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## IMPACTS OF RECREATIONAL SCUBA DIVING ON SHIP- WRECKS IN AUSTRALIA AND THE PACIFIC

### A Review

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This paper reviews the impacts of recreational scuba diving on the cultural heritage and recreational dive values of shipwrecks in marine environments in Australia and the western Pacific Ocean, excluding South East Asia. Shipwrecks are unique, fragile, non-renewable cultural resources that are an important element of underwater heritage, and are of great interest to society. Shipwrecks also offer unique, spectacular and fascinating diving experiences and have considerable aesthetic appeal to divers. Four types of diver impacts on shipwrecks were identified: the removal of artefacts as souvenirs or personal mementos by divers and disturbance to wreck sites associated with this activity; direct contact with wrecks and protective marine growth and concretions by divers and their equipment; exhaled air bubbles trapped inside wrecks from divers penetrating wrecks; and, anchor damage, which is a major threat to wrecks and considered to be more damaging to wrecks than the other impacts of diving.

This paper reviews the impacts of recreational scuba diving on the cultural heritage and recreational dive values of shipwrecks in marine environments. The study area of the review includes the waters of Australia and the western Pacific Ocean but does not include South East Asia. Although the review focuses on shipwrecks including submarines, submerged aircraft wrecks are also discussed. The review only covers the English literature and it is recognised that there is likely to be relevant French, Japanese and other Asian literature that has not been accessible. Information sources used in the review include refereed and unrefereed published literature, unpublished reports and memorandums, information brochures, booklets and other unpublished information including websites. Additionally, the review has been written by a recreational diver, certified for twenty three years, with a keen interest in wreck diving. The author has dived

wrecks in Australia, Papua New Guinea, Solomon Islands and Vanuatu, and is a member of an active independent dive club. Therefore, some of the information included in the review is based on personal observations and anecdotal information obtained through many informal discussions with divers, which in some cases are contrary to claims made in the literature.

The review outlines the values of shipwrecks and focuses on the cultural heritage and recreational dive, including tourism, values of shipwrecks; wreck disintegration processes and threats to wrecks; and, the current state of knowledge on the nature and extent of the impacts of recreational scuba diving, and associated with recreational scuba diving, on the cultural heritage and recreational dive values of wrecks. Management approaches used to mitigate and minimise diver impacts and challenges faced in managing diver impacts are reviewed,

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and comment is made on the effectiveness and suitability of these measures. The review also identifies gaps in knowledge and areas requiring research and monitoring to better determine and manage diver impacts on shipwrecks.

It is recognised that shipwrecks exist in the waters of all Pacific nations. However, there is no cohesive discussion of the impact of recreational scuba diving on shipwrecks, and the literature is very patchy and limited to a few case studies. The review therefore identifies common issues and draws together relevant case studies. The majority of the literature comes from Australia and Chuuk Lagoon in the Federated States of Micronesia (FSM), with very limited information available on the Marshall Islands, Solomon Islands and Vanuatu. This is understandable and explainable in smaller nations such as Fiji, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, Northern Mariana Islands, Palau (Republic of Belau), Papua New Guinea, Solomon Islands, Tonga, Tuvalu and Vanuatu, but not so for New Zealand. It is estimated that there are more than 2,000 shipwrecks in New Zealand waters and around 150 of these sites have been located (Churchill 1991; Maritime Archaeology Association of New Zealand (MAANZ) 2005). However, there was no literature covering the topic. It would also be expected that there would be literature available for Papua New Guinea, and more literature available on the Solomon Islands and Vanuatu, because wrecks are promoted at these locations in the dive literature and travel promotions.

A section which outlines the cultural heritage and recreational dive, including tourism, values of shipwrecks and lists other values shipwrecks have to society is followed by an overview of the range of impacts on shipwrecks from the environment and from human activities other than recreational scuba diving. A discussion of the impacts of recreational scuba diving on shipwrecks follows, together with the management approaches and measures that have been used to mitigate or minimise such impacts, and the challenges faced in managing shipwrecks. The review concludes with a discussion of the effectiveness of managing diver impacts on wrecks, the identifica-

tion of gaps in knowledge, and recommends areas where research, monitoring, and further information is required to better assess and determine the nature and extent of the impacts of recreational scuba diving on the cultural heritage and recreation dive and tourism values of shipwrecks.

## **VALUES OF SHIPWRECKS**

Shipwrecks have a range of values to society as well as to divers. The cultural and recreational dive, including tourism, values of shipwrecks shall be outlined here, together with other values shipwrecks have to society.

### **Background**

Shipwrecks are of undeniable appeal and interest to society (Delgado 1988a; Nutley 1996). They are often of great importance to communities because they are the tangible remains of events of social and cultural interest or significance, and may remain associated with a place long after the event occurred (Delgado 1988a; Kenderdine 1997). Shipwrecks have the ability to evoke intense feelings (Delgado 1988a; Kenderdine 1997) because these events demonstrate the fragility of humans and the power of the sea, and bring out extremes in human behaviour (Delgado 1988a). Stories associated with shipwreck events are of great interest to the public and have been in the past. As early as the mid seventeenth century factual accounts of shipwrecks were published and were popular and fictional accounts predate these factual accounts, often generating music, literature, art, folklore and mythology (Delgado 1988a; Kenderdine 1997). In Australia, for example, the wreck of the *Loch Ard* (sunk in 1878) in Victoria features in poetry, non-fiction publications, paintings, etchings and postcards, and is memorialised by an opera, a ball, museum displays and on-site memorials (Fielding 2003).

### **Cultural heritage values of shipwrecks**

Shipwrecks are unique, fragile, non-renewable cultural resources (Delgado 1988a & b; Hardy 1990; Heritage South Australia (SA) 2002a; Heritage Victoria 2000; Jewell 2004; Vrana & Mahoney 1995), and are an important ele-

ment of underwater heritage (Heritage Office 1994a). The cultural heritage values of shipwrecks include their archaeological, anthropological, historic, cultural and social values (Delgado 1988a; Kenderdine 1997). These values of shipwrecks have been increasingly recognised internationally since World War II (Johnson 2000; Kaoru & Hoagland 1994), due largely to their increased accessibility resulting from advances in technology, including scuba, remote sensing, global positioning systems and remotely operated vehicles (Henderson 1992; Johnson 2000; Kaoru & Hoagland 1994; Kenderdine 1997; Nutley 1996).

Shipwrecks are in effect underwater museums (Delgado 1988a; Hezel & Graham 1997; Kenderdine 1997) because a shipwreck is a type of 'time capsule'. Ships were designed to be relatively self-sufficient and were effectively sealed off from society once they left port. They only opened up when another port was reached or when another vessel was met at sea, and although some items were thrown overboard, much of what was taken aboard the ship was retained and reused (Delgado 1988a). This makes shipwrecks important cultural resources particularly because until recent times they have been relatively inaccessible, and this has meant they have been subjected to less damage and disturbance from human activities than terrestrial cultural resources, and many shipwreck sites are well preserved (Delgado 1988a & b; Kenderdine 1997). Shipwrecks provide an opportunity to study human behaviour because elements of culture were focused and enclosed on ships. Wrecks contain information that reflects the behavioural characteristics and patterns of individuals and groups on board the ship (Delgado 1988a), the culture that produced the ship, and the history of the ports visited and the area where the ship was wrecked (Delgado 1988a & b; Kenderdine 1997). Shipwrecks therefore often have significant educational value (Australian Institute of Maritime Archaeology (AIMA) & Cultural Development Office (CDO) 1994; Kenderdine 1997).

Historically ships have been important to society for exploration, trade, defence, communication, migration, passenger transport,

fisheries and recreation (AIMA & CDO 1994; Delgado 1988b; Henderson 1986; Jewell 2004; Kenderdine 1997). Therefore, shipwrecks can contain valuable information about naval architecture, shipbuilding, defence, engineering skills, technology, commerce and culture (Heritage Office 1994b; Heritage Victoria 2000) and are important records and repositories of information about our past (Coroneos 1997). The historical values of shipwrecks may be as a result of the ship being involved in or associated with historically significant events or people, because the type of vessel is significant, or as a record of the life and times of ordinary people (Heritage Office 1994b; MacLeod 1992). The sinking of a ship often results in the loss of human lives and shipwrecks are therefore often important graves or memorials, and many are associated with war (Delgado 1988a).

In Australia, there are historical records of over 7,000 shipwrecks off the vast coastline, dating back to the seventeenth century, and at least 925 sites with physical evidence of these wrecks have been located (Kenderdine 1997). Many have the potential to provide information about the history of Australian people, and are a valuable cultural resource for all Australians (AIMA & CDO 1994).

The World War II shipwrecks in Chuuk Lagoon (formerly known as Truk Lagoon), FSM (Jeffery 2003a & 2004a), are the most complete collection of relatively unsalvaged World War II shipwrecks in the world (Hezel & Graham 1997). There are more than fifty ship and ten aircraft wrecks in the lagoon, containing valuable information about how a major Japanese military base was equipped and the effects of the United States (US) blockade and bombing operations (Jeffery 2004a). The wrecks of Chuuk Lagoon were part of a battleground, and are also viewed as a war grave by Japanese people and a memorial by many Japanese and US tourists (Jeffery 2004a; Hezel & Graham 1997). More than 4,000 Japanese defence personnel were killed and wounded in World War II at Chuuk, along with 120 Chuukese, 30 Americans and others from several other nations (Jeffery 2003a & 2004b).



*Figure 1. Many shipwrecks are associated with war. Human remains near the commemorative plaque to the Japanese Servicemen located towards the stern of the Aikoku Maru, Chuuk Lagoon, Federated States of Micronesia. (Photo by Kelly Jandik 2005).*

In Vanuatu, underwater World War II sites such as the *SS President Coolidge* and the logistics dump site at Million Dollar Point, which includes shipwrecks (Stone 1997), are significant components of Vanuatu's cultural heritage (Howard 1999). In the Solomon Islands, around 50 Australian, Japanese, New Zealand and US ships are known to have sunk in the area between Guadalcanal and Tulagi in the Florida Island group, known as 'Iron Bottom Sound', an important World War II maritime battlefield. More wrecks are located in the waters of other islands in the Solomon Islands (Drew 1998).

It is estimated that there are potentially more than 200 submarine wreck sites in Australasia and the Pacific Ocean. During World War II, Japan alone is known to have lost 130 submarines, and around 10,000 crew, from a fleet of approximately 170 (Smith

1999). Nine out of the ten presumed submarine wrecks sites in Australian waters have been located. Although submarines represent a very minor portion of the total shipwreck resource, they are important because they generally remain in-tact for much longer than other types of vessels due to their greater strength and thickness and cylindrical shape (McCarthy 1998; Smith 1999). However, most submarine wrecks contain human remains, and it is considered by governments and archaeologists that submarines should not be entered or disturbed by divers, particularly where there are living relatives of those lost (McCarthy 1998).

Shipwrecks are therefore a valuable component of cultural heritage, and it is imperative that the cultural heritage values of shipwrecks are effectively protected because these resources are irreplaceable and in limited supply.



*Figure 2. Light covers in the machine room of the Fujukawa Maru, Chuuk Lagoon, Federated States of Micronesia. The presence of artefacts increases the interest and appeal of wrecks to divers (Photo by Michael McFadyen).*

For example, it is unlikely that any wooden ships of a substantial size will be wrecked in modern times. In the western Pacific region a large number of wrecks are the result of World War II and it is unlikely that shipwreck events of this scale will be repeated. In addition, the decline in the volume of shipping, changes in technology and more stringent international shipping regulations has reduced the occurrence of shipwrecks.

Heritage is important because it helps define our identities as individuals and communities, and adds meaning and perspective to our lives (Aplin 2002; Hall & McArthur 1996; McArthur & Hall 1996a). However, the significance and value different cultures, groups or individuals place on cultural resources is a reflection of their values and attitudes, as well as the nature of the particular item, because our backgrounds and experiences influence how we value heritage (Aplin 2002).

### **Recreational dive and tourism values of shipwrecks**

Shipwrecks offer unique, spectacular and fascinating diving experiences (Coroneos 1997; Delgado 1988b; Howard 1999). Many shipwrecks are important recreational resources for scuba divers (Coroneos 1997; Cuthill 1998; Delgado 1988a; Kenderline 1997), and the recreational value of shipwrecks has been well recognised amongst recreational divers (Delgado 1988b). Diving is an increasingly popular recreational activity (Lester 1983; Kaoru & Hogland 1994) which has increased substantially over the past fifteen years. It is one of the world's most rapidly growing sports and the recreational diving community is a very large, active and mobile group of people (Davis et al. 1995; Delgado 1988b; Kenderline 1997; Howard 1999; McCarthy 1983).



*Figure 3. Diver holds rifle on the SS President Coolidge, Vanuatu. Disturbance to artefacts by divers accelerates corrosion and their deterioration (Photo by Joanne Edney).*

Along with the increasing numbers of divers, there has also been an increased interest in the recreational use of shipwrecks (AIMA & CDO 1994; Kaoru & Hoagland 1994), with many divers having a keen interest in shipwrecks (Nutley 1996). This interest is expected to continue to increase as the dive community expands because the demand for unique and interesting diving, such as wreck diving, also increases (Delgado 1988b).

Ruins are interesting and evocative, and offer perspectives on the past and as ruins, shipwrecks have considerable aesthetic appeal to divers (Delgado 1988a; Kenderdine 1997). Seeing a shipwreck resting on the bottom of the seabed provides access to the past by connecting divers with the history of the ship and the wrecking event (Delgado 1988a; Kenderdine 1997). Divers are able to observe what happened to the ship and the effects of the marine environment on the wreck over time, and this enables divers to gain a greater understanding and appreciation of the importance of shipwrecks. It is the aesthetic appeal of seeing a

shipwreck on the bottom of the sea, the rich variety and abundance of marine life attracted to the wreck, and the ability to explore ruins in a foreign environment that few other people have access to, that attracts divers to wrecks (Delgado 1988a; Jeffery 1990; McCarthy 1983). The presence of a ship's cargo and the personal effects of people who were on board the ship increases the interest and appeal to divers (Bower & Smith 1991; Delgado 1988b), as does seeing other artefacts, fittings and machinery in place (Delgado 1988a; Hosty 1987; McCarthy 1983). Shipwrecks also provide excellent opportunities for photography and observation of marine life (Coroneos 1997).

With the increasing number of divers and increased interest in recreational diving on shipwrecks, recreational scuba diving has also become a major tourist activity and an important aspect of cultural tourism (Jeffery 1990; Kenderdine 1997; Nutley 1996). In Australia, in 1994 it was estimated that around two million dives were being made annually (Harriott, Davis & Banks 1997), and the dive industry in

Australia is large and continuing to grow (Smith 2003). The marine tourism industry is an important contributor to the economy, estimated to generate more than \$A1 billion annually in direct value (Harriott 2002), and the recreational diving industry is an important component of the marine tourism industry. Recreational diving was estimated to have contributed almost \$A20 million to dive and tourism businesses in Victoria in 1995, and wreck diving is recognised to be an important component of recreational diving (Heritage Victoria 2000). The wreck of the *SS Yongala* (1911) off Queensland on the Great Barrier Reef (GBR), is internationally renowned as one of the best wreck dives in the world, and recreational diving of the *Yongala* is important economically to the local dive and tourism industries (Cuthill 1998). It has been estimated that the *Yongala* earns charter operators alone over \$A1 million annually. Associated businesses also benefit (Jeffery 2003b), such as those involved in dive gear sales and rental, airlines, accommodation, restaurants, shops and taxis (Delgado 1988a). In the late 1990s, it was conservatively estimated that at least 6,400 dives per year were made by recreational divers on the *Yongala* (Cuthill 1998), and diver use has increased significantly over the past decade. It was conservatively estimated that more than 13,500 dives were made by recreational divers during the first nine months of 2001 (Jewell 2004). Other shipwrecks in Australian waters are also becoming increasingly important to charter operators (Jeffery 2003b).

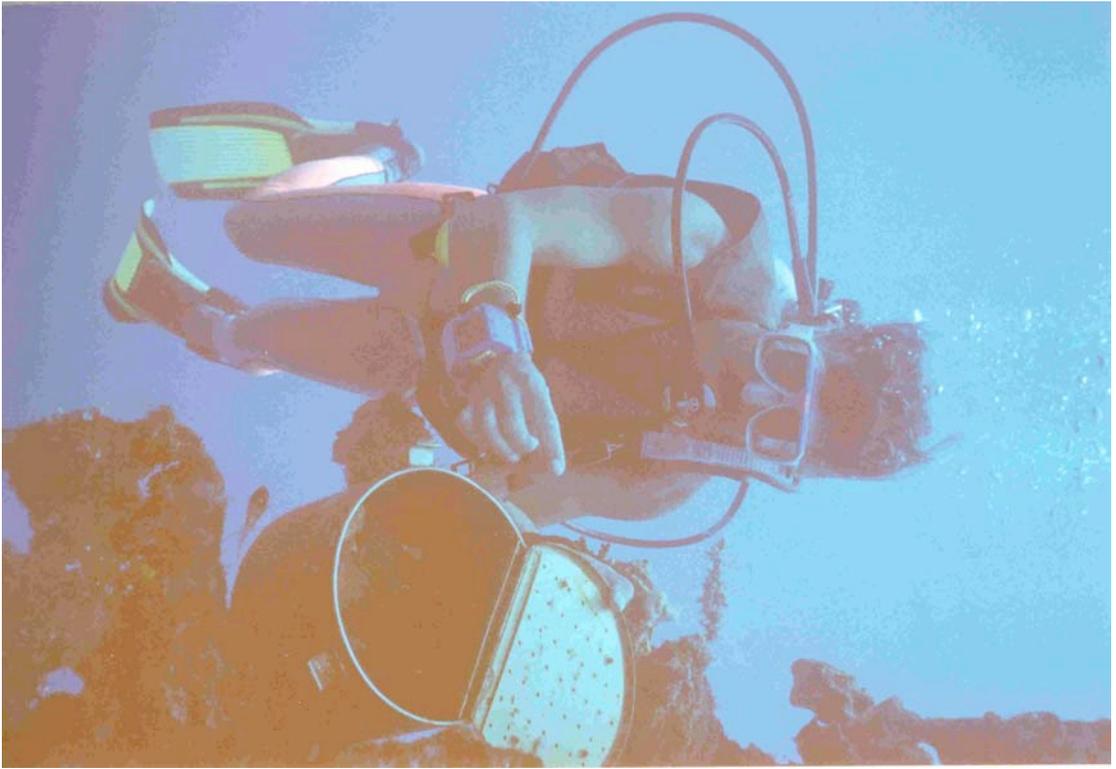
The dive tourism values of shipwrecks is also recognised by governments, for example, the Queensland Government scuttled the decommissioned *HMAS Brisbane* on 31 July 2005 off the Sunshine Coast (Department of the Premier and Cabinet 2005) to create a dive tourism attraction and artificial reef. Certain items were removed for use in interpretative displays, however, the removal of other items was minimised to maintain the ship's integrity and to ensure it provides interesting diving opportunities. It is estimated that approximately 25,000 additional divers will be attracted to the site annually, increasing diving in the region by around fifty per cent, and it is expected to re-

sult in an additional \$A1 million for the Queensland economy and the creation of around 200 local jobs (Environment Protection Agency (EPA) 2005).

The wrecks of Chuuk Lagoon, FSM, are regarded as some of the best wrecks to dive in the world and are promoted as diving attractions. The shipwrecks of Chuuk Lagoon are still relatively intact and contain much of the cargo they contained when they were sunk in 1944. Many are located in depths between thirty and sixty metres and are protected to a large degree from currents, winds and ocean swells by the reef (Jeffery 2004a & b). These wrecks are Chuuk State's largest tourism attraction and a major source of revenue (Hezel & Graham 1997; Jeffery 2003a, 2004a & b). The wrecks became popular in the early 1970s (Hezel & Graham 1997), and it has been reported that increasing numbers of divers visited Chuuk Lagoon between 1970 and 2000. It has been estimated that annually around 3,000 tourists visit Chuuk Lagoon to dive the wrecks, and it was reported that almost 10,000 tourists visited in 1996 (Jeffery 2004a).

It was the tourism values of the wrecks that led to their protection (Jeffery 2004a), and the financial returns from tourism are the reason the wrecks are valued by the Chuukese government and portions of the local community. It has also influenced how the Chuukese people regard these sites (Delgado 1988a; Jeffery 2004a). It has been recognised that the recreational value of the wrecks is largely due to the opportunity to see the contents of the wrecks such as aircraft, tanks, vehicles, guns and armourment, and that protecting these resources in-situ protects the tourism values of the wrecks (Delgado 1988a). However, management of these sites reflects their value as recreational resources rather than their cultural heritage values (Delgado 1988a; Jeffery 2004a).

The wreck of the *SS President Coolidge* in Vanuatu was protected by the government in 1983 in recognition of its emerging dive tourism potential (Stone 1997). Tourism is important to the economic development of Vanuatu and diving is an important component of Vanuatu's tourism industry, representing one quarter of all tourists.



*Figure 4. Diver displays a glass syringe and aluminium tin on the Toa Maru, Solomon Islands. Stored inside the tin was this syringe, ampules of morphine, a gas mask, shoe brush and pencil. (Photo by Joanne Edney).*

The protection of the wreck is therefore important to the tourism industry, which now depends in part on the cultural heritage values of the *President Coolidge* (Howard 1999).

In the Solomon Islands, recreational diving is also important to the tourism industry, and it has been estimated that around 5,000 divers visit Guadalcanal annually to dive the reefs and more than twelve shipwreck sites. Dive operators in the Solomon Islands recognise the value of the wrecks as tourism resources (Drew 1998).

As noted above, it is estimated that there are potentially around 200 submarine wrecks in Australasia and the Pacific. It is considered that submarines may offer even more challenging and thrilling diving opportunities than other types of vessels due to the higher risk involved (McCarthy 1998). Submarines accessible to divers in Australian waters and the Western Pacific include six J-Class submarines in Australia, in Victoria; one in the FSM, the Japanese *I-169* in Chuuk; three in the Marshall Islands, two

American submarines at Bikini Atoll, the *USS Apogon* and the *USS Pilotfish*, and the Japanese *RO-60* at Kwajalein; two in the Solomon Islands, both Japanese submarines, one unidentified and the *I-1*, near Honiara, Guadalcanal; and, two Japanese midgets in Papua New Guinea, one near Kavieng, New Ireland and the other off New Hanover, near New Ireland (Smith 1999).

Wrecks are popular and provide important recreational dive opportunities, and recreational dive tourism resulting from recreational diving on shipwrecks has been shown to be important economically (Delgado 1988a; Kenderdine 1997; Nutley 1996). The sustainable use of these sites is important not only for the protection of cultural heritage and recreational dive values, but also to protect the industries and communities that depend on the revenue from these values (Jewell 2004).

### Other values of shipwrecks

Shipwrecks have a range of values to society. In addition to the cultural heritage, recreation and tourism values discussed above, wrecks have scientific, educational and monetary values (Delgado 1988a).

Shipwrecks as artificial reefs provide important insights into reef ecology (Jeffery 2004b), and are often important for the variety of marine biodiversity attracted to them (EPA 2005; Jeffery 1990). For example, the Chuuk Lagoon wrecks are internationally recognised for the diverse and colourful marine life they have attracted (Hezel & Graham 1997; Jeffery 2004a). A preliminary assessment of the *Yongala* determined that the wreck supports a productive reef system, with the abundance of fish life being so great that accurate counts were difficult to make (Malcolm, Illidge & Wachenfield 1996), and wrecks such as the *Yongala* provide important information about the process of marine colonisation and wreck disintegration (Jewell 2004; Kenderdine 1997). Studies of artificial reefs also provide important information about processes affecting wrecks and wreck site formation, and have been created for recreational fisheries for centuries due to the recognised increase in fish populations around wrecks (Randell 1998).

In addition to the economic values of recreational diving and tourism, shipwrecks may have other economic or monetary values. The cargo of shipwrecks, the materials they were constructed from, or their machinery and fittings can have high commercial value (Delgado 1988a; Kenderdine 1997; Vrana & Mahoney 1995), and many shipwrecks are salvaged for these items of value soon after the shipwreck event occurs (Delgado 1988a; Kenderdine 1997). Salvage of shipwrecks is outlined in more detail further below.

### IMPACTS ON SHIPWRECKS OTHER THAN RECREATIONAL SCUBA DIVING

This section provides an overview of the range of impacts and threats to shipwrecks from the marine environment and human activities other than recreational scuba diving. Natural deterioration, disintegration and damage to shipwrecks will be discussed first, followed by an

outline of human impacts on shipwrecks other than recreational scuba diving, including general impacts arising from human development and use of the marine environment, commercial salvage and looting, and dynamite fishing. These impacts accelerate natural processes of wreck deterioration and disintegration.

### Natural deterioration, disintegration and damage to shipwrecks

Although the marine environment may to some extent preserve shipwrecks and their contents (Delgado 1988b), no wreck is completely stable in its environment. All wrecks are to varying extents subject to deterioration and damage from the effects of the marine environment (Hezel & Graham 1997; Kenderdine 1997; Sledge 1977). The extent of deterioration of shipwrecks is determined by depth, topography and composition of the seabed, temperature, salinity, oxygen content, sea conditions, water movement (Jeffery 1990; Kenderdine 1997; Nutley 1996), and the type of material used in the ships construction (Kenderdine 1997). Shipwrecks located in deep water often remain largely intact and in their original location because they are subject to relatively low levels of chemical, physical and biological deterioration. The structural remains of shipwrecks located in areas where there are strong currents or turbulent, highly oxygenated shallow waters may disappear completely, leaving only scattered items and parts of the ship (Nutley 1996).

As a vessel sinks lighter parts are washed away and remaining organic material such as sails, clothes, food or bodies disintegrate (Hardy 1990; Kenderdine 1997) within a short period of time (Hardy 1990). Wooden structures and other organic compounds are usually affected by biological processes relatively quickly unless covered by sediment, while metal components deteriorate more slowly through physical and chemical processes (Ward, Larcombe & Veth 1998). Wooden vessels buried under sand or mud slowly degrade and although waterlogged can remain in their original shape for centuries (MacLeod 1992). Iron vessels, however, corrode and disintegrate (MacLeod 1992) and because these shipwrecks

are the focus of recreational diving the process of their deterioration is discussed in more detail.

Oxygen accelerates corrosion (Henderson 1989; MacLeod 1989), and corrosion studies carried out on the wreck of the *USS Arizona* in Pearl Harbor, Hawaii, found that the most rapid rates of corrosion to the superstructure of the ship occurred at depths of up to two metres, lower rates of corrosion were reported at depths of six to ten metres, and corrosion rates decreased with increasing depth beyond ten metres (Henderson 1989). Although dissolved oxygen levels generally increase slightly with increasing water depth to a depth of approximately thirty metres, corrosion rate is dependant on the rate of supply of oxygen. The rate of supply of oxygen is increased by water movement which generally decreases significantly with increasing depth, reducing the rate of supply of oxygen and therefore the corrosion rate (MacLeod 1989 & 1997). In Australia, corrosion studies were undertaken on two iron shipwrecks located in the same water depth and biological zone in Port Phillip Bay in Victoria. The corrosion rate of the wreck located in a shipping channel subject to strong tidal currents was found to be approximately ten times higher than the wreck subject to less water movement (MacLeod 1992).

The corrosion rate of wrecks is greatly reduced when a layer of ferric hydroxide forms on the metal (Lindemann 1992) and this layer is covered by a layer of marine organisms that form a protective concretion over the surface of the wreck. Concretions prevent the circulation of seawater and slow the natural rate of corrosion (Kenderdine 1997; MacLeod 1992; Nutley 1996) by forming a semi-permeable membrane that separates the two parts of the corrosion cell (MacLeod 1989). The layer of marine life also encourages the formation of stable black and grey iron oxides because it maintains anoxic conditions near the exterior metal surfaces of the wreck (Henderson 1989). Corrosion studies undertaken on the *Fujikawa Maru* in Chuuk Lagoon demonstrated that the corrosion rate of metal covered by protective concretion was very sensitive to depth, with corrosion decreasing with increasing depth

(MacLeod in press a). The thickness of marine concretions on wrecks has been found to be directly related to the level of phosphorus in the metal, with higher levels of phosphorus producing thicker concretions that further reduce the rate of corrosion (MacLeod 1989 & 1998). Concretions are also important because they help retain the detail of artefacts and provide strength to structures or artefacts as the corroding metal loses strength (Randell 1998).

The decomposition of iron and steel ships have been observed to follow similar patterns. Ships sunk upright on sand generally sink into the sand to about the same level that they would normally float in water (Riley 1985). As the wreck loses strength and begins to break up, masts, stacks and midships superstructures are the first parts of the wreck to collapse (Lindemann 1992). The decks and deck beams usually collapse next, then the hull sides unsupported by bulkheads. Over time the bow and stern usually remain relatively intact. The boilers, engines, pumps, propellers, propeller shafts, steering gear and other heavy fittings also remain relatively intact and can provide support to the remaining hull. Vessels that sink upside down are relatively stable, although the upper decks collapse and machinery and fittings fall. Vessels that sink on their side deteriorate quickly, as the unsupported hull sides collapse and the wreck site becomes flat and scattered. Vessels located on a rocky seabed deteriorate the most rapidly, collapsing over and around the rocks (Riley 1985). Submarines deteriorate at a much slower rate due to their cylindrical shape and greater strength and thickness than other types of vessels, and it is considered that submarine wreck sites may remain for centuries (McCarthy 1998; Smith 1999).

Storms and other natural phenomena can cause damage to wrecks and accelerate deterioration processes (Heritage Victoria 2000; Jeffery 2004a). In Chuuk Lagoon, typhoons have disturbed marine growth and material culture to depths greater than eighteen metres, renewing corrosion and destroying fragile artefacts (Jeffery 2004a).

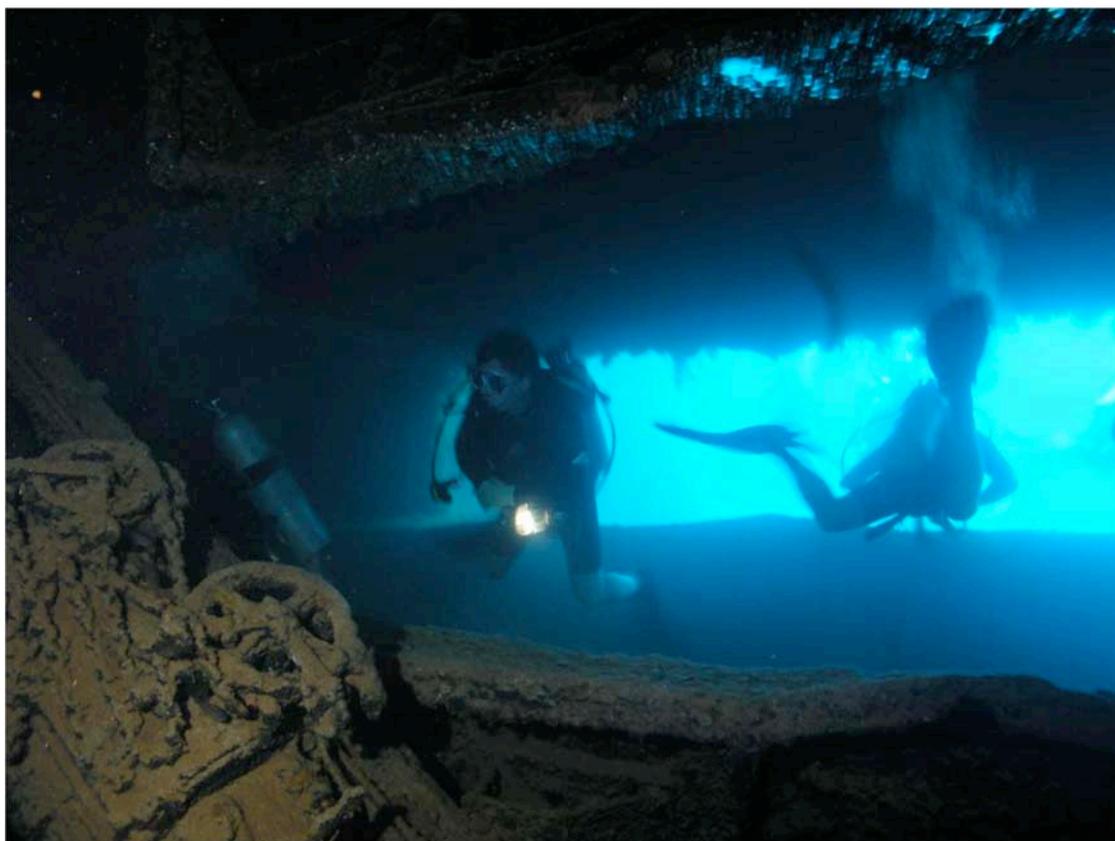


Figure 5. Divers inside the Hein Maru, Chuuk Lagoon, Federated States of Micronesia. Divers exhaled air bubbles accelerate corrosion and deterioration of wrecks (Photo by Michael McFadyen).

A typhoon in 1987 is known to have affected at least two wrecks, resulting in the collapse of the bridge of the *Sankisan Maru* and tearing open the superstructure of the *Fujikawa Maru* (Hezel & Graham 1997), and cyclone damage has been reported in Australia on the *Yongala* (Malcolm, Illidge & Wachenfield 1996). Earthquake damage has been reported to the wreck of the *SS President Coolidge* in Vanuatu, most notably damage to the famous 'Lady and the Horse' (the Lady) three dimensional ceramic wall fresco, 800mm x 730mm in size (Stone 1997). In late 1999 the Lady had two large cracks and was being held in place by rope. This was due to damage from corrosion and a number of earthquakes causing the section of wall in the First Class Smoking Room where the Lady was mounted to drop approximately 500 mm, and was particularly evident in early-mid 1999. In late January 2000, the Lady fell off the wall where she was

mounted through a doorway and landed on the lower Promenade deck, with relatively minor damage (McFadyen 2004). Divers have also reported earthquake damage to wrecks in the Solomon Islands where concretions have been shaken loose from wrecks from the frequent earth tremors (Drew 1998).

### Human impacts on shipwrecks other than recreational diving

Natural deterioration and disintegration processes of wrecks are accelerated by a wide range of human activities associated with the use and development of the marine environment (Kenderdine 1997; Sledge 1977), including dredging operations and disposal of dredge spoil to create new, deeper or wider shipping channels; extractive industries; beach replenishment; fishing activities including damage from nets, anchors, dredging and explosives (see below); laying of cables and pipes;

anchor damage from boating and shipping; land reclamation; marina developments; extensions to wharves and other harbour and navigational facilities; and, seismic testing (Heritage Office 1994b; Heritage Victoria 2000; Kenderdine 1997).

#### *Commercial salvage and looting*

Commercial salvage of vessels usually occurs very soon after a ship has been wrecked and its aim is to recover valuable cargo, engines, machinery and fittings, and all or parts of the hull (Delgado 1988a & b). Commercial salvage may also be carried out sometime after the wreck event when the value of cargo and metals increases or when there is threat of environmental damage, as was the case for the *SS President Coolidge* in Vanuatu. The ship sunk in 1942, and there was some salvage shortly after the event to recover vehicles, weapons, money, mail and some other cargo. The brass propellers were removed in 1968, a spare propeller was salvaged from a hold in 1970, and in 1971 and 1972 field gun shells, spare vehicle wheels and rifle cases were salvaged for the metals they contained. In 1976 bunker oil was salvaged from the ship due to the threat of environmental damage from the leaking oil, and in 1981 non-ferrous metals were salvaged from the engine room. As noted above, the wreck was protected in 1983 by the Vanuatu government, and no salvage or recovery of items has been permitted since this time (Stone 1997). During the 1960s and 1970s Australian and New Zealand divers acquired salvage rights to many wrecks within the western Pacific region and recovered non-ferrous metals from a number of sites, and these activities have affected most of the accessible wrecks in the Solomon Islands (Drew 1998).

Shipwrecks are also subject to treasure hunting and looting, particularly those with stories relating to possible contents of treasure (Kenderdine 1997). Treasure hunting and looting is concerned with the recovery of valuable cargoes and items from the past (Delgado 1988 a & b), and undisturbed shipwrecks containing valuable cargoes are at greatest threat (Department of Planning 1989). In the past treasure hunters primarily sought gold and silver, now

other materials and artefacts, such as porcelain, are sought for the growing marine antiques market (Delgado 1988a & b; Green 1995).

The seventeenth century Dutch shipwrecks, *Vergulde Draeck* (1656) and *Batavia* (1629), located off the coast of Western Australia (WA), were heavily looted by treasure hunters in the early 1960s particularly following the discovery of chests of silver. These wrecks were subjected to significant damage from these activities and evidence of the use of explosives at these wreck sites was reported by Police divers and divers from the University of WA (Green 1995; Henderson 1986). Around the same time, heavy looting also occurred on the eighteenth century Dutch shipwrecks the *Zeenijck* (1727) and the *Zuytdorp* (1712), and led to the WA government introducing legislation to protect historic shipwrecks and the Australian Federal government introducing the Commonwealth *Historic Shipwreck Act 1976* (Green 1995 & 1996; Hosty 1987; Jeffery 1992 & 2003b; Kenderdine 1997).

#### *Dynamite fishing*

In Chuuk Lagoon, ordnance is removed from the wrecks by the Chuukese for use in homemade bombs used for dynamite fishing. Although dynamite fishing and the removal of objects from the wrecks is illegal, it has been widely and regularly practiced and has resulted from increased public knowledge of the wrecks as a result of recreational scuba diving. For example, it has been reported that all of the six inch shells that were in the *Fujikawa Maru's* first hold were removed, the *San Francisco Maru* had a large portion of its ordnance removed, and mines aboard the *Nippo Maru* were noted to be disappearing one by one in the late 1980s (Hezel & Graham 1997).

Dynamite fishing damages protective marine life and concretions, and causes mechanical damage to nearby wrecks (Jeffery 2003a), and damage from dynamite fishing has been reported on the *Fujikawa Maru*. The mast and the aft section of the bow gun turret collapsed and the bulkheads below the bow gun partially caved in, weakened by the explosions (Hezel & Graham 1997). Evidence of the effects of repeated dynamite fishing was observed on the

upper decks of the wreck in 2002, where only thin layers of concretion remained and accelerated corrosion and decay of the wreck was observed to be occurring (MacLeod in press a).

### **Impacts on cultural heritage, recreational dive and tourism values of shipwrecks resulting from disturbance and damage**

Any disturbance to a shipwreck site diminishes its cultural heritage, recreational dive and tourism values (Delgado 1988b). Accidental and deliberate damage to wrecks disturbs the mechanical and biological equilibrium of the site (Jefferson 1988; Nutley 1987), as any disturbance to sediments or damage to protective marine growth and concretions can alter light, oxygen and temperature levels, accelerating the deterioration of the wreck or object (Jefferson 1988). Once a ship has been wrecked the remains cannot be added to or replaced, so once damaged or disturbed, such as through the disturbance or removal of artefacts, the site cannot be restored to its original condition or state (Delgado 1988a & b; Heritage SA 2002a).

Disturbance and damage to sites results in a loss of site integrity and loss of the historical, social or cultural associations held by communities (Kenderdine 1997). Any disturbance to a wreck site can destroy or distort the archaeological information it contains (Heritage Office 1994b; Kenderdine 1997), because once removed from their context and location artefacts lose their association and significance (Delgado 1988a). Artefacts need to be carefully documented, mapped, plotted, analysed and interpreted in the context of the site complex rather than as discrete and unrelated items (Kenderdine 1997; Nutley 1996). There is a loss of historical and scientific information from the wreck because of the loss of the recorded context and the loss or deterioration of artefacts removed or disturbed (Department of Planning 1989). In Australia, the widespread access to shipwrecks has resulted in the archaeological values of the majority of known shipwrecks off the coast of New South Wales (NSW) being diminished (Nutley 1996).

Commercial salvage and looting of shipwrecks usually involves excavations of wreck sites. However, these excavations are under-

taken to obtain items of commercial value, often as quickly and efficiently as possible (Delgado 1988b; Johnston 1993) and are therefore not carefully recorded. The vast majority of artefacts encountered that are not valuable commercially are discarded (Johnston 1993) and are often destroyed because these activities destabilise the site (Nutley 1996). Appropriate conservation and curation of artefacts recovered during commercial salvage or looting often does not occur, and these recovered objects rapidly deteriorate and are lost (Jefferson 1988).

Recovery of archaeological material is also destructive because any excavation disturbs a site and therefore the equilibrium of the site (Kenderdine 1997; Nutley 1987; Ward, Lacombe & Veth 1998). Any form of excavation can diminish the recreational dive values of shipwrecks by diminishing the aesthetic appeal and making diving less interesting. A big part of the enjoyment of wreck diving is in seeing artefacts, fittings and machinery in place (Delgado 1988a; Hosty 1987; McCarthy 1983), therefore archaeological excavations should be left in a state that preserves the identity of the site as a shipwreck to minimise this impact (Hosty 1987; McCarthy 1983). Excavations should only be carried out in special circumstances, when they can reveal important information that could not otherwise be answered and artefacts can be properly conserved (Bright 1997; Delgado 1988a & b; Kenderdine 1997), or where the site is threatened with destruction (Bright 1997).

Likewise, other sources of damage will diminish aesthetic and recreational values of wrecks. For example, in Chuuk Lagoon, the mast of the *Shinkoku Maru* was demolished by the government because it was a navigational hazard, although it is also popular with divers (Hezel & Graham 1997). Any damage or disturbance to a wreck will accelerate its deterioration and eventual loss, diminishing the wreck's cultural heritage, recreation and tourism values (Heritage SA 2002a & b; Nutley 1996).

## IMPACTS OF RECREATIONAL SCUBA DIVING ON SHIPWRECKS

This section discusses the impacts of recreational scuba diving, and associated with recreational scuba diving, on the cultural heritage and recreational dive, including tourism, values of shipwrecks. The first part discusses boat anchor damage, followed by an assessment of the impact of divers souveniring artefacts, and other diver use impacts. The management approaches used to mitigate or minimise the impacts on cultural heritage and recreation values, and challenges to managing these impacts on shipwrecks concludes this section.

### Anchor damage

Anchor damage is a major threat to shipwrecks (NSW Heritage Office 2000; Heritage SA 2002b) and occurs as a result of a range of human activities, such as fishing, shipping and recreational boating. Anchor damage is also specifically associated with recreational scuba diving of wrecks, and anchors are considered to be more damaging to wrecks than the other impacts of diving (NSW Heritage Office 2000) discussed below. Even a small reef anchor attached to a five metre dingy can exert great force and cause significant physical damage to a wreck. Timbers, fittings and superstructure are easily broken, and protective concretions and marine growth are dislodged. When iron is uncovered in this way it generates renewed corrosion on affected parts, and these parts are reported to corrode at a rate ten times faster than prior to the damage occurring (Department of Planning 1989; NSW Heritage Office 2000; Heritage SA 2002b).

In Australia, boat anchor damage is considered to be a major contributing factor to the weakening and deterioration of the superstructure of the *Yongala*, and is a major management concern (Cuthill 1998; Malcolm, Illidge & Wachenfield 1996; May 1985). The superstructure of the vessel, including the promenade deck and upper deck containing the drawing room and first class dining saloon, collapsed between the inspections carried out in 1981 and 1982 by the Queensland Museum (May 1985). Old and new anchor damage was also visible on the wreck when it was inspected by the Queens-

land Department of the Environment (DoE) in 1996, and anecdotal evidence of some dive charter boat skippers dragging their anchors over the site has also been reported (Malcolm, Illidge & Wachenfield 1996). In Chuuk Lagoon, FSM, it is recognised that the continued use of anchors is contributing to the damage and disintegration of the wrecks (Lindemann 1992). The mast of the *Hanakawa Maru* and the smokestack of the *Fujikawa Maru* were known to have been broken off after being hit by boat anchors (Hezel & Graham 1997).

### Souveniring, Fossicking and associated Activities

Some divers remove artefacts from wreck sites as souvenirs or personal mementos, or as a way to make money, and this practice was common in the 1960s and early 1970s (Anderson 1997; Jeffery 1993). This section discusses impacts on shipwrecks and submerged aircraft from recreational divers, and includes taking artefacts as personal mementos or souvenirs; the removal of artefacts by divers as a way to make money; fossicking for artefacts and activities associated with these actions; and the removal of artefacts commercially as a result of recreational scuba diving. These activities overlap to varying degrees with looting and treasure hunting discussed above.

It is considered that the desire to retain an enduring or tangible reminder of the wreck diving experience, or to own a part of history, and through this a sense of connection to the wreck and history, motivates divers to take objects from wrecks as personal souvenirs. In the past there may also have been status attached to owning wreck artefacts because of the level of knowledge and skill required and the real or perceived danger or risk involved in their recovery (Fielding 2003). In 2002 in Victoria, Australia, questionnaires were sent to custodians of shipwreck artefacts that had been declared during and following the 1993 amnesty declared under the Commonwealth *Historic Shipwrecks Act 1976*. Reasons given by respondents for collecting the artefacts were to retain a memento of the dive; because they had an interest in a particular wreck or maritime history; an interest in technological and cultural change;

as a tangible reminder of the risks or danger involved in diving shipwrecks; and, a desire to pass the artefacts on to family members. There was also a perception that it was permissible to collect artefacts prior to the enactment of historic shipwreck legislation, and that collecting the artefacts better protects them than leaving them in-situ (Philippou 2004).

Historic shipwrecks are protected in Australia by the Commonwealth *Historic Shipwrecks Act 1976*, and most states also have legislation that protects underwater cultural heritage (Kenderdine 1997; McIntyre 1992; Nutley 1996). The *Yongala* was located by divers in 1958, and it is known that these divers removed a safe from inside the wreck. The propeller was salvaged by divers in the 1950s using explosives, and the oil burning lamps stored in the lamp locker were removed and were displayed in a private museum in far north Queensland (May 1985). Inspections of the wreck in 1981, 1982 and 1996 reported damage to and removal of artefacts from the wreck by divers (May 1985; Malcolm, Illidge & Wachenfield 1996). The 1981 inspection by the Queensland Museum reported damage to a safe in the officer's quarters caused by divers, and in 1982 the Museum undertook another inspection of the *Yongala* and it was reported that the safe still remained in the cabin, although it had been moved by divers. Two navigational lamps that had been concreted to iron storage brackets were also reported to have been badly damaged by divers (May 1985).

In 1996 inspections of the exterior of the *Yongala* were undertaken by the Queensland DoE. Three artefacts, two portholes and a fan, were reported to have been moved and displayed in more obvious positions. It was considered probable that dive guides had illegally entered the wreck and obtained and relocated these objects so that divers could view them, due to the ban on penetrating the wreck that may otherwise have prevented divers from viewing these objects. Small scale interference of other artefacts by divers was also noted. However, it was considered that diver damage was unlikely to be a major cause of damage to the wreck because the exterior of the *Yongala*

supports a very high proportional cover of marine growth, with more than 80 per cent of the exterior surface of the wreck covered with a relatively robust layer of marine benthos (Malcolm, Illidge & Wachenfield 1996). It is considered that major structural damage to the *Yongala* wreck will be the result of natural causes (Cuthill 1998).

In NSW, the majority of shipwrecks have been subjected to souveniring and disturbance by divers since the 1950s when scuba equipment became available (Heritage Victoria 2000; Nutley 1996 & 1998). For example, the wreck of the *Walter Hood* (1870) located off the south coast of NSW has been visited by recreational divers since the 1950s. Although the removal of objects has been undocumented, large quantities of artefacts are known to have been removed by souvenir hunters. The bell was removed in 1975, and other items known to have been removed include cutlery, bottles, ceramics, penknives, sextant shades, taps, decorative floor tiles, lead shot, weights, and sheathing from the hull (Smith 1993). It is known that the wreck of the *SS Catterthun* (1895) on the NSW mid-north coast has continued to have artefacts removed as souvenirs, although the removal of the objects has been undocumented (Bower & Smith 1991). The *SS Duckenfield* (1889) is located off the NSW coast north of Sydney, and received immediate legal protection following its discovery. However, many artefacts and objects were removed by divers and large areas of protective concretion on the wreck are reported to have been broken away resulting from diver and anchor damage (Department of Planning 1989; Nutley 1998).

The wreck site of the *Dunbar* (1857) is located in shallow water off Sydney, NSW, and is easily accessible to a large and active recreational dive community. The *Dunbar* has been dived since the 1950s and the site has been heavily denuded by souvenir hunting divers. It has been reported that explosives were used by divers to dislodge artefacts at the wreck site in the 1950s and 1960s (Nutley & Smith 1992). The wreck of the *Centurion* (1887) is located in Sydney Harbour, and is also easily accessible to a large number of divers. It was known to recreational divers in the 1950s and 1960s and re-

gained popularity in the late 1970s. Use of the site has increased with the increasing numbers of divers, and the impact of souveniring has been marked. For example, brass rods that were once plentiful and scattered throughout the wreck site were gradually removed as souvenirs by divers during the 1980s, and a number of remaining structures are considered to have been moved from their original locations by divers (Hardy 1990).

In Victoria the greatest damage to wrecks is considered to have been caused by divers looting and removing souvenirs. Many wreck sites had objects removed as souvenirs and to make money, for example, valuable copper, bronze, brass and lead fittings that could be sold as scrap metal (Anderson 1997). The wrecks of the *RMS Australia* (1904), *Cheviot* (1887) and *Light of Ages* (1868) were destroyed by souvenir hunters and looters using explosives to extract concreted or buried artefacts (Anderson 1997; Clark 1985), and even objects considered by heritage managers to be undesirable or of little interest to recreational divers have been removed from wrecks. For example, as a result of declarations made under the Commonwealth *Historic Shipwrecks Act 1976* amnesty during the early 1990s, it was discovered that thirty three panes of window glass were removed from the wreck of the *Loch Ard* (1878) by a recreational diver wanting to possess a tangible part of history. Many other mundane items were removed from the wreck by divers and the majority of these items did not appear to be of any commercial value or to have any particular functional use or value (Fielding 2003).

The ship and aircraft wrecks of Chuuk Lagoon, FSM, are also legally protected, however, the removal of artefacts by divers as souvenirs, or associated with recreational scuba diving, continues to occur (Hezel & Graham 1997; Jeffery 2004a). It is considered that these wrecks are the targets of souveniring and looting because they are so well known locally and internationally (Hezel & Graham 1997) as a result of recreational scuba diving. Small objects are particularly targeted due to the ease of removal, and theft by dive guides combined with souvenir collecting by recreational divers has

greatly reduced once abundant artefacts on these wrecks (Lindemann 1992).

The *Fujikawa Maru* is the wreck considered to have been subjected to the most amount of theft of artefacts by divers. Crystal glasses and silverware in the bridge area used by the ship's officers are known to have been removed from the wreck, and chinaware was reported to be disappearing rapidly in the late 1980s. A medical kit and aluminium canisters that contained salve for gas attacks, along with an almost one metre high etched porcelain water filter were reported to have been taken from the wreck by divers. An open galley area that once contained several large cooking pots was observed to have only one remaining and it was regularly moved around by divers. The manufacturer's name plate was removed from the ship's telegraph on the stern deck. A typewriter was moved to a more prominent location on the gunwales of the wreck to make it easier to photograph, however, it was accidentally knocked off and fell another 15 metres to the bottom. It was damaged from the fall and is not easily visible to divers. An incident was also reported where a dive guide found a small plate hidden in a glove on the bridge floor, thought to conceal and protect it from other divers or in preparation to remove it. The rear deck of the wreck has a large collection of artefacts relocated from other parts of the wreck where they are viewed and photographed by divers (Hezel & Graham 1997).

The *Nippo Maru*, a relatively recently discovered wreck, had pistols removed from the decks by divers, along with deer antlers that had been carried for good luck by the Japanese seamen. Brass lanterns and serving platters from the galley and crews quarter have been removed from the *Shinkoku Maru*, the manufacturer's plate from the main engine of the *Suzuki* was reported to have been removed by divers, and on the *Sankisan Maru* medicine bottles, pencil erasers and 7.7 mm bullets have been taken. Dive guides contribute to disturbance of artefacts and encourage this practice among divers, for example, there were reports that dive guides had used bullets to spell out greetings to their customers on the *Gosei Maru* (Hezel & Graham 1997).

In 2002 the wreck of the *Sapporo Maru* was discovered, and within 24 hours of the wreck being dived to verify its identity, the ship's bell which had been found in its original position on the bridge, had gone missing. Ship's bells are much sought after by souvenir hunting divers and this was reported to be the last ship's bell remaining in-situ in Chuuk Lagoon. A Police investigation found that a local dive guide had removed the bell and concealed it on the wreck site. The bell is rumoured to still be on the site, although the present location is not known (Jeffery 2004a). Some of the machine guns disappeared from the Betty Bomber aircraft wreck and it is not certain whether they were removed from the site or moved and hidden around the site. Additionally, a large cannon and one of the cockpit seats were removed and placed outside the aircraft, presumably for ease of photography (Hezel & Graham 1997).

The quantity of artefacts taken from the Chuuk Lagoon wrecks by divers has been of such an order of magnitude that it appears to be organised. There is a growing market for World War II artefacts, and dive guides have reported being approached to supply artefacts for sale to supply the growing market for World War II artefacts in the US and other countries. One dive guide was observed to remove armloads of dishes from one of the wrecks and claimed to be sending them to a museum when confronted by his customers. However, it is considered highly likely these items were sold to collectors (Hezel & Graham 1997).

In the Republic of the Marshall Islands divers are reported to have souvenired china-ware, ammunition and casings, manufacturer's plates from engines and equipment, bottles, canteens, and rubber soles for boots from wrecks. Divers have also removed varying sized pieces of aluminium from aircraft wrecks that are later discarded because the pieces have no meaning or significance to the diver (Look & Spennemann 1993).

Although not well documented, it is recognised that souveniring of artefacts by divers occurs in Vanuatu. In 1980 a Dutch tourist visiting Vanuatu by yacht is known to have died as a result of decompression sickness after

attempting to remove an artefact from the *SS President Coolidge*. As noted above the wreck was protected in 1983, and most divers are accompanied by dive guides. However, divers have been known to remove artefacts even when accompanied by dive guides, and artefacts have been removed since the wreck was protected. For example, one dive operator has observed artefacts removed by divers, including a pistol, and confiscated artefacts found (Stone 1997). Personal observations made by the author when diving the *Coolidge* in 1993, 1996, 2002 and 2006, observed a notable loss of artefacts from the wreck and deterioration of the wreck on each return visit, particularly in 2002. In the Solomon Islands recreational diving has resulted in the disappearance of small artefacts from the wrecks and has had a visible impact on the sites (Drew 1998).

Removal of artefacts as souvenirs can lead to extensive damage (Heritage SA 2002a; Malcolm, Illidge & Wachenfield 1996). Even if objects are not removed, divers fossicking for artefacts often dislodge and disturb objects and destabilise the site, leaving it more susceptible to further dispersal by wave action and currents (Department of Planning 1989; Nutley 1996), and accelerates corrosion and deterioration of the wreck (Heritage SA 2002a). Divers often touch and move artefacts to examine and better observe them. It is also common practice for dive guides to have a collection of artefacts placed in strategic locations around wreck sites. These artefacts are shown to divers (see Figure 4) and often passed around and handled.

Disturbance to artefacts from souvenir hunting also accelerates corrosion and deterioration by removing protective coatings around objects (Nutley & Smith 1992). Similarly, fossicking for artefacts and touching artefacts to examine or photograph them will accelerate corrosion and deterioration. Disturbance may diminish the integrity of the wreck site (Look & Spennemann 1993) and this diminishes the cultural heritage values of a wreck, particularly in terms of the archaeological potential of the site (Heritage SA 2002a; Malcolm, Illidge & Wachenfield 1996).

When artefacts are removed as souvenirs they are removed from their context, and their importance is often lost because their provenance becomes forgotten and lost as they are usually unrecorded or poorly documented, greatly reducing the archaeological potential. Many of these artefacts are held in undocumented private collections and end up in homes, garages, back yards, museums, and public parks, and undergo inappropriate or crude conservation treatment at best (Kenderdine 1997; Nutley 1996; Philippou 2004), because conservation of artefacts from submerged shipwrecks is costly and often a long term process (Jefferson 1988; Kenderdine 1997). Souvenirizing also diminishes recreation values and will impact adversely on tourism (Nutley 1996), because seeing artefacts and fittings in place increases the interest and appeal of a wreck to divers (Bower & Smith 1991; Delgado 1888a; Hosty 1987; McCarthy 1983).

### **Diver use impacts**

Shipwrecks are fragile and very susceptible to diver use impacts (Jewell 2004). When divers make direct contact with wrecks marine organisms may be disturbed and destroyed leaving the metal exposed, accelerating corrosion and deterioration (Jewell 2004; Lindemann 1992). Damage to protective marine growth not only accelerates the deterioration of wrecks, it also affects aesthetic values and appeal particularly when spectacular marine growth is damaged (Hezel & Graham 1997). Indirect contact by divers, such as exhaled air bubbles, also contributes to the deterioration of wrecks (Jeffery 2003a; Jewell 2004; Lindemann 1992).

Inexperience, unsecured equipment, incorrect weighting and poor buoyancy control are causes of diver contact with shipwrecks. Contact with wrecks also occurs due to a lack of knowledge and understanding about the importance of the protective marine growth to the stability of a wreck (Jewell 2004). The cumulative impact of these many unintentional actions by divers has a marked impact on the rate of decay of a wreck (Lindemann 1992). For example, in Vanuatu, the metal frame that once framed the *Lady* on the *SS President Coolidge* was eventually broken off, the cumulative

impact of divers hanging onto the frame while stopped to look at the *Lady* (Stone 1997). Mechanical damage from diver's equipment, such as tanks, breaking open concretions is evident on the wreck particularly areas subject to frequent diver traffic (Sterling Smith 2005, pers. comm., 29 March).

The wrecks of Chuuk Lagoon are showing signs of wear and tear from thirty years of recreational diving use and are under increasing pressure and threat (Jeffery 2003a & 2004a). Corrosion studies undertaken on the wrecks in Chuuk Lagoon in 2002 (MacLeod in press a & b) estimate that many of the shipwrecks may retain their existing integrity for about the next ten to fifteen years, then will be subject to significant collapse. This is a safety concern for divers and an environmental risk from any uncontrolled leakage of fuel and oil from the wrecks as they disintegrate (Jeffery 2004a).

While it is recognised that intentional and unintentional contact with wrecks accelerates their deterioration, no studies have been undertaken to measure the frequency or consequences of diver contact with wrecks. However, studies have been carried in Vanuatu and Australia on diver contacts with reefs and these studies are relevant to this review. A survey of the amount of contact made by divers with reefs was carried out by Howard (1999) on the island of Efate in Vanuatu. In this survey, diver contact with reefs was found to be closely related to the amount of contact the dive guide made with the reef. Most contact with reefs occurred after initial descent, when stopped to observe something or when swimming through narrow spaces, such as swim throughs or when penetrating a wreck (Howard 1999).

The ecological impact of divers on reefs has been studied in Australia. It is considered that where moorings are not used, boat anchors cause more damage to marine biota than divers (Harriott 2002), and diver impacts on marine ecosystems are considered small in comparison to storm and wave damage (Harriott 2002; Harriott, Davis & Banks 1997). A study on the effects of recreational scuba diving on coral reefs on the GBR found that on average, divers made contact with the substratum 5.4 times

during a ten minute portion of a thirty minute dive. The most common contact with reefs resulted from fin kicks (58%) and holding (32%), and fin kicks were the main cause of damage to coral. The study also found that although frequent contact may be made by divers, incidents of damage were small and few divers damaged coral. It was recognised that although the ecological impacts may be small, the aesthetic impact on reefs from diver use was not considered in the study (Rouphael and Inglis 1995). Aesthetic impacts are more difficult to quantify and determine (Davis et al. 1995; Rouphael and Inglis 1995), however, it is recognised that degradation of dive sites and overcrowding reduce diver amenity (Davis et al. 1995).

Studies undertaken of diver impacts in marine protected areas in Eastern Australia also found that relatively few contacts were made with reefs by the majority of divers, few contacts damaged corals, and most divers did not damage coral. The mean number of diver contacts with the substratum during a thirty minute dive, ranged from 35 to 121 (Davis et al. 1995; Harriott, Davis & Banks 1997), and this would compare with an average of 16.2 contacts over thirty minutes if the results from the Rouphael and Inglis (1995) study were extrapolated to thirty minute dives. The majority of contacts were made by diver's fins, which accounted for around 78 per cent of coral breakages. Poor buoyancy control and poor finning skills were reported to be the cause of most diver contact with the reef, and divers using cameras also have increased contact because they try to remain still for photography (Harriott 2002; Harriott, Davis & Banks 1997). Howard (1999) also observed poor buoyancy control to be the most common cause of diver contacts with reefs in Vanuatu. However, this survey also found that only around eight per cent of divers surveyed recognised that incorrect buoyancy could result in impacts on reefs.

While there have been no studies undertaken to determine the frequency of diver contacts with shipwrecks, studies carried out on reefs give an indication of the frequency of diver contact that may be expected. Observations made by Howard (1999) in Vanuatu of higher

frequencies of diver contact occurring when swimming through confined spaces, such as wrecks, indicate that the frequency of diver contact with wrecks would be expected to be higher than reported on reefs. In addition, because the marine growth and other protective layers on wrecks are generally considered fragile, it is likely that contact with these protective layers would have a more significant impact on wrecks than the ecological impacts of diver contacts with reefs.

Exhaled air bubbles from divers penetrating wrecks can also accelerate corrosion and affect the stability and longevity of a wreck, first by damaging the layer of marine growth (Jeffery 2003a; Jewell 2004; Lindemann 1992), then by setting vertical currents in motion that remove the protective layer of rust (Lindemann 1992). A third way by which exhaled air bubbles may accelerate the corrosion rate is through increasing the supply of oxygen.

The impact of exhaled bubbles resulting in increased corrosion has not been quantified but is widely acknowledged within the recreational diving community as an impact of diving. Responses by a number of diver operators to the survey undertaken in Vanuatu by Howard (1999) identified that the actions of divers were unsustainable on wrecks because of the increased corrosion resulting from divers exhaled air bubbles, and these operators perceived the greatest threats to wrecks to be from divers and earthquakes. The effects of increased corrosion from divers' exhaled bubbles are visible on the *SS President Coolidge*, particularly the parts of the wreck subject to frequent diver traffic (Sterling Smith 2005, pers. comm., 29 March).

### **Management approaches and mitigation of diver impacts to shipwrecks**

Any use of cultural heritage sites inevitably results in some type of physical, chemical, biological, social, cultural or economic impact. This will affect heritage values and visitor enjoyment and satisfaction (Jewell 2004; McArthur & Hall 1996a; Pearson & Sullivan 1995) because it is recognised that the quality of the visitor experience is directly related to the condition of the cultural resource. However, re-

search and monitoring of the nature and level of visitor use impacts on cultural heritage has been patchy (McArthur & Hall 1996 a & b), and even more patchy for underwater cultural heritage, as demonstrated by this review.

As discussed above, there has been a dramatic increase in numbers of recreational divers, and this has placed pressure on shipwreck sites from the range of impacts associated with this activity (Kenderdine 1997), and the cumulative impact of increased use. The increasing recreational use of shipwrecks by divers requires management to protect cultural heritage and recreation values (Cuthill 1998) because these values are easily damaged from the impacts of recreational scuba diving activities (Howard 1999). An important and ongoing challenge in the management of shipwrecks is providing access to these sensitive sites while at the same time protecting them from the impacts of diver use (Nutley 1998). Sustainability of sites is important for maintaining cultural heritage and recreational dive values, and economically for the dive and tourism industries (Jewell 2004). It has been increasingly recognised that removal of objects and other damage to wrecks diminishes recreational values resulting in a loss of income to commercial operators. Removal of objects and damage to wrecks is increasingly being discouraged by operators, and the need to protect wrecks has been included into wreck diver training courses (Green 1995 & 1996; Kenderdine 1997; Nutley 1996).

#### *Regulatory and non-regulatory management approaches*

There are widely varying attitudes to underwater cultural heritage (Green 1995; Kenderdine 1997) and different approaches to shipwreck management have been adopted by different nations (Kenderdine 1997; Smith 1999). This is due in part to the value placed on shipwrecks by communities and the values of those responsible for the management of the wrecks. However, it was the growing appreciation of cultural heritage, combined with recognition of the detrimental impact of the range of human activities on wrecks that led to their legal protection (Kenderdine 1997).

Anchors are considered to cause more damage to wrecks than the other impacts of diving (NSW Heritage Office 2000) described above. In Australia, it is illegal to anchor on an historic shipwreck (Heritage SA 2002b; NSW Heritage Office 2000) and mooring buoys have been installed, or recommended to be installed at certain wreck sites, such as the *Yongala*, to prevent anchor damage (Heritage SA 2002b; MacLeod 1998; Malcolm, Illidge & Wachenfield 1996; Nutley 1998). Although this is a relatively simple management action to implement few wreck sites in the study have moorings, or the type of moorings that will not cause damage to wrecks.

Promotion of wrecks gives recognition to the cultural and social significance of the wrecks (Strachan 1995), however, it is recognised that increased public awareness of shipwrecks can also result in negative impacts (Nutley 1987). In Chuuk Lagoon there has been reluctance to install moorings on the wrecks because it was considered likely to increase damage to wrecks from divers removing artefacts and ammunition because the wrecks are easily identified, and there is no surveillance in place to prevent these activities from occurring (Hezel & Graham 1997; Lindemann 1992). However, two of the live-aboard dive charter boat operators have installed moorings adjacent to a number of wrecks and plan to install more to reduce ongoing anchor damage to the wrecks (Jeffery 2004b). It is important that surveillance and compliance programs are also put in place in conjunction with any promotion of wrecks to eliminate or minimise impacts of increased public awareness.

Public access and developing active partnerships with the community for the management of shipwrecks is an important part of the effective management of these resources (Delgado 1988b), and limiting or preventing recreational use of sites is an ongoing debate (Hall & McArthur 1996). Successful management of shipwrecks requires a cooperative approach between management agencies and the recreational diving community (Cooper 1998; Lester 1983). For example, recreational dive groups can be involved in monitoring sites for indications of impacts from various sources, in re-

porting any illegal activities to management authorities (Cooper 1998; Delgado 1988b; Jefferson 1988), and self regulation (Jefferson 1988). However, in cases where public education has failed to prevent damage by divers, and the wreck is significant, fragile or culturally sensitive, it may be appropriate to ban access (Delgado 1988b). For example, diving is prohibited on the wreck of the *I-124* Japanese submarine wreck near Darwin, Australia, and human remains were removed from the *I-169* wreck in Chuuk due to these wreck sites being war graves (McCarthy 1998; Smith 1999). Although diving was not banned on the *I-169*, after the human remains were removed that section of the submarine was depth charged (Hezel & Graham 1997).

Diver attitudes and behaviour have changed considerably over the last two or three decades, and divers are now recognising the cultural values of shipwrecks and the need to leave sites intact (Green 1996; Heritage Victoria 2000; Jeffery 1990; Strachan 1995). Throughout Australia, the diving community has been a major advocate for the protection and research of shipwrecks (Kenderdine 1997), and has been responsible for the location, documentation and protection of many wrecks (Delgado 1988a; Kenderdine 1997; McCarthy 1983; Nutley 1996). A survey of diver attitudes towards shipwreck protection was undertaken in Western Australia in the early 1980s, and involved circulating questionnaires to five dive shops throughout Perth. Even then, the majority (87%) of respondents sympathised with the cultural heritage management aims of legislation in place, while only a small minority (8%) were against it. An overwhelming majority of respondents (92%) recognised that diving was permissible on protected wrecks and removal of objects was not permitted, and a portion of this group (11%) also thought a permit was required to dive these wrecks (Lester 1983).

Historic shipwrecks are protected in Australia by the Commonwealth *Historic Shipwrecks Act 1976*, which recognises and protects the historic, scientific, education and recreation values of shipwrecks (Jeffery 2003b; Kenderdine 1997; McCarthy 1983; Strachan 1995). The legislation includes fines and impris-

onment for breaches of certain provisions of the Act, the establishment of the national shipwreck and historic relic database, the ability to regulate the use of sites, and an obligation to report any wreck discovered (Heritage Victoria 2000; Jeffery 2002 & 2003b; Kenderdine 1997). As a result of the legislation, guidelines were released by the government for the management of shipwrecks to enable wrecks to be better managed and to develop a more consistent approach to management across the states (AIMA & CDO 1994). Public access guidelines were developed for public for use of wrecks (Department of Arts and Administrative Services 1993; Kenderdine 1997), and a national research plan was developed by the government, however it has not been widely used (Jeffery 2003b). Financial assistance is provided to the States by the Federal government to implement the National Historic Shipwreck Program (Jeffery 1992; Kenderdine 1997), and most states also have legislation that protects submerged cultural heritage (McIntyre 1992; Nutley 1996).

Education is the principle strategy used by the NSW Heritage Office to protect the underwater heritage of NSW, and includes community awareness and involvement programs, publications, exhibitions, posters and contact with the dive industry and dive organisations (Heritage Office 1994b). Education and involvement leads to increased awareness of the value and importance of wrecks (McCarthy 1983), and education is required to modify attitudes (Clark 1985). One strategy for participation arising from concern about the protection of shipwrecks was the establishment of amateur archaeological associations in Australia. These groups worked closely with professionals to locate and document sites and assist in their management and protection (Jeffery 1983; McCarthy & Garratt 1998; Nutley 1996 & 1998), and although these associations produced a lot of valuable work, efforts became uncoordinated as the groups tended not to have common goals, with some members interested mainly in recovering artefacts, and others protection. These associations were therefore limited in their ability to influence divers (Nutley 1998). Other examples of diver

involvement are the NSW Wreck Survey Project (1982 – 1985) and Wrecks Alive program (1999 – presently), which encourage dive shops, clubs and individual divers to research and document wrecks. This has enabled more information to be gained, and importantly these programs have been at least partly successful in the recreational dive community gaining some sense of ownership for the management and protection of these sites (Smith 2003).

It was recognised that belonging to amateur maritime archaeological associations would not appeal to all divers, particularly those who prefer to be unconstrained when wreck diving, and underwater wreck trails were aimed at meeting this need (Hosty 1987). Underwater interpretive wreck trails have been developed in Australia in Victoria, NSW, WA and SA, and include concrete plinths on shipwreck sites with information plaques attached as well as published information. Their aim is to attract divers to the site and to increase appreciation and protection of the cultural heritage values of the wrecks (Green 1995; Nutley 1996; Philipou & Staniforth 2003; Strachan 1995), and for commercial operators to recognise the recreation and tourism values of shipwrecks (McCarthy & Garratt 1998). It was also considered that publicising these wrecks would reduce diver pressure on more fragile or important wrecks (Hosty 1987).

Permit systems are another approach used to manage diver impacts on shipwrecks in Australia. In 1996, the wreck of the *Lady Darling* (1890) was discovered off the south coast of NSW, and is protected by legislation. As a trial, access to the wreck required a permit and permits were issued to a limited number of local dive charter operators, with the aim of gaining support from the local community to protect the wreck as a tourist attraction. A mooring was installed at the wreck site cooperatively by the dive charter operators issued with permits. More than 400 divers had visited the site by the end of June 1997 and inspections of the wreck were carried out by NSW Heritage Office to assess its condition. The impact of divers was considered minimal because it was reported that virtually no items

had been removed from the wreck and even portholes were still intact. The trial of this permit system was considered successful, due in part to the site access arrangements (Nutley 1998). It was noted above that the *SS Duckenfield* has been subjected to anchor damage and heavy souveniring of objects by divers. The *SS Duckenfield* was also legally protected, and permits were also required to enter the wreck's protected zone (Nutley 1998). However, in this case the permit system has not reduced the impacts of recreational diving.

Another management strategy is to manage some shipwrecks primarily as recreational rather than cultural resources to reduce pressure on the more culturally significant wrecks or wrecks that cannot be effectively monitored and managed, for political, administrative or logistical reasons. It also provides an opportunity to educate people about the importance of protecting and conserving shipwrecks (Vrana & Mahoney 1995). Ships are also scuttled to provide recreation opportunities, for example, in Western Australia, a wreck scuttling strategy was implemented to create recreational opportunities for divers with the aim of taking the pressure off wrecks of important cultural heritage value. This strategy was considered successful in achieving its aims (McCarthy & Garratt 1998). As noted above, in Australia, the *ex-HMAS Brisbane* was scuttled in 2005 to provide a dive tourism attraction. The site is to be declared a Conservation Park to maintain the ship's cultural, historic and aesthetic values, and long-term management of the site is the responsibility of Queensland Parks and Wildlife Service. Recreation and conservation values are proposed to be enhanced by prohibiting anchoring, fishing and other boating and watercraft activities at the site. Management and protection of the site is to be achieved through the development of partnerships between the community, commercial operators and other stakeholders. The Queensland Parks and Wildlife Service have estimated that 75 divers on the wreck at any one time is the maximum for a sustainable carrying capacity, but consider 50 to be the optimal number of divers. This estimate was based on a review of best practice management

at other comparable sites in Australia and consultation with the commercial dive tourism industry and other stakeholders (EPA 2005). However, the report does not identify the specific sites or management practices reviewed.

In Australia, the Historic Shipwrecks Program is managed in the context of economic constraint and competing priorities, while needing to manage increasing recreational dive use of wrecks and the impacts of that use (McIntyre 1992). Concerns were raised in 2001 about the decline in funding and support to the program, for example, the 1999/2000 budget allocation to the states, territories and Norfolk Island was \$460,000, and reduced to \$330,000 in 2000/2001 (Jeffery & Moran 2001). Shortcomings that limit effectiveness of legislation in protecting shipwrecks in Australia are due to the limited resources allocated for the implementation of legislation and management of resources, jurisdictional issues, and limitations and loopholes in the legislation (Kenderdine 1997). The Act and National Historic Shipwreck Program are considered to require review (Jeffery 2003b), as the Act was last amended in 1985 and the program was last reviewed in 1990, and not all recommendations of the review were implemented even though community interest and visitation have increased (Jeffery & Moran 2001).

An example of the management constraints and challenges faced in Australia is illustrated by the wreck of the *Yongala* in Queensland. The wreck is protected and disturbance to the wreck and penetration of the wreck is prohibited. Permits are required to dive the wreck, and the Museum of Tropical Queensland is responsible for issuing these permits and has primary management responsibility for the *Yongala*. The *Yongala* is located within the GBR Marine Park, therefore the GBR Marine Park Authority also assumes responsibilities for managing the site, and has identified the wreck as an important resource (Cooper 1998; Cuthill 1998; Jewell 2004). However the *Yongala*, which is an important and high profile wreck, does not have a formal management plan or strategy in place (Cooper 1998; Cuthill 1998). Cultural heritage has been given a far lower priority over environmental and ecological impacts

management in Queensland, considered largely due to limited resourcing (Cooper 1998). This is highlighted by a report on the impacts of marine tourism on the GBR which noted the importance of cultural and social impacts (Harriott 2002). However, this was the only mention of cultural values in the report, which was essentially a review of the ecological impacts of marine tourism. Although it is estimated that there are up to 2,000 wrecks located on the GBR, only a few have been identified and little work has been done in Queensland on cultural resource management of shipwrecks, with some notable exceptions (Cooper 1998). Additionally, although the *Yongala* has been reported to earn charter operators more than \$A1 million annually and significant financial benefits to associated businesses (Jeffery 2003b; Jeffery & Moran 2001), the wreck managers are not able to collect revenue to assist in the management of the *Yongala*, because the *Historic Shipwrecks Act 1976* does not make provision for this type of management strategy (Jeffery & Moran 2001).

In Chuuk Lagoon, FSM, recent management actions include a side scan sonar survey of the wrecks, a corrosion study, and interpretation, including a booklet and six signs to be located on two islands (Jeffery 2004b). The wrecks of Chuuk Lagoon are protected under Chuukese, FSM and US law. The Chuukese and FSM laws prohibit interference with these sites, and impose fines and imprisonment for breaches (Jeffery 2004a & b). The legislation requires all divers on Chuuk wrecks to be accompanied by a licensed guide (Hezel & Graham 1997), and it is estimated that \$US 90,000 is raised each year from permits to dive the wrecks (Jeffery 2004a). However, although legislation and a guide system are in place, as well as an active program to evaluate the resource base, the wrecks continue to be subjected to damage and have artefacts removed (Carrell 1991; Hezel & Graham 1997; Jeffery 2004a & b). If this situation is left unchecked it will diminish cultural heritage and recreational values of the wrecks (Carrell 1991).

While the wrecks are legally protected, law enforcement action has been inconsistent. Many reports of breaches of the law to the Pol-

ice have not been followed up, and in cases where they have been, action has rarely been taken against the offenders. In addition, it has been reported that a former Police chief and his deputy were avid wreck divers and removed a large personal collection of artefacts (Hezel & Graham 1997). More recently, the ship's bell that was removed from the *Sapporo Maru*, noted above, was investigated by the Police but not considered an illegal activity because although removal damaged the wreck, the bell had not been removed from the wreck site (Jeffery 2004a).

In addition to licensed guides accompanying divers on all dives, security guards check divers' bags when they return from diving the wrecks, and this may have prevented some artefact theft. However, in cases where divers were found to have artefacts the guards rarely contacted Police, and on some occasions it is known that the guard did not confiscate the artefacts. Another issue is that due to limited resourcing, responsibility for enforcement has by default become the responsibility of the licensed dive guides, who have no law enforcement authority or training. This situation is made more difficult because it is contrary to Chuukese cultural norms to confront a person, particularly a visitor, even where a major breach of the law has been committed. Most Chuukese will avoid confrontation with divers about stolen artefacts (Hezel & Graham 1997).

Current management of the Chuuk wrecks is ineffective, and three key management actions have been recommended: preventing illegal removal of artefacts, preventing dynamite fishing, and implementing a better mooring system (Hezel & Graham 1997; Jeffery 2004b). It has also been recommended that surveys of the ship and aircraft wrecks be carried out, and more detailed mapping of the sites and their contents (Jeffery 2004a). Surveillance of the wrecks is also required if the wrecks are to be protected (Hezel & Graham 1997). However, cultural resource management is a low priority in Chuuk due to the current economic and social climate, and is a major challenge to the management of these sites (Jeffery 2004a). In order to improve management effectiveness it is considered that a cooperative management

approach involving all stakeholders in all aspects of management would be beneficial, and would include the Chuukese community and government, the Americans and the Japanese (Jeffery 2004b).

Challenges facing the Chuuk government in managing the wrecks are overlapping jurisdictional issues, competing priorities for available funding, inadequate interpretation (Jeffery 2004a) and inconsistent enforcement of legislation (Hezel & Graham 1997). However, resourcing is difficult even in prosperous countries, and the management of over 50 shipwrecks is an enormous task. In addition, the Chuukese government is operating within foreign management systems that differ from the values and priorities of the local community (Jeffery 2004a).

In the Solomon Islands, it is illegal to remove World War II artefacts from the country. There is no shipwreck management program, however, the government and tourist operators support protection of the wrecks because of their cultural and economic importance (Drew 1998). It was noted above that the *SS President Coolidge* is legally protected, however, there does not appear to be any shipwreck management program in place in Vanuatu either.

As noted above, around 150 of 2,000 shipwrecks in New Zealand waters have been located, and although 1,200 of the shipwrecks are protected by legislation, most sites have been disturbed and continue to have artefacts removed by divers (Churchill 1991; MAANZ 2005). However, only one case has been taken to Court and was dismissed by the High Court, due to a loophole in the legislation (MAANZ 2005). The MAANZ was established in 1989 because of a growing awareness of a need for maritime archaeology to be controlled and directed in New Zealand (Churchill 1991), despite this there is a notable lack of literature on this topic from New Zealand.

#### *Physical intervention and conservation measures*

A number of physical intervention and conservation measures are also used to mitigate the impacts of diver and environmental damage to wrecks. In some cases where in-situ conservation cannot be achieved, salvage excavation

may be the management approach used to recover archaeological, anthropological and historical information from wreck sites being damaged or under imminent threat of damage. This approach was used more commonly in the past (Delgado 1988b; May 1985), for example, in WA artefacts were salvaged from the wrecks of the *Vergulde Draeck*, *Batavia* and *Cumberland* (1830) to prevent theft by divers (Henderson 1986). In Queensland, *Yongala* artefacts considered to be at threat from divers and able to be conserved and displayed by the Queensland Museum were recovered by the Queensland Museum in the early 1980s (May 1985). More recently, it was recommended that an underwater interpretive display of selected *Yongala* artefacts be provided at the wreck site for divers, to prevent their removal and relocation on the wreck (Malcolm, Illidge & Wachenfield 1996). However, it is questionable whether this strategy would discourage the practice or whether it would encourage more items to be collected and moved for display, and as discussed above, disturbance to artefacts and the wreck accelerates deterioration.

In Vanuatu, following earthquake damage to the *Lady* on the wreck of the *SS President Coolidge*, the *Lady* was removed from the water then remounted upright in the First Class Dining Room. This action was undertaken allegedly due to the recreation and tourism values of divers from Australia seeing the *Lady* in place on the wreck. Although the *Lady* was placed out of context, not in her original location or mounted in her original orientation (McFadyen 2004), she continued to be very popular with divers. Since then she has been remounted in her original orientation but still remains in the First Class Dining Room rather than in her original location in the Smoking Room (pers. obs. October 2006). However, many other divers either question the appropriateness of the action, or share the views expressed by McFadyen (2004) and disagree with the action, and have difficulty understanding the apparent primary aim or motivation of some divers for only diving the *Coolidge* to see and kiss the *Lady*.

Another management approach that may be applied to in-situ conservation of shipwrecks is

the use of cathodic protection. Corrosion of wrecks can be slowed by cathodic protection (MacLeod in press a) through the use of sacrificial anodes, usually aluminium or zinc, attached to the iron shipwreck to corrode in preference to the wreck (Nutley 1987). Cathodic protection has been trialled in South Australia on the wrecks of the *Zanoni* (1867) and *Santiago* (1945), to slow corrosion and extend the life of the wreck. These trials were considered successful (Jeffery 2003b; MacLeod 1998). It has also been recommended that the feasibility of cathodic protection be investigated for the wreck of the *Fujikawa Maru* in Chuuk Lagoon so that it may remain an outstanding diving attraction, and to prevent the leakage of fuel and oil from the wreck (MacLeod in press a).

Site stabilisation of wrecks, for example sand bagging, can also greatly reduce the rate of corrosion of a wreck's structure and artefacts (MacLeod 1997). Sand bagging was used to stabilise the wreck of the *William Saltbouse* (1841) in Victoria to protect certain parts of the wreck and wreck site from deterioration and collapse at risk from the effects of divers and environmental factors, in particular the strong currents (Hosty 1989).

These physical intervention and conservation measures and approaches are used to a lesser extent than the regulatory and non-regulatory management approaches discussed earlier but are important elements of shipwreck management.

## CONCLUSION AND RECOMMENDATIONS

In-situ conservation of shipwrecks is widely recognised as the preferred management approach (Delgado 1988b; Green 1995; Kenderdine 1997; Jeffery 2004b). A cultural resource management approach to managing shipwrecks is concerned with the *in-situ* management of shipwrecks and includes identifying, assessing and managing the range of values they represent to the community and the manager, including cultural resource, recreation and tourism values (Delgado 1988b; Kenderdine 1997). It is important to know what resources exist and their location, to assess their values and significance, identify and assess potential

impacts, and develop management strategies that reflect the identified values and their significance to society and protect and enhance these values (Delgado 1988b; Jeffery 2004a; Kenderdine 1997). In-situ protection of wrecks is not only important to maintain cultural resource values, it is also important for maintaining recreational dive and tourism values. Dive charter operators are becoming more aware of the importance of retaining artefacts on site and protecting wrecks from damage by divers in recognition of the recreation and tourism values (Heritage Victoria 2000; Kenderdine 1997; Nutley 1996), and there is greater awareness of the legislation in diver training (Heritage Victoria 2000).

The use of legislation has played an important role in the protection of shipwrecks from the impacts of divers (Clark 1985; Green 1996; Jewell 2004; Lester 1983; Nutley 1987), however, as has been demonstrated in the above examples, legislation alone will not ensure their protection. Legal protection of a wreck in itself will only provide minimal protection. There must also be surveillance of the site and enforcement of the legislation (Clark 1985; Jeffery 1983). Management approaches that include a high level of regulation are costly and often reduce visitor satisfaction because they limit freedom and the ability for visitors to meet needs of self expression and escape (McArthur & Hall 1996a). Legislation has been most effective when combined with diverse long-term education programs (Nutley 1987 & 1998), and compliance with legislation is higher where there is emphasis on education rather than threats of fines and legal action (Nutley 1987).

The use of permits to prevent the removal of and disturbance to artefacts and wrecks was one of the regulatory management approaches discussed above, and it was reported by Nutley (1998) that this approach was successful when trialled on the *Lady Darling* in NSW, Australia. However, some divers disagree with this assessment, as recent anecdotal reports from divers note that many objects have been removed from the wreck. It should be noted that the assessment made by Nutley (1998) was made shortly after initial diver access to the

wreck, and may not reflect what has occurred over a longer time period. It was noted above that permits were also required to enter the protected zone for the *SS Duckenfield* in NSW, and that the wreck continues to be damaged by divers. In this case, the limitations of the permit system were due to there being no criteria for obtaining a permit, with permits granted to anyone who applied, and no supervision or surveillance of permit holders (Nutley 1998).

Interpretation can enhance a visitor's appreciation and understanding of a site and increase enjoyment of the experience (Jewell 2004; Pearson & Sullivan 1995). When used effectively interpretation can be an important management tool. Interpretation can influence visitor behaviour and attitudes and enhance visitor experience by communicating and educating about a site's significance and the range of values that make it unique. Visitors better appreciate and value a site when they understand why it is important (Jewell 2004). Management of visitors should be aimed at minimising the unavoidable impacts on cultural resources resulting from visitor use and maximising appreciation and enjoyment (Jewell 2004; Pearson & Sullivan 1995). Effective interpretation can assist in achieving long and short term conservation management aims for shipwrecks, and interpretive opportunities can encourage divers to visit wrecks and to appreciate them (Philippou & Staniforth 2003).

Jewell's (2004) study of the *Yongala* included a survey of the effectiveness of interpretation on diver attitudes and awareness of shipwreck values. The interpretive information provided was a slate with a diagram of the wreck, identifying features of the wreck and information about the wreck. This information placed the wreck into a broader historical, social and environmental context to provide the diver with a greater appreciation and awareness of the wreck and what it once was. The slate was found to be an effective tool in changing diver attitudes towards the *Yongala* and understanding the reasons for penetration of the wreck being prohibited. It was considered that this management approach was more effective in gaining diver compliance and protection of the wreck than legislation and the consequences of

breaching it. Diver attitudes and awareness of the impacts of contacts with wrecks, and the application of correct and appropriate diving techniques to prevent contact and damage, may be more important in protecting shipwrecks from damage than legislation (Jewell 2004).

It is important that interpretation is properly targeted and matched to the needs of visitors and their level of understanding if it is to be effective in changing attitudes (Jewell 2004). Understanding visitor motivation and behaviour, as well as needs and aspirations and how to meet these, is also an important part of management (Jewell 2004). Therefore, understanding the needs, expectations and levels of satisfaction of divers is important when designing management strategies that will protect wrecks and enhance recreation and tourism experiences (Cuthill 1998).

Studies on underwater trails indicate they may be effective in enhancing protection and conservation of wrecks, but studies have not been carried out on whether trails are effective in enhancing visitor experience. This is important because enhanced visitor experience may result in a continuing interest in a site (Jewell 2004). There has been one recent critical review of these trails in Australia by Philippou & Staniforth (2003), and this review found that one of the major shortcomings of the trail system was that the target audiences were not properly identified and many of the publications limited their audience. Trail interpretative information, including signs, information sheets, posters, books and kits, generally gave little information about the heritage values or significance, or failed to express it in a way that made it clear to most members of the community. Important information for divers, such as a site description and information about accessibility, often was not included. Additionally, trails were rarely promoted outside of local or regional areas (Philippou & Staniforth 2003), therefore claims that underwater wreck trails are of value to tourism may be questionable. Further evaluation is required to assess diver satisfaction, whether they are effective in enhancing visitor experience, whether they are effective in modifying diver behaviour and attitudes and gaining support for the protection of

shipwrecks, and to determine levels and patterns of use.

Visitor behaviour can be modified positively when high quality experiences are provided that satisfy their needs and expectations (Hall & McArthur 1996). Cultural heritage managers have sometimes used mediocre examples of cultural heritage for interpretation to prevent damage to more significant sites. However, people react positively to quality and well interpreted places of outstanding value are more appreciated and less subjected to damage than mediocre sites (Pearson & Sullivan 1995). One of the management strategies outlined in above was the provision of recreational wrecks, including scuttled wrecks, or the use of less important or sensitive wrecks for interpretive trails to take the pressure off more significant or fragile sites. This strategy may not always be successful because it does not meet the aspirations and needs of all divers. Many divers may want to dive historic and significant wrecks, or dive a particular wreck or types of wrecks. Although McCarthy & Garratt (1998) considered the WA scuttling program successful in reducing diver pressure on shipwrecks with important cultural heritage values, the literature reinforces that critical voices are few and there is an absence critical evaluation of the effectiveness of scuttling programs. This may indicate that there is a false level of certainty about the success of these programs. Vessels scuttled for recreational diving are usually modified prior to scuttling to improve diver safety. For example, modifications carried out on the *ex-HMAS Brisbane* before it was scuttled included the removal of doors and hatches, widening of openings, removal of unfixed objects such as furniture, making large openings to the exterior of the wreck to allow light penetration, sealing certain entrances to restrict access to parts of the wreck, removal of contaminants, and removal of cabling and wires (EPA 2005). While most divers would agree with the need to remove contaminants, not all divers agree with the other actions, such as altering openings and access to the wreck. Some wreck divers regard wrecks prepared in this way provide a sanitised, less interesting and less challenging wreck diving experience, because it is not an authentic

wreck diving experience. However, these views are not recognised in the literature.

As noted in the introduction, there has been no cohesive discussion of the impact of diving on shipwrecks and the literature is very patchy and limited to a few case studies. Management approaches and measures adopted to reduce or eliminate diver impacts on shipwrecks are therefore based on very limited and patchy information. While the case studies have highlighted examples of diver impacts, these impacts have generally not been well documented or based on any systematic or long term research or monitoring. Assessment of the many and varied impacts on shipwrecks is difficult (Kenderdine 1997), however, change can be assessed by closely monitoring wreck sites and compiling comparative data about the various impacts. This requires significant resources and needs to be undertaken regularly (Kenderdine 1997). Research and monitoring of the nature and level of diver use impacts on wrecks is required to properly assess the extent of the problem, and it is recommended that the work is undertaken in the following areas to address the gaps in information and to provide a basis for better informed management decisions and approaches to diver impacts on wrecks.

As noted above, the causes of diver contacts with wrecks have been identified. Studies are required to assess the frequency, types, causes and consequences of diver contacts with wrecks, in particular, the impact of diver contacts with protective marine growth and concretions, how this affects rates of corrosion, and recovery times for areas that have been damaged. The effects of increased corrosion resulting from divers exhaled air bubbles is well recognised by divers, and research is required to assess the extent of this impact. While the above case studies have provided examples of souveniring by recreational divers, described the nature of the activity and demonstrated that this activity has an impact on wrecks, research is required to establish the rate, patterns and extent of souveniring of artefacts occurring, and to better understand the motivation for this behaviour. The amenity values of wrecks and the range of factors that affect

amenity values and diver satisfaction, such as the presence of other divers, removal of and damage to artefacts, environmental damage, diver use impacts and other human damage to wrecks, also needs to be studied. There needs to be a better understanding of current diver attitudes and awareness of diver impacts on shipwrecks, and the aspirations and needs of the range of recreational divers, and more work is required on the effectiveness of education and involvement programs and strategies in changing diver attitudes. The tourism values of recreational diving are recognised, however, comprehensive assessments of the economic value of recreational diving of shipwrecks is required to more accurately demonstrate these values. Finally, the effectiveness of management approaches and measures used to reduce or eliminate diver impacts require evaluation.

There is no uniform approach to the protection and management of shipwrecks arising from the diversity of political systems, cultures and economic development of the various nations in the study area (Smith 1999), and evaluation of the effectiveness of the various management approaches and measures discussed in achieving conservation of shipwrecks is required. Effective protection of wrecks depends on public education, public participation and self-regulation by the recreational diving community (Jefferson 1988). Management approaches implemented should be ones that protect the cultural and recreational dive values of shipwrecks but in a manner that is appropriate to local management structures and culture of the nation and community involved.

Although this paper reviews the impacts of diving and the management of diver impacts, it is recognised that shipwrecks need to be valued by the community as a whole, not just by divers (Jeffery 2002). It is important that wreck programs are aimed at the whole community, not just sections of it (Delgado 1988b; Jeffery 1993; Kenderdine 1997; Nutley 1987; Philipou & Staniforth 2003) because the community as a whole are the taxpayers, a major source of funds for wreck programs, and whose support, including political, is important to achieving conservation of historic shipwrecks (Jeffery 2003b).

**ABBREVIATIONS**

ACT	Australian Capital Territory
AIMA	Australian Institute of Maritime Archaeology
CDO	Cultural Development Office
DoE	Department of the Environment
EPA	Environment Protection Agency
FSM	Federated States of Micronesia
GBR	Great Barrier Reef
MAANZ	Maritime Archaeological Association of New Zealand
NSW	New South Wales
SA	South Australia
Scuba	Self contained underwater breathing apparatus
US	United States of America
WA	Western Australia

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**BIBLIOGRAPHY**

- Aplin, G. (2002). *Heritage identification, conservation, and management*. Oxford University Press, South Melbourne, Victoria. Pp. 1-14 & 113-138.
- Anderson, R. (1997). *Wrecks on the reef: A guide to the historic shipwrecks at Port Phillip Heads*. Heritage Council of Victoria, Melbourne, Victoria.
- Australian Institute for Maritime Archaeology & Australian Cultural Development Office. (1994). *Guidelines for the management of Australia's shipwrecks*. Australian Institute for Maritime Archaeology & Australian Cultural Development Office, Canberra, ACT.
- Bower, R. & Smith, T. (1991). *SS Catterthun (1881-1895): Case for declaration as an historic shipwreck*. Heritage Branch, Department of Planning, Sydney, NSW.
- Bright, L. S. (1997). Minimal impact archaeology. in J. P. Delgado (ed.), *Encyclopaedia of underwater and maritime archaeology*. British Museum Press, Bloomsbury, London. Pp. 278-279.
- Carrell, T. L. (1991). Management recommendations and conclusions. in T. L. Carrell (ed.), *Micronesia submerged cultural resources assessment*. Southwest Cultural Resources Center Professional Papers Number 36, National Park Service, Santa Fe, New Mexico. Pp. 549-553.
- Churchill, D. (1991). The Maritime Archaeological Association of New Zealand MAANZ (Inc.). *Bulletin of the Australian Institute for Maritime Archaeology* 15(1), pp. 7-10.
- Clark, N. (1985). Shoal waters in underwater cultural resource management – the site assessment dilemma'. in M McCarthy (ed.), *Iron ships & steam shipwrecks: Papers from the first Australian seminar on the management of iron vessels & steam shipwrecks*. WA Maritime Museum, Western Australia. Pp. 13-18.
- Cooper, D. (1998). Issues in cultural resource management: A case study from the Great Barrier Reef. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 125-126.
- Coroneos, C. (1997). Wreck survey project: Shipwrecks of New South Wales project date 1993-5. *Report for the NSW Heritage Office, Sydney, NSW*.
- Cuthill, M. (1998). Managing the *Yongala* historic shipwreck. *Coastal Management* 26, pp. 33-46.
- Davis, D., Harriott, V., MacNamara, C., Roberts, L. & Austin, S. (1995). Conflicts in a marine protected area: Scuba divers, economics, ecology and management in Julian Rocks Aquatic Reserve. *Australian Parks & Recreation* Autumn, pp. 29-35.
- Delgado, J. P. (1988a). The value of shipwrecks. in J Waldron Murphy (ed.), *Historic shipwrecks: Issues in management*. Partners for Livable Places and the National Trust for Historic Preservation, Washington DC. Pp. 1-10.
- Delgado, J.P. (1988b) Historical overview. in J Waldron Murphy (ed.), *Historic shipwrecks: Issues in management*, Partners for Livable Places and the National Trust for Historic Preservation, Washington DC. Pp. 11-20.
- Department of the Arts and Administrative Services. (1993). *Historic shipwrecks: Public access guidelines*. Department of the Arts and Administrative Services, Canberra, ACT, Australia.
- Department of Planning. (1989). *SS Duckenfield (1875 – 1889): A case for declaration as an his-*

- toric shipwreck. Heritage Branch, Department of Planning, Sydney, NSW.
- Department of the Premier and Cabinet. (2005). 31 July 2005 *Ex-Brisbane* sinks off Sunshine Coast. Ministerial Media Statements, Department of the Premier and Cabinet, Queensland Government, viewed 2 August 2005, <<http://statements.cabinet.qld.gov.au/cgi-bin/display-statement.pl?id=7890&db=media>>.
- Drew, T. (1998). Solomon Islands: Guadalcanal shipwrecks revisited. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 71-74.
- Environment Protection Agency. (2005). *Public benefit test for a proposed conservation park for the ex-HMAS Brisbane*. Environment Protection Agency, Queensland Government, Brisbane, Queensland.
- Fielding, K. (2003). A pane in the past: the *Loch Ard* disaster and a few bits of glass. *Bulletin of the Australasian Institute for Maritime Archaeology* 27, pp. 1-8.
- Green, J. (1995). Management of maritime archaeology under Australian legislation. *Bulletin of the Australian Institute for Maritime Archaeology* 19(2), pp. 33-44.
- Green, J. (1996) Management of maritime archaeology under Australian legislation, in L Smith & A Clarke (eds), *Issues in management archaeology*. Tempus Archaeology and Material Culture Studies in Anthropology, vol. 5, Anthropology Museum, University of Queensland, Queensland. Pp. 85-98.
- Hall, C. M. & McArthur, S. (1996). The human dimension of heritage management: Different values, different interests, different issues, in C. M. Hall & S. McArthur (eds), *Heritage management in Australia and New Zealand: The human dimension*. Oxford University Press, Melbourne, Victoria. Pp. 2-21.
- Hardy, D. (1990). A century on the sea-bed: the *Centurion*. *Bulletin of the Australian Institute for Maritime Archaeology* 14(2), pp. 23-34.
- Harriott, V. J. (2002). *Marine tourism impacts and their management on the Great Barrier Reef*. CRC Reef Research Centre Technical Report No. 46, CRC Reef Research Centre, Townsville, Queensland.
- Harriott, V. J., Davis, D. & Banks, S. A. (1997). Recreational diving and its impact in marine protected areas in Eastern Australia. *Ambio* 26(3), pp. 173-179.
- Henderson, G. (1986). *Maritime archaeology in Australia*. University of Western Australia Press, Nedlands, Western Australia. Pp. 1-4, 10-15, 91, 121-171.
- Henderson, S. (1989). Biofouling and corrosion study. in *USS Arizona Memorial and Pearl Harbour National Historic Landmark submerged cultural resources study*. Southwest Cultural Resources Center Professional Papers No. 23, National Parks Service, Santa Fe, New Mexico.
- Heritage Office. (1994a). *Underwater heritage: Local government guidelines*. Heritage Office, Sydney, NSW.
- Heritage Office. (1994b). *Underwater heritage: Principles and guidelines*, Heritage Office, Sydney, NSW.
- Heritage South Australia. (2002a). *Shipwreck guidelines 2: Diving shipwrecks*. Heritage South Australia, Department for Environment and Heritage, Adelaide, SA.
- Heritage South Australia. (2002b). *Shipwreck guidelines 1: Anchoring on shipwrecks*, Heritage South Australia, Department for Environment and Heritage, Adelaide, SA.
- Heritage Victoria. (2000). *Victorian Heritage Strategy: Shipwrecks 2005*. Heritage Victoria, Melbourne, Victoria.
- Hezel, F. X. & Graham, C. (1997). *Truk underwater archaeology: Truk's underwater museum: A report on the sunken Japanese ships, Federated States of Micronesia*. Micronesian Resources Study, US National Parks Service, San Francisco, California.
- Hosty, K. (1987). Historic shipwreck legislation and the Australian diver. Past, present and future. *Bulletin of the Australian Institute for Maritime Archaeology* 11(1), pp. 21-25.
- Hosty, K. (1989). Bagging the *William Saltbouse*: Site stabilization work on the *William Saltbouse*. *Bulletin of the Australian Institute for Maritime Archaeology* 12(2), pp. 13-16.
- Howard, J. L. (1999). How do scuba diving operators in Vanuatu attempt to minimise their impact on the environment?. *Pacific Tourism Review* 3(1), pp. 61-69.
- Jefferson, M. L. (1988). Developing a state management program. in J Waldron Murphy (ed.), *Historic shipwrecks: Issues in management*. Partners for Livable Places and the National Trust for Historic Preservation, Washington DC. Pp. 35-44.
- Jeffery B. (1983). The development of maritime archaeology in South Australia. In W Jeffery & J Amess (eds), *Proceedings of the Second Southern Hemisphere Conference on Maritime Archaeology*. South Australian Department of Environment and Planning and the Commonwealth Department of Home Affairs and Environment, Adelaide, SA, Australia. Pp. 83-91.

- Jeffery, B. (1990). Realising the cultural tourism potential of South Australian shipwrecks. *Historic Environment* 3 & 4, pp. 72-76.
- Jeffery, B. (1992). Current approaches to the underwater cultural heritage – strengths and weaknesses. The Australian perspective. *Historic Environment* 9(3), pp. 9-10.
- Jeffery, B. (1993). Maritime archaeology: what's in it for Australian's?. *Bulletin of the Australian Institute for Maritime Archaeology* 17(2), pp. 1-6.
- Jeffery, B. (2002). The UNESCO Convention on the Protection of the Underwater Cultural Heritage: Implications for the Federated States of Australia. *Bulletin of the Australasian Institute for Maritime Archaeology* 26, pp. 75-82.
- Jeffery, B. (2003a). *World War II sites in Truk Lagoon, Federated States of Micronesia*. Chuuk Historic Preservation Office, Weno, Chuuk, FSM.
- Jeffery, B. (2003b). *South Australian maritime heritage program 1970s – 2002: Projects, activities and bibliography*. Heritage Branch, Department for Environment and Heritage, Heritage Branch, Adelaide, SA.
- Jeffery, B. (2004a). World War II shipwrecks in Truk Lagoon: The role of interest groups. *CRM* 1(2), Summer, pp. 51-67.
- Jeffery, B. (2004b). World War II underwater cultural heritage sites in Truk Lagoon: Considering a case for World Heritage listing. *International Journal of Nautical Archaeology* 33(1), pp. 106-121.
- Jeffery, B. & Moran, V. (2001). Going down?: The foundering of the National Historic Shipwrecks Program. *Bulletin of the Australian Institute for Maritime Archaeology* 25, pp. 121-127.
- Jewell, B. (2004). The effectiveness of interpretation on diver attitudes and awareness of underwater shipwreck values – *SS Yongala*, a case study. *Bulletin of the Australasian Institute for Maritime Archaeology* 28, pp. 43-62.
- Johnson, C. (2000). For keeping or for keeps? An Australian perspective on challenges facing the development of a regime for the protection of underwater cultural heritage. *Melbourne Journal of International Law* 1, pp. 19-34.
- Johnston, P.F. (1993). Treasure salvage, archaeological ethics and maritime museums. *International Journal of Nautical Archaeology* 22(1), pp. 53-60.
- Kaoru, Y. & Hoagland, P. (1994). The value of historic shipwrecks: Conflicts and management. *Coastal Management* 22, pp. 195-211.
- Kenderdine, S. (1997). *Culture and heritage: Shipwrecks and associated objects*. Australia: State of the Environment Technical Paper Series (Natural and cultural heritage), Department of the Environment, Canberra, ACT.
- Lester, S. (1983). Maritime archaeology: an enquiry into sport diver attitudes, in W Jeffery & J Amess (eds), Proceedings of the second southern hemisphere conference on maritime archaeology. South Australian Department of Environment and Planning and the Commonwealth Department of Home Affairs and Environment, Adelaide, SA. Pp. 391-407.
- Lindemann, K. (1992). *Hailstorm over Truk Lagoon*. Pacific Press Publications, Belleville, Michigan.
- Look, D. W. & Spennemann, D.H.R. (1993). *For future use: A management conservation plan for the World War II sites in the Republic of the Marshall Islands*. Republic of the Marshall Islands Historic Preservation Office and US National Parks Service, San Francisco, CA, and the Johnstone Centre for Parks, Recreation & Heritage, Albury, NSW.
- McArthur, S. & Hall, C. M. (1996a). Visitor management: Principles and practice. in C. M. Hall & S. McArthur (eds), *Heritage management in Australia and New Zealand: The human dimension*. Oxford University Press, Melbourne, Victoria, Australia. Pp. 37-51.
- McArthur, S. & Hall, C. M. (1996b). Visitor research and monitoring. in C. M. Hall & S. McArthur (eds), *Heritage management in Australia and New Zealand: The human dimension*. Oxford University Press, Melbourne, Victoria, Australia. Pp. 52-73.
- McCarthy, M. (1983). Wrecks and recreation. in W Jeffery & J Amess (eds), Proceedings of the Second Southern Hemisphere Conference on Maritime Archaeology. South Australian Department of Environment and Planning and the Commonwealth Department of Home Affairs and Environment, Adelaide, SA. Pp. 381-389.
- McCarthy, M. (1998). The submarine as a class of archaeological site. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 61-70.
- McCarthy, M. & Garratt, D. (1998). The Western Australian Maritime Museum's wreck access and outreach program. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 127-132.
- McFadyen, M. (2004). Diving the *SS President Coolidge*. Michael McFadyen's Scuba Diving Website, viewed 26 August 2005, <<http://www.michaelmcfadyenscuba.info/articles/cool95.htm>>.
- McIntyre, D. (1992). Introduction. *Historic Environment* 9(3), pp. 1-4.
- MacLeod, I. D. (1989) The application of corrosion science to the management of maritime archaeo-

- logical sites. *Bulletin of the Australian Institute for Maritime Archaeology* 13(2), pp. 7-16.
- MacLeod, I. (1992). Current approaches to the underwater cultural heritage – strengths and weaknesses. Materials conservation management. *Historic Environment*. 9(3), pp. 11-16.
- MacLeod, I. (1997). Corrosion studies'. in J. P. Delgado (ed.), *Encyclopaedia of underwater maritime archaeology*. British Museum Press, Bloomsbury, London. Pp. 111-113.
- MacLeod, I. D. (1998). In-situ corrosion studies on iron and composite wrecks in South Australian waters: implications for site managers and cultural tourism. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 81-90.
- MacLeod, I. D. (in press a). A new corrosion mechanism for iron shipwrecks in seawater: A study of the *Fujikawa Maru* (1944) in Chuuk Lagoon, Federated States of Micronesia. Submitted for review to the *International Journal of Nautical Archaeology*, 7 pages.
- MacLeod, I. D. (in press b). In-situ corrosion studies on wrecked aircraft of the Japanese Imperial Navy in Chuuk Lagoon, Federated States of Micronesia. Submitted for review as a prepaper for the International Council of Museums – International Committee for Conservation Triennial Meeting, 12-16 September 2005, The Hague, The Netherlands, 8 pages.
- Malcolm, H., Illidge, P. & Wachenfield, D. (1996). Preliminary assessment of *Yongala* Monitoring. *Internal Memorandum, Department of Environment, Townsville, Queensland*.
- Maritime Archaeological Association of New Zealand. (2005). *Maritime archaeology*. Viewed 19 June 2005, <<http://www.maanz.welington.net.nz/maanz/mari.htm>>.
- May, S. (1985). *SS Yongala*: A history and site inspection report. in M McCarthy (ed), *Iron ships & steam shipwrecks: Papers from the first Australian seminar on the management of iron vessels & steam shipwrecks*. WA Maritime Museum, Western Australia. Pp. 128-130.
- NSW Heritage Office. (2000). *Guideline note: anchoring on shipwrecks*. NSW Heritage Office, Parramatta, NSW.
- Nutley, D. (1987). Maritime heritage protection: education as the long arm of the law. *Bulletin of the Australian Institute for Maritime Archaeology* 11(1), pp. 29-33.
- Nutley, D. (1996). Underwater cultural heritage management. in L Smith & A Clarke (eds), *Issues in management archaeology*, Tempus Archaeology and Material Culture Studies in Anthropology, vol. 5, Anthropology Museum, University of Queensland, Queensland, pp. 99-105.
- Nutley, D. (1998). Ten years of shipwreck access and management practices in New South Wales. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 115-118.
- Nutley, D. & Smith, T. (1992). *Dunbar (1854-1857): Conservation Management Plan*. Maritime Archaeology Program, NSW Heritage Office, Sydney, NSW.
- Pearson, M. & Sullivan, S. (1995). *Looking after heritage places: The basics of heritage planning for managers, landowners and administrators*. Melbourne University Press, Melbourne, Victoria, Australia. Pp. 30-57 & 277-306.
- Philippou, C. (2004). Collection management for shipwreck relics: amnesty artefacts significance assessment Victoria 2003 interim report. *Bulletin of the Australasian Institute for Maritime Archaeology* 28, pp. 25-32.
- Philippou, C. & Staniforth, M. (2003). Maritime heritage trails in Australia: An overview and critique of the interpretive programs. in J. D. Spirek & D. A. Scott-Ireton (eds), *Submerged cultural resource management: Preserving and interpreting our maritime heritage*. Kluwer Academic/Plenum Publishers, New York, NY. Pp. 135-149.
- Randell, S. (1998). Marine growth on shipwrecks. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 107-108.
- Riley, J. (1985). The waterline theory of iron ship disintegration. in M McCarthy (ed), *Iron ships & steam shipwrecks: Papers from the first Australian seminar on the management of iron vessels & steam shipwrecks*. WA Maritime Museum, Western Australia. Pp. 191-197.
- Rouphael, T. & Inglis, G. (1995). *The effects of qualified recreational SCUBA divers on coral reefs*. Technical Report No. 4, CRC Reef Research Centre, James Cook University, Townsville, Queensland.
- Sledge, S. (1977). The wreck inspection programme at the Western Australian Museum: Responsibilities, aims and methods. in *Papers from the first southern hemisphere conference on maritime archaeology*. Ocean's Society of Australia, Perth, Western Australia. Pp. 80-90.
- Smith T. (1993). The *Walter Hood*: walking the waters. *Bulletin of the Australian Institute for Maritime Archaeology*. 17(2), pp. 43-46.
- Smith, T. (1999). Submarines by the sea full: The Pacific's unique archaeological resource. *Bulletin of the Australian Institute for Maritime Archaeology* 23, pp. 79-85.

- Smith, T. (2003). Shipwreck trails: Public ownership of a unique resource? An Australian perspective. in J. D. Spirek & D. A. Scott-Ireton (eds), *Submerged cultural resource management: Preserving and interpreting our maritime heritage*. Kluwer Academic/Plenum Publishers, New York, NY. Pp. 121-133.
- Strachan, S. (1995). Interpreting maritime heritage: Australian historic shipwreck trails. *Historic Environment* 11(4), pp. 26-35.
- Stone, P. (1997). *The Lady and the President: The life and loss of the S.S. President Coolidge*. Oceans Enterprises, Yarram, Victoria.
- Vrana, K. J. & Mahoney E. M. (1995). Impacts on underwater cultural resources: Diagnosing change and prescribing solutions. in P. F. Johnston (ed.), *Underwater archaeology: Proceedings from the Society for Historical Archaeology conference*. The Society for Historical Archaeology, Washington, DC. Pp. 176-180.
- Ward, I. A. K., Larcombe, P. & Veth, P. (1998). Towards new process-oriented models for describing wreck disintegration – an example using the *Pandora* wreck.. *Bulletin of the Australian Institute for Maritime Archaeology* 22, pp. 109-114.

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