, little of this English merchant vessel's hull or cargo of African elephant tusks and copper manilla bracelets survives due to fishing impacts. The wreck may be the only English Royal Africa Company ship found. Photo: © Odyssey Marine Exploration.*

Off Spain, highly destructive fishing techniques have had disastrous consequences on marine fauna, "often accompanied by the disappearance of entire undersea archaeological sites" (Negueruela, 2000: 180). Trawling in coastal waters in the Far East has been defined as the most serious threat to underwater cultural heritage off China and Taiwan (Kuen-chen, 2006: 19). The same holds true for the Wadden Sea off the Netherlands (Manders, 2006).

In addition to the author's opinion that fishing impacts comprise the least known, but geographically most severe anthropogenic threat to underwater cultural heritage, in his former capacity as President of the Institute of Nautical Archaeology at Texas A&M University Prof. James Delgado (2009: 3) argued that:

> "The world's greatest 'museum' rests at the bottom of the sea, and it is under an unparalleled assault that makes the looting of the National Museum in Baghdad, or the Taliban's demolition of the Buddhas of Bamiyan in Afghanistan, pale in comparison. Every day deep sea trawlers smash through shipwrecks, scraping them away and destroying fragile remains of the past that have remained undisturbed for millennia… Every shipwreck destroyed in the fashion is lost forever... We cannot afford to simply stand by, nor can we blindly hope that opposing trawling or regulating it will solve the problem."

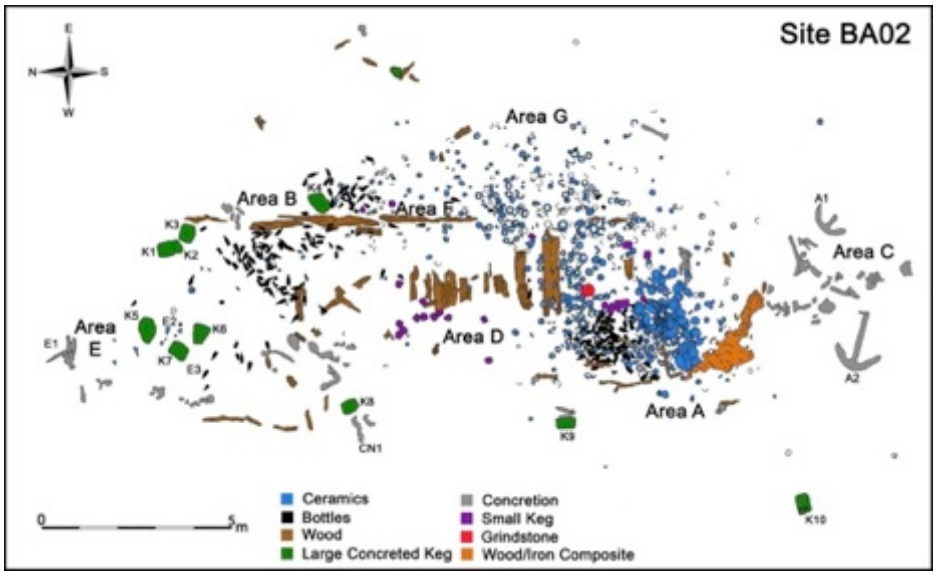

Fig. 19. The Jacksonville 'Blue China' shipwreck of c. *1854, found by Odyssey Marine Exploration at a depth of 370 metres, 70 nautical miles off southern Florida, after shrimp fishermen snagged 'oriental' ceramics over a period of 40 years. Other than a well-preserved pile of Staffordshire pottery in Area A, the cargo has been heavily dragged out and destroyed. Photo: © Odyssey Marine Exploration.*

The above cross-section of impacted sites contains a dizzying array of natural, technological and archaeological x-factors that dictate at the micro level varying levels of damage and preservation that are not scientifically understood. In exactly the same way that many variables determine the effects of ploughing on archaeological remains on land, including soil and bed rock type, topography, type and condition of the archaeological remains, previous cultivation and the type and usage of current cultivation equipment (Lambrick, 1980), an interlocking set of factors will condition levels of shipwreck preservation impacted by bottom fishing:

• Sediment composition and structure. Is a wreck deeply concealed under relatively stable sediments or within a dynamic environment, leaving artefacts and timbers susceptible to exposure and impact by bottom gear?

• Site topography and elevation: wrecks lying on a flat, sandy seabed are at greater risk than those on slopes, flanked by natural boulders, undulating rock surfaces or durable ship's structure that cushion remains from damage.

• Natural site preservation: prior to impacts, sites may be well preserved and coherent or already badly scattered through natural deterioration and looting. Absence of data about the effects of bottom current motion is a significant x-factor in this equation.

• Fishing impact form: long lines or lobster/crab potting are less aggressive forms of impact than beam trawling and scallop and clam dredges.

• Previous impacts: the number of times that a wreck has been impacted will affect levels of preservation and mechanical erosion.

• Historical timeframes of equipment usage: sites impacted post-1950s by bottom gear towed by boats with more powerful engines and synthetic nets that are more robust than hemp will be more susceptible to damage.

Bearing these grey areas in mind, at the current level of study six general types of impacts caused by fishing equipment may be proposed (Table 1), ranging from the breakage of struck artefacts (Type 1) to more extensive site destruction through the snagging and dislocation of hull timbers (Type 6).

Fig. 20. A collection of iron anchors snagged in trawl nets off Scotland. Photo: Scottish Fisheries Museum, Fife.

6. Seeking sustainability

Just as archaeologists have realized in relation to ploughing on land that the future will contain a wholly modified rural environment, where the opportunity to locate and study well-preserved sites is rapidly declining (Yorston *et al*., 1990: 67-8), it is unavoidable not to reach an identical conclusion for the impact of bottom fishing on global underwater cultural heritage. There is no reason to be left treading water, however. The trials and tribulations of ploughing on land and extant mitigation policies underwater provide modern templates for modelling suitable protocols for safeguarding elements of the deep. How can parity of esteem for sunken wrecks with land sites be developed?

Society must acknowledge as a fundamental truth that irreversible damage has been inflicted on delicate underwater cultural heritage in the past and, unchecked, will continue. Just as metal detecting and ploughing have supplied unexpected new primary data, we have no alternative but to seek positives, not problems, in mitigating fishing impacts. Society needs seafood and the continued commitment of fishing communities. No single magic bullet exists and solutions lie beyond the scope of this paper. However, some basic universal observations may be applicable.

A line in the sand could be drawn by imposing what may be termed a Wreck Amnesty for Fishermen (WAF) to declare inadvertently snagged artefacts, along the lines of those initiated more generally for divers in Australia in 1993 (that resulted in 20,000 artefacts being declared; Rodrigues, 2009), the UK in 2001 and Bermuda in 2003. Funded monitoring programmes can also be cost-efficient and yield dramatic results.

An excellent model is English Heritage and Wessex Archaeology's protocol for reporting finds of archaeological value exposed and recovered by sand and gravel dredges sponsored by the former Aggregate Levy Sustainability Fund. The protocol came into effect in 2005 and applied to the wharves and vessels of all British Marine Aggregate Producers Association (BMAPA) companies in the United Kingdom and on the Continent, primarily the Netherlands. An associated Awareness Programme generated significant self-enlightenment and goodwill within the BMAPA. Each wharf or vessel has a voluntary Site Champion, who reports discoveries to a Nominated Contact within the company who, in turn, alerts Wessex Archaeology staff. Fresh finds are investigated through an Implementation Service.[6] Some 784 finds have been declared since 2005, dating from the Palaeolithic period onwards.

Despite greater secrecy by fishermen about the locations of their hangs, often over valuable grounds, there is reason to be optimistic that a similar education and outreach programme established by port, fishing or government authorities for fishing vessels could yield promising results. Results of the Fishing Protocol for Reporting Archaeological Discoveries focused on the Sussex Inshore Fisheries Conservation Area are not yet available.[7]

Sustainable management that is proactive rather than reactive requires access to a monetary war chest. Marine archaeology is infamously badly resourced. Applying the global concept of the 'polluter pays' principle offers an obvious route to salvation: just as the dredging and offshore gas and oil industries are charged with reducing the effects of mitigation on shipwrecks or submerged prehistoric settlements at risk, the far more geographically wide footprint of the fishing industry could be 'taxed' in the same way at the national level. Where this maroons sites located beyond territorial waters not subject to national legislation – crisscrossed by commercial trawlers to depths of 2,000m (Roberts, 2007: 309) – remains a labyrinthine legal issue.

Ultimately, the optimum means of managing fishing impacts demands awareness of the size and character of the resource, compiled through comprehensive offshore surveys using side-scan sonar and magnetometers. Technologically, such programmes are achievable; financially, they are likely to be non-starters. Thus, it would seem most realistic to deal with the current issue on a site by site basis. The UK model of objectively classifying sites according to significance (evidential, historical, aesthetic and communal value: Dunkley, 2008) could transfer seamlessly to fishing industry-impacted wrecks as a sound means of management.[8]

Practical on-site mitigation options are widely varied, from non-disturbance to intrusive measures. At the most benign end of the spectrum, the modern trend favouring preservation *in situ* is not universally viable on many fished seabeds. Exclusion and buffer zones and geofencing are increasingly being considered for unique marine habitats, where they are identified as the fundamental underpinning of management (Roberts, 2007: 376-7. While the conversion of select fishing grounds containing shipwrecks into marine parks is realistic in shallows, it is a fool's paradise beyond sight of land and in international waters, where it is hard to envisage how legislation and funding will be obtained to monitor and impose fines as necessary.

The concept of exclusion zones within marine ecology is to permit the regeneration of fish populations and marine habitats, and is not an open-ended initiative. The ring-fencing of a shipwreck, by contrast, would need to be a permanent measure with all the financial and administrative repercussions entailed. Seeking consensus to turn the equivalent of the total 30% of world seabed's required to save fishing stocks into shipwreck reserves (Roberts, 2007: 378, 381) is unlikely to be received positively by heads of states.

The preference for *in situ* preservation in some heritage circles has evolved out of financial restrictions, awareness of the massive costs of excavation, conservation and publication (the 'Mary Rose Syndrome') and ecological concepts of sustainability triggered by concern over mankind's hyper-exploitation of the natural world. Because archaeological remains do not breed and lack the propensity for self-generation (Carman, 2004: 256), in some cases excavation and not preservation may be the most sustainable form of protecting finite and non-renewable trawled resources: removing remains at risk from harm's way.

This historical particularism model (cf. Bass, 1983: 103) should not be ignored because it has a global tradition for both sites endangered by development and those of major evidential value and has justified widespread excavation projects and recoveries from complete hulls, including the Gela wreck of 600 BC off Sicily, the Ma'agan Michael wreck of 400 BC off Israel, to extensive assemblages from the 18th-century corsair wrecks undergoing excavation off St. Malo, France, and the entire 7 x 6m 'Seahenge' timber circle built in 2049 BC at Holme-next-the-Sea in Norfolk. Least we forget, large-scale excavation is the cornerstone of archaeology and comprehension of the sunken past for science and public alike (cf. Bass, 2011: 10).

Integrated solutions as exist on land are likely to remain a pipedream underwater in the near future, where the past is envisioned to a greater degree as more of a luxury than as a resource (Giesecke, 1987: 227). Assessing what should be saved and what may be sacrificed requires an understanding of the character and scale of the resource, its archaeological and cultural significance and value, what has been lost, what is most vulnerable and where the most serious risks lie – no means task and a call for brave decisions.

The reality is also confused by the rhythms of the global fishing industry. Wreck impacts are obviously embedded within fishing intensity. Statistics compiled by the Food & Agriculture Organization of the United Nations reveal that global capture fisheries production in 2008 stood at about 90 million tonnes, with an estimated first-sale value of $93.9 billion, comprising about 80 million tonnes from marine waters and 10 million tonnes from inland waters. By 2008, an army of 44.9 million people was directly engaged in capture fisheries or aquaculture. For each person employed, about three further jobs are produced in secondary activities, creating a total of over 180 million jobs worldwide. Analyses indicate that the global fishing fleet comprises about 4.3 million vessels of which 59% are engine powered.[9] Fishing is huge business of major economic and social value. To demand that the industry must tiptoe around the sunken past is a Utopian ideal that has no chance of becoming reality.

In one respect there is a warped saving grace within these figures if assessments that over-exploitation has reached the point of no return prove accurate. For instance, in the UK 14.2 times more landings were made in 1937 than today (Thurstan *et al*., 2010: 5). The proportion of overexploited, depleted or recovering stocks reached 32% in 2008 and most of the top ten species, which account in total for about 30% of the world marine capture fisheries production, are fully exploited. Estimates suggest that globally most of the world's major fishery species have declined by 75-95% or more (Roberts, 2012: 46). Many studies suggest that fishing of the post-1970 scale has hit the end of the line and that decimated stocks will see a dramatic curtailment in offshore fishing. In this model the peak curve of damage inflicted on shipwrecks may have spiked.

Changes in technology may also improve the fate of the deep. Over the last 15 years, for instance, the Dutch trawler fleet has been cut by at least 50% due to the quota system. Pulse trawling is also undergoing trials in Holland that relies on a self-steering foil and lighter bottom gear installed with an electronic tickler system that both saves on fuel and is suggested to decrease bottom contact by up to 84%. Despite concerns that this technology may electrocute mass localized fish stocks, ICES reviews of experiments are encouraging.[10]

Whether large-scale bottom trawling and scallop dredging continue unabated or cease entirely, marine archaeology finds itself wandering confused around a moral maze. If fishing prevails at current levels, steps need to be taken towards sustainable mitigation. If it declines, the discipline will be left with severe wounds for which raising funds to record and understand the scale of former impacts will be a hard sell. Whatever the fate of the deep, with so little perceived commercial value underwater cultural heritage is always likely to be politically judged a hindrance. Shipwrecks and impacted prehistoric sites will remain rooted to the bottom of the marine-based food chain. Saving and protecting a minor sample of the most significant elements of this history has to remain the realistic priority.

Acknowledgements
Special thanks for advice and comments on this paper are extended to Dr. Thomas F. King and Prof. Robert Hohlfelder (University of Colorado at Boulder). Greg Stemm kindly read this text and provided access to Odyssey Marine Exploration's extensive database on deep-sea shipwrecks. I am indebted to Stuart Bacon (Suffolk Underwater Studies), Nico Brinck, Richard Keen, Bob Peacock, Charles Trollope, Ton van der Horst (Archeo Nautic) and Sterling Vorus for sharing unpublished data and their first-hand experience of offshore trawling and its effects. Douglas McElvogue and Simon Davidson offered pointers to literature and some impacted sites.

Various organizations generously provided data about fishing snags and photographs of artefacts to include in this report: Philip Armitage, Curator, Brixham Heritage Museum; Meredith Greiling, Curator of Maritime History, Aberdeen Maritime Museum; Linda Fitzpatrick, Curator, Scottish Fisheries Museum, Fife; the J. Paul Getty Museum, Villa Collection, Malibu, California; the National Maritime Museum, Greenwich; Chris Read, Fraserburgh Heritage Centre; Dayna Woolbright, Assistant Curator, Great Yarmouth Museums. All errors in this paper are my own.

Notes

1. See *Archaeological Damage from Offshore Dredging: Recommendations for Pre-Operational Surveys and Mitigation during Dredging to Avoid Adverse Impacts* (US Mineral Management Service, 2004); *UKCS. Offshore Oil and Gas and Wind Energy Strategic Environmental Assessment* (Wessex Archaeology, 2009).

2. *Dunwich Bank, Suffolk. Designated Site Assessment: Archaeological Report* (Wessex Archaeology, Salisbury, 2006), 4.

3. See http://www.maritimeasia.ws/desaru/site.html.

4. Beltramo, C., *The Impact of the Fishing Trawling on the Shipwrecks along the Italian Coast of the North Adriatic Sea*: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/impacting-factors/trawling-and-fishing.

5. Foley, B., *Impact of Fishing on Shipwrecks*: http://www.whoi.edu/sbl/liteSite.do?litesiteid=2740&articleId=4965.

6. See *Protocol for Reporting Finds of Archaeological Interest. Annual Report to BMAPA 2009-2010* (Wessex Archaeology, 2010).

7. For the Fishing Protocol for Reporting Archaeological Discoveries, see http://fipad.org.

8. See also *Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment* (English Heritage, 2008), 28-32.

9. *State of World Fisheries and Aquaculture 2010* (Food & Agriculture Organization of the United Nations, Rome, 2010), 5-8.

10. See http://www.ices.dk/committe/acom/comwork/report/2009/Special%20Requests/ Netherlands%20Pulse%20Trawl.pdf.

Bibliography

Armitage, P. and Armitage, K., 'An Unexpected 'Catch' for the Brixham Trawler *Catear*', *Medieval Ceramics* 29 (2005), 44-5.

Auer, J., Thomsen, M.H. and Maarleveld, T., 'Knudedyb Ahoy!', *Maritime Archaeology Newsletter from Denmark* 23 (2008), 10-14.

Ballard, R.D., 'Searching for Ancient Shipwrecks in the Deep Sea'. In R.D. Ballard (ed)., *Archaeological Oceanography* (Princeton University Press, 2008), 131-47.

Barag, D., 'A Survey of Pottery Recovered from the Sea off the Coast of Israel', *Israel Exploration Journal* 13 (1963), 13-19.

Barto Arnold, J. and Weddle, R., *The Nautical Archaeology of Padre Island. The Spanish Shipwrecks of 1554* (New York, 1978).

Bass, G.F., 'A Plea for Historical Particularism in Nautical Archaeology'. In R.A. Gould (ed.), *Shipwreck Anthropology* (University of Mexico Press, 1983), 91-104.

Bass, G., 'The Development of Maritime Archaeology'. In A. Catsambis, B. Ford and D.L. Hamilton (eds.), *The Oxford Handbook of Maritime* Archaeology (Oxford University Press, 2011), 3-22.

Beltrame, C. and Gaddi, D., 'Report on the First Research Campaign on the Napoleonic Brick, *Mercure,* Wrecked off Lignano, Udine, Italy in 1812', *International Journal of Nautical Archaeology* 31.1 (2002), 60-73.

Bingeman, J., *The First HMS* Invincible *(1747-58). Her Excavations (1980-1991*) (Oxford, 2010).

Brennan, M.L., 'The Disarticulation of Ancient Shipwreck Sites by Mobile Fishing Gear: a Case Study from the Southeast Aegean Sea', *INA Quarterly* 36.4 (2010), 4-5.

Brinck, N., 'Ordnance for the New Zeven Provinciën', *Journal of the Ordnance Society* 20 (2008), 25-33.

Byskov, S., 'Parts of a Wooden Shipwreck Found in the Wadden Sea', *Maritime Archaeology Newsletter from Denmark* 21 (2006), 16-17.

Carman, J., 'Putting Remains Back into History: Creating a Sustainable Historic Environment'. In T. Nixon (ed.), *Preserving Archaeological Remains In Situ?* (MOLAS, London, 2004), 254-60.

Christoffersen, J., 'The Danish National Record of Marine and Maritime Sites'. In D.H. Keith and T.L. Carrell (eds)., *Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference* (Society for Historical Archaeology, Kingston, 1992).

Clover, C., *The End of the Line* (London, 2005).

Cunningham Dobson, N. and Kingsley, S. 'HMS *Victory*, a First-Rate Royal Navy Warship Lost in the English Channel, 1744. Preliminary Survey & Identification'. In G. Stemm and S. Kingsley (eds.), *Oceans Odyssey. Deep-Sea Shipwrecks in the English Channel, the Straits of Gibraltar and the Atlantic Ocean* (Oxford, 2010), 235-80.

Cunningham Dobson, N. and Kingsley, S., *A Late 17th-Century Armed Merchant Vessel in the Western Approaches (Site 35F)* (OME Papers 23, Tampa, 2011).

Curwen, E.C., 'Recent Finds off the Sussex Coast', *Sussex Notes and Queries* 1 (1927), 190-1.

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).

Darvill, T. and Fulton, A., *MARS: the Monuments at Risk Survey of England, 1995. Summary Report* (London, 1998).

Delgado, J., 'Inside INA. A Letter from the President', *INA Quarterly* 36.3 (2009), 3.

Dumas, F., *Deep-Water Archaeology* (London, 1962).

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 Biogeochemistry in the North Sea', *Geochemical Transactions* 14 (2001), 1-6.

Ferrari, B., *Physical, Biological and Cultural Factors Influencing the Formation, Stabilisation and Protection of Archaeological Deposits in UK Coastal Waters* (Ph.D. Thesis, University of St. Andrews, Scotland, 1994).

Flatman, J., 'The Origins and Ethics of Maritime Archaeology – Part 1', *Public Archaeology* 6.2 (2007), 77-97.

Flemming, N.C., *The Scope of Strategic Environmental Assessment of North Sea Areas SEA3 and SEA2 in Regard to Prehistoric Archaeological Remains* (Department of Trade and Industry: Report Nr TR_014, 2002).

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.

Gaffney, V., Fitch, S. and Smith, D., *Europe's Lost World. The Rediscovery of Doggerland* (York, 2009).

Gerth, E., Cunningham Dobson, N. and Kingsley, S., 'The Jacksonville 'Blue China' Shipwreck (Site BA02): A Mid-19th Century American Coastal Schooner off Florida'. In G. Stemm and S. Kingsley (eds.), *Oceans Odyssey 2. Underwater Heritage Management & Deep-Sea Shipwrecks in the English Channel & Atlantic Ocean* (Oxford, 2011), 143-220.

Giesecke, A.G., 'The Future Underwater'. In P. Throckmorton (ed.), *History from the Sea. Shipwrecks and Archaeology* (Barcelona, 1987), 226-27.

Goodburn, D.M., 'Possible Dugout Trawled from the Sea Near Covehithe', *Saxon* 48 (2008).

Guasch, R.P., 'Underwater Archaeology in Andalusia (Almeria and Granada)', *International Journal of Nautical Archaeology* 2.1 (1973), 107-19.

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

Henry, N., 'Un témoin du commerce négrier: l'épave des Poulins'. In M. L'Hour and E. Veyrat (eds.), *La mer pour mémoire. Archéologie sous-marine des épaves Atlantiques* (Paris, 2005), 178-9.

Hinchliffe, J., 'Effects of Ploughing on Archaeological Sites: Assessment of the Problem and some Suggested Approaches'. In J. Hinchliffe and R.T. Schadla-Hall (eds.), *The Past Under the Plough* (London, 1980), 11-17.

Irion, J.B., Ball, D. and Horrell, C.E., 'The US Government's Role in Deepwater Archaeology: The Deep Gulf Wrecks Project', *International Journal of Historical Archaeology* 12 (2008), 75-81.

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.

Keen, R., 'Guernsey, Channel Islands: Little Russel Amphora Site A', *International Journal of Nautical Archaeology* 8 (1979), 87.

King, E., 'An Account of an old Piece of Ordnance, which some Fishermen Dragged out of the Sea near the Goodwin Sands, in 1775', *Archaeologia* 5 (1779), 147-57.

Kingsley, S., 'Deep-Sea Fishing Impacts on the Shipwrecks of the English Channel & Western Approaches'. In G. Stemm and S. Kingsley (eds.), *Oceans Odyssey. Deep-Sea Shipwrecks in the English Channel, the Straits of Gibraltar and the Atlantic Ocean* (Oxford, 2010), 191-234.

Kingsley, S., Cunningham Dobson, N. and Van de Walle, F., *Balchin's* Victory *(Site 25C): Shipwreck Monitoring & Cannon Impacts, 2008-2012* (OME Papers 24, Tampa, 2012).

Kuen-chen, F., 'China (Including Taiwan)'. In S. Dromgoole (ed.), *The Protection of the Underwater Cultural Heritage. National Perspectives in Light of the UNESCO Convention 2001* (Leiden, 2006), 17-41.

Lambrick, G., *Archaeology and Agriculture* (Council for British Archaeology & Oxfordshire Archaeological Unit, Leamington, 1977).

Lambrick, G., 'Effects of Modern Cultivation Equipment on Archaeological Sites'. In J. Hinchliffe and R.T. Schadla-Hall (eds.), *The Past Under the Plough* (Directorate of Ancient Monuments and Historic Buildings, London, 1980), 18-21.

Lambrick, G., 'The Management of Archaeological Sites in Arable Landscapes'. In T. Nixon (ed.), *Preserving Archaeological Remains In Situ?* (London, 2004), 188-96.

Linnane, A., Ball, B., Munday, B., van Marlen, B., Bergman, M. and Fonteyne, R., *A Review of Potential Techniques to Reduce the Environmental Impact of Demersal Trawls* (Irish Fisheries Investigations No. 7, 2000).

Manders, M.R., 'The In Situ Protection of a 17th-Century Trading Vessel in the Netherlands'. In R. Grenier, D. Nutley and I. Cochran (eds.), *Underwater Cultural Heritage at Risk: Managing Natural and Human Impacts* (ICOMOS, Paris, 2006), 70-2.

Marx, D., 'NOAA's Stellwagen Bank National Marine Sanctuary', *INA Quarterly* 36.4 (2010), 8.

Marx, R., 'Deep Sea Treasure Hunting', *Wreck Diving Magazine* 18 (2009), 54-61.

Mattusch, C.C., *The Victorious Youth* (Los Angeles, 1997).

Momber, G., 'Drowned and Deserted: a Submerged Prehistoric Landscape in the Solent, England', *International Journal of Nautical Archaeology* 29.1 (2000), 86-99.

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.

Negueruela, I., 'Managing the Maritime Heritage: the National Maritime Archaeological Museum and National Centre for Underwater Research, Cartagena, Spain', *International Journal of Nautical Archaeology* 29.2 (2000), 179-98.

Parker, A.J., *Ancient Shipwrecks of the Mediterranean and the Roman Provinces* (BAR Int S. 580, Oxford, 1992).

Pearson, C.E. and Hoffman, P.E., *The Last Voyage of* El Nuevo Constante. *The Wreck and Recovery of an Eighteenth-Century Spanish Ship off the Louisiana Coast* (Louisiana State University Press, 1995).

Petriaggi, R., 'Le satyre de Mazara del Vallo: s'agit-il d'un original Grec?', *Archaeologia Maritima Mediterraea* 4 (2007), 193-98.

Pownall, T., 'Memoire on the Roman Earthen Ware Fished up within the Mouth of the River Thames', *Archaeologia* 5 (1779), 282-90.

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

Roberts, C., *Ocean of Life* (London, 2012).

Rodgers, B.A., 'Conservation of the Chesapeake Bay Mystery Gun'. In J. Barto Arnold III (ed.), *Underwater Archaeology Proceedings from the Society for Historical Archaeology Conference* (Baltimore, 1989), 134-37.

Rodrigues, J., 'An Amnesty Assessed. Human Impact on Shipwreck Sites: the Australian Case', *International Journal of Nautical Archaeology* 38.1 (2009), 153-62.

Royal, J.G., 'In Distress. Rescuing a Roman Merchantman 1700 Years Later', *INA Quarterly* 36.4 (2010), 9.

Royal, J.G. and Tusa, S., 'The Levanzo I Wreck, Sicily: a 4th-century AD Merchantman in the Service of the *Annona*?', *International Journal of Nautical Archaeology* 41.1 (2012), 26-55.

Sakellariou, D., Georgiou, P., Mallios, A., Kapsimalis, V., Kourkoumelis, D., Micha, P., Theodoulou, T. and Dellaporta, K., 'Searching for Ancient Shipwrecks in the Aegean Sea: the Discovery of Chios and Kynthos Hellenistic Wrecks with the Use of Marine Geological-Geophysical Models', *International Journal of Nautical Archaeology* 36.2 (2007), 365-81.

Sibella, P., *The George McGhee Amphora Collection at the Alanya Museum, Turkey* (INA Quarterly 29.1, Texas, 2002).

Sjostrand, S and Syed Idrus, L.L., *The Wanli Shipwreck and its Ceramic Cargo* (Department of Museums, Malyasia, 2007).

Smith, R.A., 'The Wreck on the Pudding-pan Rock, Herne Bay, Kent', *Proceedings of the Society of Antiquaries* 21 (1907), 268-92.

Smith, R.A., 'The Diving Operations on Pudding-pan Rock, Herne Bay, Kent, and on the Gallo-Roman Red Ware Recently Recovered from the Rock', *Proceedings of the Society of Antiquaries* 22 (1909), 395-415.

Thurstan, R.H., Brockington, S. and Roberts, C.M., 'The Effects of 118 Years of Industrial Fishing on UK Bottom Trawl Fisheries', *Nature Communications* (May 2010), 1-6.

Van Kolfschoten, T. and van Essen, H., 'Palaeozoological Heritage from the Bottom of the North Sea'. In N.C. Flemming (ed.), *Submarine Prehistoric Archaeology of the North Sea: Research Priorities and Collaboration with Industry* (Council for British Archaeology, York, 2004), 70-80.

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, 2008).

Verhart, L.B.M., 'Fishing for the Mesolithic. The North Sea: a Submerged Mesolithic Landscape'. In A. Fischer (ed.), *Man and Sea in the Mesolithic. Coastal Settlement Above and Below Present Sea Level* (Oxford, 1995), 291-302.

Vorus, S., 'Trawling for Treasure,' *National Fisherman* (June 1997), 19-29.

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.

Yorston, R.M., Gaffney, V.L. and Reynolds, P.J., 'Simulation of Artefact Movement due to Cultivation', *Journal of Archaeological Science* 17 (1990), 67-83.

Young, C., Chadburn, A. and Bedu, I., *The Stonehenge World Heritage Site Management Plan. Consultation Draft July 2008* (English Heritage, 2008).

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

