An Engineers Explanation

of the

Unprecedented Breakup Of Ships Placed As Reefs.

By

Werner F. Hoyt, PE

Marine/Mechanical Engineer

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Vallejo, California, USA

Werner F. Hoyt

Digitally signed by Werner F. Hoyt
DN: cn=Werner F. Hoyt, o=Allied Defense Recycling, LLC, ou=Program Manager, email=WernerHoyt@aol.com, c=US
Date: 2011.04.02 22:13:55 -07'00'

BACKGROUND

The HMAS Canberra was the first FFG-7 Class Hull to be reefed for ship disposal. The failure of the HMAS Canberra hull to superstructure was announced and explanations sought.

AUTHORS BACKGROUND RELATIVE TO OPINION:

Masters Thesis in aluminum metallurgy at US Naval Postgraduate school in the processing of Aluminum alloys, supporting studies in corrosion control, Naval Engineering, and metallurgy associated with failure analysis.

Ship repair and overhaul of ships in service and ship disposal with observations of extensive corrosion failures with moisture present in the presence of galvanic potential on US Naval Vessels undergoing repair.

Experience in conducting RFI elimination repairs to warships undergoing overhaul 1980-1996.

Experience in corrosion control processes for the repair and modernization of Naval Vessels 1980 to 1996: CG (Leahy), CG-26 (Belknap), LHA(Tarawa), FFG-7(Perry), FF-1040(Ramsey), FF-1054(Knox), DDG (Adams), DDG (Spruance), CG(Ticonderoga).

BACKGROUND OF CONSTRUCTION RELATED TO THE FAILURE:

JOINT DESIGN

The practice of ship construction with aluminum superstructures began in the 1950's continuing into the 1960's. To solve the problem of joining the dissimilar structures and the problems of galvanic corrosion ship construction practices utilized electrical isolation to prevent formation of galvanic cells. This design was utilized heavily in US Naval Warship design and construction due to the decreased weight of the aluminum superstructure. The Perth, Hobart, and Swan utilized this type of construction. (T-15)

The design used a di-electric material between the aluminum and steel plates, the plates were drilled and riveted together with an insulating sleeve and stainless huckbolt (rivet). This prevented direct contact between the aluminum and steel where galvanic cells could form. Mechanical joints between aluminum and steel indirect contact less in the presence of an electrolytic medium (conducting fluid).will typically result in the aluminum plate corroding through in 2 years or less for a quarter inch plate material.

By the late 1970's Radio Frequency Interference (RFI) due to insufficient grounding was recognized as a major problem on warships. RFI is caused by ungrounded ships materials behaving as antennas absorbing radio frequency energy and re-radiating it in harmonic frequencies. This results in increased electromagnetic signatures in an Electronic Warfare Environment, Degradation of Radar Systems, and interference with radio signal reception. The solution was a major program to ground these sources to the ship's hull. This was accomplished by welding a bimetallic bonding strap formed from a steel lug, copper cable, and aluminum lug to the ship's hull. Metal was replaced with non-metal Graphite Reinforced Plastic lifelines and handrails where possible to eliminate RFI emissions. The effect of this program was the establishment of a fully electrically grounded aluminum superstructure to the steel hull with many highly conductive paths between the two structures until the welded attachment points corrode away at which point in time the corrosion model returns the dielectric model. The rate at which this would take place depends up on the following is a function of

1. # of bonding straps from steel hull to aluminum superstructure
2. the conditions at each strap with respect to paints covering the aluminum lug
3. the area immediately around the weld location.

Condition	Preservation Description	Corrosion Rate of Lug	Effect
Well preserved	Fully intact paint	Delayed until corrosion protection fails	Corrosion is pushed to unpreserved areas away from the bonding strap.
Partially preserved	Paint degradation exposing the aluminum lug	Immediate attack by galvanic exposing more metal and expanding area of corrosion	Corrosion is focused on the bonding strap aluminum lug. Rate of corrosion very rapid due to the relative surface area driving the process - many m2 cathodic (protected) - Several cm2 anodic (sacrificial) -
Un preserved	No paint or preservative protecting the aluminum lug	Immediate generalized attack of entire lug	Corrosion is focused on the bonding strap aluminum lug. Rate of corrosion very rapid due to the relative surface area driving the process - many m2 cathodic (protected) Several cm2 anodic (sacrificial

The net effect of galvanic corrosion processes for riveted construction with bonding straps will be relatively immediate return to the di-electric model due to focused corrosion attack at the points of bonding.

Problems with the riveted design relating to corrosion, bonding, and in particular fabrication/repair cost for new construction or vessel alteration led to the development of a bi-metallic joint in the early 1960's which gained acceptance in ship design and was incorporated into the FFG-7 class design.

Typical superstructure joint design utilized for the FFG-7 class frigates hulls built in the United States for/or under license to Australia, or under license to other navys utilized a bi-metallic explosion bonded joint enabling welding the aluminum superstructure on one side to the steel hull on the other side. This joint provided a 100% efficient conductivity path between the hull and superstructure. This method provided electrical connection at all locations from the hull to the superstructure as opposed to every 4 to eight feet as would be found in ships with aluminum superstructures modified as a result of correcting RFI deficiencies.

METALURGY

FFG-7, Knox Class, Adams Class, and other pre-Falklands warships utilized aluminum superstructures for weight reduction in the superstructure to increase stability of the ships. They uniformly utilized 5000 series aluminum alloys. The characteristic of the alloy that makes it useful is it's weldability without the requirement for heat treatment. This alloy utilizes copper for interstitial reinforcement of the aluminum at the level of the crystal structure. Aluminum alloy is batch formed to the required consistency poured into a large ingot. It is later reheated at the plate mill and rolled to the desired thickness. This process creates long thin and flat crystals in the metal plate. The thinner plate thickness generates thinner the plate crystals. The copper tends to diffuse to the grain boundary when the material age hardens generating its strength and characteristic hardness. It is the interstitial copper in the aluminum crystal which provides its mechanical strength.

CORROSION

TYPE OF CORROSION

Corrosion of aluminum in a reefed ship is driven by galvanic corrosion. The more noble metal is protected by the less noble metal. The chemical process is driven by electrical potential. (Appendix A) In this case the aluminum becomes the sacrificial metal. Normally zinc is utilized to protect the steel as a sacrificial anode or an active cathodic protection system is employed while the ship is in service. When reefed the aluminum becomes the sacrificial anode. This drives the general corrosion process between the steel hull and aluminum. Corrosion rate is a function of area of the aluminum superstructure and the steel hull in contact with the electrolyte (seawater). In this case the exposed area of the hull in contact is 10 to 30 times the area of the aluminum overall. The area highest corrosion activity will be unprotected plate nearest to the bonding joint.

AMPLIFYING FACTORS TO THE BASIC PROCESS ARE:

1) Inter-granular corrosion (Appendix B)

5000 series aluminum alloys are specifically susceptible to intergranular corrosion on account of either phases anodic to aluminum being present along grain boundaries or due to depleted zones of copper adjacent to grain **boundaries** in copper-containing alloys. Alloys that have been extruded or otherwise worked heavily, with a microstructure of elongated, flattened grains, are particularly prone to this damage.

Characteristics of the aluminum as it transitions from the bi-metalic joint to the plate.

Joint- Thick rolled plate explosion bonded to steel – flattened grain structure.

Weld – rounded unflattended grain structure formed as part of welding.

Structural plate above joint – one 5 mm to 20 mm thickness depending on location and application. The thinner the plate the thinner, flatter and longer the metal grain structure.

What this means to the reefed ship is the corrosion propagates down the grain boundary separating and lifting the metallic grain away from the underlying structure. This accelerates by orders of magnitude the rate of corrosion that would be experienced by cast aluminum without the presence of copper by ranging from 10 to 1,000.

2) Errosion Corrosion (Appendix B)

Erosion-corrosion: Erosion-corrosion is associated with a flow-induced mechanical removal of the protective surface film that results in a subsequent corrosion rate increase via either electrochemical or chemical processes. It is often accepted that a critical fluid velocity must be exceeded for a given material. The mechanical damage by the impacting fluid imposes disruptive shear stresses or pressure variations on the material surface and/or the protective surface film. Erosion-corrosion may be enhanced by particles (solids or gas bubbles) and impacted by multi-phase flows. The morphology of surfaces affected by erosion-corrosion may be in the form of shallow pits or horseshoes or other local phenomena related to the flow direction.

What the above statement means to the reefed ship is that the sand embedded in the water turbulence will assist in causing exfoliated aluminum flakes of metal to be scoured away from the surface exposing new material. Even without the presence of sand and debris the effect of the high energy environment will be to cause exfoliated aluminum flakes to work and peel away exposing new fresh material.

3) Mass transport-control (Appendix B)

Mass transport-control: Mass transport-controlled corrosion implies that the rate of corrosion is dependent on the convective mass transfer processes at the metal/fluid interface. When steel is exposed to oxygenated water, the initial corrosion rate will be closely related to the convective flux of dissolved oxygen towards the surface, and later by the oxygen diffusion through the iron oxide layer. Corrosion by mass transport will often be streamlined and smooth.

What this means to the reefed ship is an increased presence of oxygen due to the high energy environment generating large flows of water through and around the structure.

In summary the relative value of the effects on corrosion are

1- General Galvanic Cell which drives the process
2- Interstitial grain boundary corrosion which accelerates the process
3- Erosion – the mechanical refreshing of the surface exposing new material aggravates the corrosion rate.
4- Mass Transport control – insures that fresh dissolved oxygen is always available at the surface.

ENERGY PRESENT AT THE REEFING SITE:

Energy of the site is a function of wave height (trough to crest) squared times its period. This means that if the mean wave height doubles along with the wave period the site energy working on the reefed ship is 8 times higher. An average increase of 1.3 in wave height and period doubles the wave energy present.

Tidal energy present – mean tidal flow rates based on local geography coupled with ocean currents. Unable to qualitatively evaluate Canberra and Adelaide Reef sites.

OBSERVATIONS:

In relation to Adelaide the following qualitative observations can be made

1 – Sea states at the Avoca Beach location were reported to author as substantially higher than at the location Canberra was reefed which indicates that the site energy environment is higher, likely on the order of 2x.

2 – Canberra insulating materials were left intact. The court has ordered complete removal of the ship has been cleaned of all insulating materials from the inside of the ships shell providing direct access for oxygenated water.

3- Both Adelaide and Canberra are of identical construction methods. Differences in hull length for this assessment are considered to have a negligible effect.

4 – The base effect of galvanic corrosion on Adelaide will be similar to Canberra

5 – The effect of interstitial grain boundary corrosion will be amplified accelerating the overall failure/separation of aluminum superstructure from the steel hull of Adelaide due to

a) The increased erosion
b) Increased presence of oxygen,

resulting from the higher energy ocean environment where Adelaide will be situated versus the energy of the environment where the Canberra was reefed.

OTHER MODES OF HULL FAILURE:

Structural Design/Fabrication process – Ship design utilizes plates welded together. Weld lines create lines along which material properties of the material differ from the parent hull plating. In the case of the New Zealand ships there was a history of known structural problems. (Appendix C)

Breakup of three ships within 6 months to one year resulted in closure, temporary closure of the reefing sites to diving or warnings of significantly increased diving hazards. (Appendices C, D. E)

Waikato (F-55) – broken during reefing just at the deckhouse break.

Wellington (F-69) – broken during the storm event with recorded waves of nearly 13 meters. Wave motions generate significant movement underwater of similar magnitudes below the wave to a depth under the trough equal to or exceeding the wave height. This equates to 26 meters below the top of the wave.

In the case of the New Zealand ships the breakup was driven by structural week points of steel hull structures, failure propagated along the Heat Affected Zone (HAZ) adjacent to welds by brittle fracture propagation based on the description of the breakups. A characteristic of brittle fracture is clean straight line fracturing of a structure typically along a weld. In these cases breakup generated by the reefing event itself or as a consequence of storm activity. The F69 settled to the bottom much more rapidly than planned (Appendices C, D, E) generating increased loading of the weld line. Failure is likely have initiated at one of the scuttling charge points along the bottom of the ship that initiated the start of the crack.

Reefing the HMAS Adelaide presents a similar possibility with a class history of structura lweek points and fixes. (Appendix C-1). Coupled with intentional weakening of the hullfor divers accesses and placement of scuttling charges to create flooding openings increases the risk of a similar event.

CONCLUSIONS:

1) The HMAS Adelaide will be exposed to galvanic corrosion processes.
2) The highest rates of corrosion will be at the plate immediately above the bimetallic strip. This is borne out by the observed failure of the helicopter hanger shell detaching on the Canberra.
3) The local environment energy will accelerate those processes.
4) The HMAS Adelaide will begin see superstructure failures more rapidly than her sister ship the HMAS Canberra.
5) Probability of structural failure in 18 months – Certain based on the HMAS Canberra.
6) Probability of hull structural failure in 12 months or less – Very high based on the increased energy environment and aggravating corrosion factors of both vessel preparation and reefing location.
7) Probability of hull structural failure at time of reefing – low to moderate. No failure was observed during the Canberra Reefing. Failure cannot be ruled out unless diver access locations are identical and reefing scuttling charge locations are identical. Water temperature evaluations of reefing sites for F59/Canberra/Adelaide would provide a qualitative assessment of likelihood of a brittle fracture event during scuttling.
    a. Warmer – less likely.
    b. Same – equal probability.
    c. Colder – more likely.
8) Probability the diving site will be closed to divers or significant hazard warnings posted due to structural failure in 18 months or less (Appendices E & F) – Certain.
9) Probability of debris as a result of corrosion degradation of superstructure and internal components coming ashore within 18 months (Appendices C& F) – Certain.

APPENDIX A

From the Engineering Toolbox - http://www.engineeringtoolbox.com/electrode-potential-d_482.html

The **potential difference** between an anode and a cathode can be measured by a voltage measuring device. The absolute potential of the anode and cathode cannot be measured directly. Defining a standard electrode, all other potential measurements can be made against this standard electrode. If the standard electrode potential is set to zero, the potential difference measured can be considered as the absolute potential.

Standard Hydrogen Electrode

- The half-cell in which the hydrogen reaction takes place is called the **Standard Hydrogen Electrode - SHE**

Standard Electrode Potential

- The potential difference measured **between** metal M, and the Standard Hydrogen Electrode - SHE

The electrochemical series consists of a list of metals which have been arranged in order of their standard electrode potentials. (The list has been reduced to those materials of concern in the reefing process)

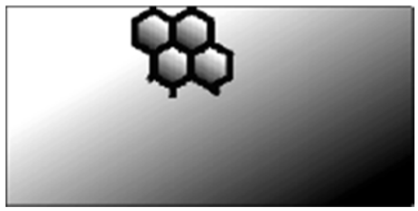
Element	Electrode Potential *(Volts)*
Aluminum	-1.67
Zinc	-0.76
Iron	-0.44
Hydrogen	+0.00
Copper	+0.34

IMPORTANT! Metals which are higher in the electrochemical series displace metals which are lower in the sequence, which means when connecting two metals, the metal with lowest potential will corrode

APPENDIX B

http://www.corrosion-doctors.org/Forms-intergranular/intergranular.htm

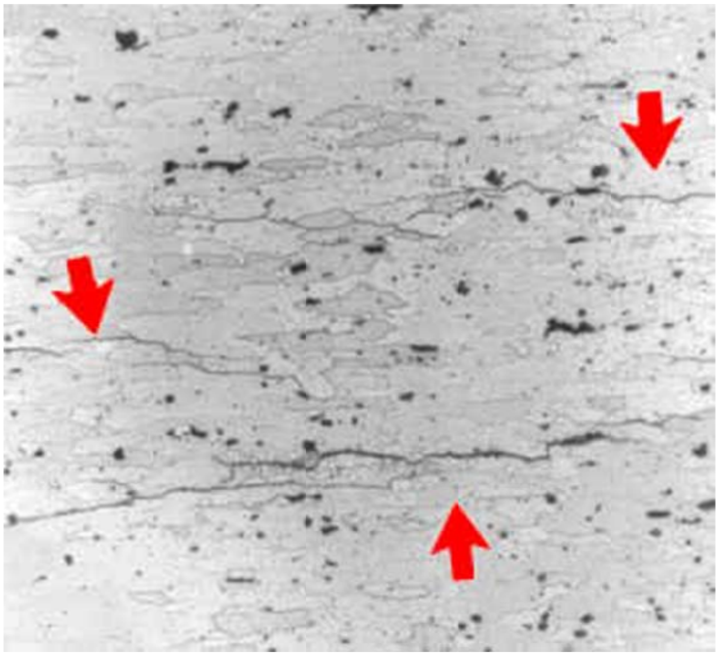
Intergranular Corrosion



The microstructure of metals and alloys is made up of grains, separated by grain boundaries. Intergranular corrosion is localized attack along the grain boundaries, or immediately adjacent to grain boundaries, while the bulk of the grains remain largely unaffected. This form of corrosion is usually associated with chemical segregation effects (impurities have a tendency to be enriched at grain boundaries) or specific phases precipitated on the grain boundaries. Such precipitation can produce zones of reduced corrosion resistance in the immediate vicinity.

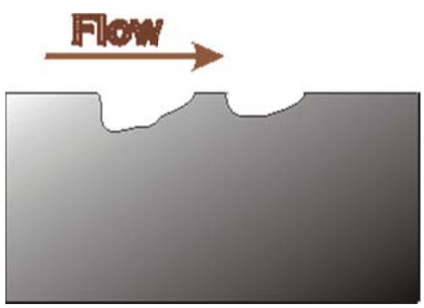
The attack is usually related to the segregation of specific elements or the formation of a compound in the boundary. Corrosion then occurs by preferential attack on the grain-boundary phase, or in a zone adjacent to it that has lost an element necessary for adequate corrosion resistance - thus making the grain boundary zone anodic relative to the remainder of the surface. The attack usually progresses along a narrow path along the grain boundary and, in a severe case of grain-boundary corrosion, entire grains may be dislodged due to complete deterioration of their boundaries. In any case the mechanical properties of the structure will be seriously affected.

Many aluminum base alloys are susceptible to intergranular corrosion on account of either phases anodic to aluminum being present along grain boundaries or due to depleted zones of copper adjacent to grain **boundaries** in copper-containing alloys.Alloys that have been extruded or otherwise worked heavily, with a microstructure of elongated, flattened grains, are particularly prone to this damage.



Intergranular corrosion of a failed aircraft component made of 7075-T6 aluminum (picture width = 500 μm)

Erosion Corrosion



Erosion corrosion is an acceleration in the rate of corrosion attack in metal due to the relative motion of a corrosive fluid and a metal surface. The increased turbulence caused by pitting on the internal surfaces of a tube can result in rapidly increasing erosion rates and eventually a leak. Erosion corrosion can also be aggravated by faulty workmanship. For example, burrs left at cut tube ends can upset smooth water flow, cause localized turbulence and high flow velocities, resulting in erosion corrosion. A combination of erosion and corrosion can lead to extremely high pitting rates.

Erosion-corrosion is most prevalent in soft alloys (i.e. copper, aluminum and lead alloys). Alloys which form a surface film in a corrosive environment commonly show a limiting velocity above which corrosion rapidly accelerates. With the exception of cavitation, flow induced corrosion problems are generally termed erosion-corrosion, encompassing flow enhanced dissolution and impingement attack. The fluid can be aqueous or gaseous, single or multiphase. There are several mechanisms described by the conjoint action of flow and corrosion that result in flow-influenced corrosion: (reference)

Mass transport-control: Mass transport-controlled corrosion implies that the rate of corrosion is dependent on the convective mass transfer processes at the metal/fluid interface. When steel is exposed to oxygenated water, the initial corrosion rate will be closely related to the convective flux of dissolved oxygen towards the surface, and later by the oxygen diffusion through the iron oxide layer. Corrosion by mass transport will often be streamlined and smooth.

Phase transport-control: Phase transport-controlled corrosion suggests that the wetting of the metal surface by a corrosive phase is flow dependent. This may occur because one liquid phase separates from another or because a second phase forms from a liquid. An example of the second mechanism is the formation of discrete bubbles or a vapor phase from boiler water in horizontal or inclined tubes in high heat-flux areas under low flow conditions. The corroded sites will frequently display rough, irregular surfaces and be coated with or contain thick, porous corrosion deposits.

Erosion-corrosion: Erosion-corrosion is associated with a flow-induced mechanical removal of the protective surface film that results in a subsequent corrosion rate increase via either electrochemical or chemical processes. It is often accepted that a critical fluid velocity must be exceeded for a given material. The mechanical damage by the impacting fluid imposes disruptive shear stresses or pressure variations on the material surface and/or the protective surface film. Erosion-corrosion may be enhanced by particles (solids or gas bubbles) and impacted by multi-phase flows. The morphology of surfaces affected by erosion-corrosion may be in the form of shallow pits or horseshoes or other local phenomena related to the flow direction.

Cavitation: Cavitation sometimes is considered a special case of erosion-corrosion and is caused by the formation and collapse of vapor bubbles in a liquid near a metal surface. Cavitation removes protective surface scales by the implosion of gas bubbles in a fluid. Calculations have shown that the implosions produce shock waves with pressures approaching 415 MPa. The subsequent corrosion attack is the result of hydro-mechanical effects from liquids in regions of low pressure where flow velocity changes, disruptions, or alterations in flow direction have occurred. Cavitation damage often appears as a collection of closely spaced, sharp-edged pits or craters on the surface.

In offshore well systems, the process industry in which components come into contact with sand-bearing liquids, this is an important problem. Materials selection plays an important role in minimizing erosion corrosion damage. Caution is in order when predicting erosion corrosion behavior on the basis of hardness. High hardness in a material does not necessarily guarantee a high degree of resistance to erosion corrosion. Design features are also particularly important.

It is generally desirable to reduce the fluid velocity and promote laminar flow; increased pipe diameters are useful in this context. Rough surfaces are generally undesirable. Designs creating turbulence, flow restrictions and obstructions are undesirable. Abrupt changes in flow direction should be avoided. Tank inlet pipes should be directed away from the tank walls, towards the center. Welded and flanged pipe sections should always be carefully aligned. Impingement plates of baffles designed to bear the brunt of the damage should be easily replaceable.

The thickness of vulnerable areas should be increased. Replaceable ferrules, with a tapered end, can be inserted into the inlet side of heat exchanger tubes, to prevent damage to the actual tubes. Several environmental modifications can be implemented to minimize the risk of erosion corrosion. Abrasive particles in fluids can be removed by filtration or settling, while water traps can be used in steam and compressed air systems to decrease the risk of impingement by droplets. De-aeration and corrosion inhibitors are additional measures that can be taken. Cathodic protection and the application of protective coatings may also reduce the rate of attack.

Mechanically Assisted Corrosion

Mechanical forces (e.g. tensile or compressive forces) will usually have little if any effect on the overall corrosion of metals. Compressive stresses do not cause cracking. In fact, shot peening is often used to reduce the susceptibility of metallic materials to fatigue, SCC, and other forms of cracking. However, a combination of tensile stresses and a specific corrosive environment is one of the most important causes of sudden cracking-type failures of metal structures.

Stress corrosion cracking (SCC) and other types of environmental cracking are also the most insidious forms of corrosion because environmental cracks are microscopic in their early stages of development. In many cases, they are not evident on the exposed surface by normal visual examination, and can be detected only by special techniques. Optical or scanning electron microscopy (SEM) of failed sections may be required to fully identify them. As the cracking penetrates farther into the material, it eventually reduces the effective supporting cross section to the point where the structure fails by overload or, in the case of vessels and piping, escape (seepage) of the contained liquid or gas occurs.

Environmental cracking is defined as the brittle fracture of a normally ductile material in which the corrosive effect of the environment is a causative factor. Environmental cracking can occur with a wide variety of metals and alloys and includes all of the types of corrosion failures listed below:

- **Corrosion fatigue**

- **Hydrogen embrittlement**
- **Hydrogen-induced cracking (HIC), a cathodic process**
- **Hydrogen stress cracking**
- **Liquid metal cracking(LMC), usually a physicochemical process**
- **Stress corrosion cracking (SCC), an anodic process**
- **Sulfide stress cracking (SSC)**

Cracking usually is designated as either **intergranular (intercrystalline)** or **transgranular (transcrystalline)**. Occasionally, both types of cracking are observed in a failure. Intergranular cracks follow the grain boundaries in the metal. Transgranular cracks cross the grains without regard for the grain boundaries. The morphology of the cracks may change with the same material in different environments.

Failures generally do not result from the ordinarily applied engineering loads or stresses. Engineering loads, however, are often additive to the residual stresses already present in the structure. These residual stresses result from fabricating processes (e.g. deep drawing, punching, rolling of tubes into tubesheets, mismatch in riveting, spinning, welding, etc.).

Residual stresses will remain in a structure unless it is annealed or otherwise thermally stress relieved following fabrication, a practice that becomes increasingly impractical as a system gets larger or more complex. Cooling from the high temperatures required may also induce internal stresses because of nonuniform cooling. In fact, very slow, controlled cooling is a prerequisite for effective stress relief.

Corrosion products from general corrosion or other forms of corrosion may build up between mating surfaces and, because they occupy so much more volume than the metal from which they are produced, generate sufficient stresses to cause SCC. In the example shown in the following **Figure**, moisture working down the steel rod in combination with the galvanic corrosion due to the contact with the bronze support caused enough rust build-up to generate high stresses and induce SCC.

APPENDIX C

FRIGATE COMPARISON DATA

WARSHIP	SCUTTLING DATE & LOCATION	DATE OF BREAK UP & FATE	AVERAGE WAVE HEIGHT	AVERAGE STORM WAVE HEIGHT
HMNZS Canterbury F421 (group 3) Leander Class Frigate Yarrow (Shipbuilders), Glasgow, Scotland 2945 tonnes Dim. 113.4m x 13.1m x 55m	3 November 2007 Deep Water Cove, Bay of Islands NZ Sank in 2 mins, 53 secs Lies in 38 metres of water	Still intact but very deep dive at 38m and has not given high expected economic returns.		
HMNZS Waikato F55 (group 2) Leander Class Frigate Harland & Wolff Heavy Industries, Belfast Northern Ireland 2450 tonnes Dim. 113 m x 12m x 6m	18 Dec 2000 2 miles south of Tutukaka entrance in Ngunguru Bay, NZ Sank in 2 mins, 40 secs Rests in 28m deep water on 35,39.165 South and 174,32.670 East.	The Waikato sustained damage due to the incredible speed of sinking, taking only 2 minute 40 seconds, splitting at the construction join directly in front of the bridge on impact with the seabed. Described as if cut by torches with a rule line, the area of damage is a known weakness point on this particular group of Leander Class frigates on an otherwise very solid ship. 2002 the sunken Waikato's bow was separated from the rest of the ship in heavy weather. Broken in two between the gun turret and the bridge. This construction group (2) of frigate was known to incur splits in its hull at this point and Leander frigates constructed after this (Group 3) were improved and highly reinforced in this area. Notably in the NZ Navy the remaining Leander frigates, the HMNZS Wellington and the HMNZS Canterbury, are both group 3 construction. Nearly a metre wider than the Waikato and with a different construction technique when joining the superstructure to the bow section, this damage is unlikely to re-occur should these vessels also become artificial reefs. (P Crosby, Naval Architect, Chief of Naval Construction, RNZN) The wreck is basically upright with the bow completely separated from the wreck but very nearby. You go down the radar mast and then you can swim out to the bow. Coming back you go to the stern and swim through the helicopter hangar and then into the bridge. Just before the bows breaks off there is a twin turret with the guns still attached.		

HMNZS Wellington (Previously HMS Bacchante) F69 (group 3) Leander Class(or Type 12A) Frigate Vickers, Sheffield, UK 3100 tonnes Dim. 113.5m x 13m	13 Nov 2005 800 metres from: Island Bay, Wellington, NZ Sank in 1 mins 55 secs The GPS marks are as follows; Original bow:- 41 21 210 S 174 46 828 E (present position) Aft end of bow:- 41 21 125S 174 46 807 E Port forward corner of broken centre section:- 41 21 137 S 174 46 808 E Bridge (now starboard, forward corner of broken centre section):- 41 21 148 S 174 46 787E Port, forward corner of broken stern section:- 41 21 138 S 174 46 783 E Original stern:- 41 21 145 S 174 46 767 E (present position) Lies in 25 metres of water	The 2006 storm broke it into three parts. Material then came ashore inc a lot of cork. Cork washed up on the beach for over a year after the sinking. Since the sinking the local beach has suffered severe erosion – it is unknown whether this was caused by the frigate or the storm that broke it up as the two events coincided. The ship has been declared off limits to divers by the Wellington Harbourmaster. See Appendix 1 for Monitoring report. See Appendix 2 for Dive Wreck Map (in three pieces).		Severe storm 4/5 March 2006. 12.8 metre swell recorded South coast of Wellington, at or near low tide at peak of storm. (ref Baring Head wave recorder readings; c/o Wellington Harbour Master). Waitangi storm 2002: 13.2 m occurred at king high tide, resulting in coastal damage in a number of areas. 4 storms of this scale recorded up until 2006.
HMAS Canberra FFG-02 RAN pennant No. USN Hull No FFG-18 Frigate Flight II design Oliver Hazard Perry 'Adelaide' Class Unit Identification code: 20971 Todd Pacific Shipyards, Seattle, USA	October 2009 2-3 km from Ocean Grove, Geelong, Victoria The waypoint for the centre of the ex HMAS Canberra Reef site is: Latitude: 38° 17.9869′ S (38.29978195° S / 38° 17′ 59.22″ S) Longitude: 144° 32.6102′ E (144.5435028° E / 144° 32′ 36.61″ E) Lies in 20 metres of water	February 2011. The helicopter hanger on the port side of the ex-HMAS Canberra has separated from the main super structure. As a result the frames and plating on the port side are moving 30mm vertically and 150mm horizontally which may pose a hazard to divers in this area as the structure may move unexpectedly. There are a large number of loose items in the lower deck and mid-ships areas of the vessel including lockers, cabinets, panelling and ducting. Canberra has already tipped from an angle of 3 degrees to an angle of 22 degrees. Recreational divers warned to stay away from these areas of the vessel to avoid the risk of personal injury.		

4100 tonnes Dim 138 x 14.3 x 7.5m				
HMAS Adelaide FFG-01 RAN pennant No. USN Hull No FFG-17 Frigate Flight I design Oliver Hazard Perry 'Adelaide' Class Unit identification code: 20970 Todd Pacific Shipyards, Seattle, USA 4100 tonnes Dim. 138 x 14.3 x 7.5	Avoca Beach, NSW 1.4 km off North Avoca and 1.7km off Avoca Beach	-	See Goodwin Report	See Goodwin Report

APPENDIX C-1

Adelaide class frigates it seems have well documented 'hull twisting and cracking problems' from when they were built. Looks like it could be a specific design fault?

http://www.defenseindustrydaily.com/australias-hazardous-frigate-upgrade-04586/

Australia's Adelaide Class & Its Upgrade Program

ESSM from FFG 3
(click to view full)

The FFG-7 Oliver Hazard Perry class was produced as a capable 3,600t-4,100t anti-submarine platform, with some secondary air defense and anti-ship capabilities via its SM-1 Standard and RGM-84 Harpoon missiles, and which could be bought in large enough numbers to fill the US Navy's needs. The ships' **hull twisting and cracking problems were solved** early on, and they proved they could take a hit and stay afloat when the USS Stark was struck by 2 Iraqi Exocet missiles during the Iran/ Iraq war. By FFG-36, the "FFG-7 Flight III (Long)" variant was the sole US production version, with an extra 8 feet of length that let it accommodate larger and more capable SH-60 Seahawk helicopters instead of the SH-2 Sea Sprites.

http://www.globalsecurity.org/military/systems/ship/ffg-7-upgrade.htm

FFG-7 OLIVER HAZARD PERRY-class Upgrades

Displacements have steadily increased, to the detriment of stability. FFG 59 was delivered at 4,100 tons full load, although the class was designed for 3,600 tons and with only 39 tons planned growth margin. These ships are particularly well protected against splinter and fragmentation damage, with 19-mm aluminum-alloy armor over magazine spaces, 16-mm steel over the main engine-control room, and 19-mm Kevlar plastic armor over vital electronics and command spaces. Because of a hull twisting problem, doubler plates have been added over the hull sides amidships just below the main deck. Speed on one turbine alone is 25 knots. The auxiliary power system uses two retractable pods located well forward and can drive the ships at up to 6 knots. Fin stabilizers began to be backfitted in earlier units, beginning with FFG 26, in 1982.

Early in their operational lives, ships of the **FFG 7 Class began to develop serious cracking in the superstructure, which extended from side-to-side and for approximately 70% of the length. These cracks were serious in that they could extend down into the hull portion of the ship and provided a way for water to flood important weapons system spaces. Detailed inspections were made, analyses undertaken, and model-scale tests conducted. Fixes compatible with the entire class were developed and installed. Tests were conducted at sea**

and were found to be satisfactory; further fixes were then carried out on all ships of the FFG 7 Class.
PERRY-class ships were produced in two variants, known as "short-hull" and "long-hull", with the later variant being eight feet longer than the short-hull version. The long-hull ships [FFG 8, 28, 29, 32, 33, 36-61] carry the SH-60B LAMPS III helicopters, while the short-hull units carry the less-capable SH-2G.
The units with long hulls (FFG 7, 8, 15, 28, 29, 32, 36-61) were to have had the sonar suite upgraded to SQQ-89(V)2, with SQS-56 hull sonar retained, SQR-19 towed linear passive hydrophone array added, and SQQ-28 helicopter sonobuoy datalink system added. There were, however, significant delays in the development of the SQQ-89's processor equipment, and many ships received the SQR-18A towed array with SQR-17 processor as an interim fit. FFG 8 received the towed array during FY 87, along with FFG 55-60; in FY 88, FFG 28, 29, 32, 36, and 39 were equipped; in FY 90, FFG 7 and 15 received the system during overhauls (FFG 7 was lengthened and received the SQQ-89 suite but was not equipped with RAST, leaving her unable to employ SH-60B helicopters); under the FY 91 budget, FFG 9, 48-50, and 52 were modified, and in FY 92, FFG 20 and 51 were equipped. FFG 12 is unusual in having the electronics fit for the LAMPS-III system and in having the towed sonar array but not having had the hull extension to permit flying SH-60B LAMPS-III helicopters. As of 1997, two variants of the SQQ-89 sonar system were in service on this class: SQQ-89(V)10 on FFG 14, 30, 34, 37, 50, 51, 52, and 54, with SQR-19B(V)2 towed array sonar; and SQQ-89(V)2 on FFG 7-9, 11-13, 15, 28, 29, 32, 33, 36, 38-43, 45-49, 53, 55-59, and 61, with SQR-19(V)2 and the UYQ-25A(V)2 processor.
For Arabian Gulf service, FFG 22 and 47 were equipped in 1991 with 25-mm Mk 38 Bushmaster low-angle chain guns amidships on the main deck, and others have since had the weapon added when on deployment. FFG 47 received a Kingfisher mine-avoidance modification to her SQS-56 sonar. FFG 37 conducted trials with the McDonnell Douglas Astronautics Mast-Mounted Sight (a modified helicopter electro-optical device) atop the pilothouse, with the display being in the CIC.
USS Halyburton (FFG-40) completed a Norfolk docking availability in March 2000 in which she received a prototype installation of a new ship service diesel engine on its number four generator. The new engine replaces its originally configured Detroit Diesel 16V-149 series, which is presently installed on all Oliver Hazard Perry (FFG-7) Class frigates. One of the primary drivers for the effort to re-engine the frigate diesels was life cycle affordability. The Detroit Diesels were of a two-stroke design that are no longer in production. This engine is a high-cost driver to the Fleet through high overhaul costs and relatively low time between major overhauls. It is a major item on the Top Management Attention and Top Management Issues (TMA/TMI) program, which assesses items that show undesirable metrics and are costly to maintain. In addition, this engine does not meet current EPA and proposed IMO emission requirements.
The FFG 7 Modernization Program was designed to extend the lifespan of this hull class through 2019. These frigates fulfill a protection of shipping mission as anti-submarine warfare combatants for amphibious expeditionary forces, underway replenishment groups, and merchant convoys.
Carderock Division Philadelphia worked closely with Program Executive Office Ships, NAVSEA 05, Bath Iron Works Planning Yard, Fleet Type Commanders, Original Equipment Manufacturers, and Navy Inventory Control Point (NAVICP) to ensure these installations are completed by 2010.
Under this fully funded multi-year and multi-million dollar program, the following core hull, mechanical, and electrical (HM&E) equipment and systems will be upgraded aboard these ships:

- ShipAlt FFG 7-423K—Ship Service Diesel Generator. The existing four engines aboard these ships will be replaced with the Caterpillar Model 3512B engine. The contract to build the engines was awarded to Caterpillar, Inc., Peoria, IL, in May 2002. Unlike previous Navy diesels, which are almost exclusively controlled by mechanical devices, this engine is completely electronically controlled, which increases fuel economy, tolerates and sustains light loading, and complies with current emission regulations. It also allows for easier troubleshooting. The technical point of contact for this effort is James Spaulding (9324).

- ShipAlt FFG 7-429K—Reverse Osmosis. The existing evaporator system is being replaced with Reverse Osmosis (RO) units. The contract to manufacture the RO units was awarded to Aqua

Chem, Inc., Knoxville, TN, in May 2002. There will be two 6,800 gallon-per-day units. High purity water requirements for gas turbine water wash, etc. will be sent through an additional 2,000 gallon-per-day high purity RO unit. The technical point of contact for this effort is Richard Steck (9232).

- ShipAlts FFG 7-452K—Ventilation Modifications. This combines several existing ShipAlts into a single package. This will provide consistent machinery space ventilation configuration and eliminate overlaps in design and installation.

- Control Console modifications for ShipAlts 423K, 429K and 452K are being integrated by Debra Dezendorf (9554). Additionally, the Diesel Start Air Compressor (SAC) system will have additional new instrumentation incorporated on the control console to assist in troubleshooting and maintenance. The technical point of contact on the SAC is Jim Buttram (9124).

- ShipAlt FFG 7-436K—Commercial-Off-the-Shelf Slewing Arm Davit (SLAD). The existing track-way davit is being replaced with a commercial-off-the-shelf davit. Manufacture of this commercial davit, which utilizes all electric technology, was awarded to Welin-Lambie Limited, UK, in June 2002. The technical point of contact for this effort is Walter Nowak (9731). Code 9731 is also overseeing an Alteration Installation Team (AIT) for shipboard installation of the davit and associated rigid inflatable boat (RIB) platform. SLAD installation was performed on *USS Kauffman* in April, 2003. The onsite point of contact for the AIT effort was Philip Anshant (9731).

- ShipAlts FFG 7-438K and 439K—Self Contained Breathing Apparatus (SCBA). The SCBA is replacing the existing shipboard oxygen breathing apparatus. SCBA is an NIOSH approved open circuit breathing device supplied from a compressed air cylinder via ShipAlt 438K. It has a recharging capability directly from the high pressure air system via a charging station is added via ShipAlt 439K. NSWCCD-SSES Code 916.3 is providing the alteration installation for this effort. The points of contact are Kenneth Jones (916.3) and David Thompson (9443).

- Additional HM&E ShipAlts are 468K Fuel Return for the Diesel Engine and 262K, which improves the fire-fighting reliability capability in the bilge area of Auxiliary Machinery Room No. 3.

- Associated Combat Systems upgrades, associated with the FFG Modernization Program are ShipAlt 360K (CWIS 1B) and ShipAlt 383K (NULKA).

The key to the success of this program to date has been the teaming between all involved. It's run well; there's total buy-in and support from the technical and contracting codes; and George has done a top-notch job in managing it.
On 14 May 2003 installation for the FFG 7 Modernization
Program began aboard *USS Kauffman* (FFG 59), which is the first of 30 ships to be upgraded under this program. Work is being conducted aboard FFG 59 during a 20-week availability at Colonna Shipyard in Norfolk, VA. Work on *USS Kauffman* was scheduled for completion in October 2003. The next ship scheduled for this modernization was *USS Hawes* (FFG 53), which begins its availability in September 2003.
http://www.abc.net.au/news/stories/2008/01/02/2130610.htm

Dud frigates are an inherited nightmare: Fitzgibbon

By Alexandra Kirk and staff

Posted Wed Jan 2, 2008 4:31pm AEDT
Updated Wed Jan 2, 2008 4:40pm AEDT

A Navy whistleblower says the frigates' anti-missile and anti-torpedo systems could not be integrated. (Department of Defence)

- **Related Story:** Govt 'playing politics' over warship claims: Minchin

Australia's front line guided missile frigates are still not able to be sent into battle, despite a $1.5 billion upgrade.

The project to modernise the 1970's ships is running four years late, and according to News Limited papers this morning, sailors are quitting because their ships can not be deployed in the Middle East or any other conflict zone.

In the report a Navy whistleblower says the frigates' anti-missile and anti-torpedo systems could not be integrated. The source describes the electronic support measures as a joke.

New Defence Minister Joel Fitzgibbon says it is another nightmare Labor's inherited from the Coalition that will have to be managed "as best it can".

"This is just one of a number of projects which we are now learning in government, are going to be a real problem for the new Government," he said.

"We're determined to work sensibly through them, and to deliver the Navy, and indeed all of the services, the level of capability that they need or require to adequately defend the nation."

Mr Fitzgibbon says he has very serious concerns about the frigates.

"This is just another example of a government trying to create 21st century capability out of old ships and air frames," he said.

"You'll recall the Seasprite helicopter, where the government, the former government, was trying to make a 21st century helicopter out of a 1960s airframe.

"In the case of the Adelaide class, they were trying to make a 21st century warship out of vessels built in the early 1970s, which were only ever designed to operate between 20 and 25 years."

Some commentators have suggested it was the wrong decision to buy the frigates in the first place, and the decision was made in order to save money.

They say that the problem stems from a long way back and that taxpayers are now paying for it.

Mr Fitzgibbon says the chickens are coming home to roost.

"Certainly trying to make a 21st century warship out of such an old vessel always carried very, very significant risk," he said.

"I could spend a long time this morning criticising the former Howard government, but I'd much rather talk about the future and how we go forward.

"We're trying to assess this project now, trying to determine the level of the problem.

"It's very, very complex of course, but again we're just determined to get on with the job, and to deliver to the navy the capability it requires."

APPENDIX D


F69 Wreck Site Map
N
S
Bridge access by qualified wreck divers only.
Bridge is intact and has a swim in hole in the roof.
Penetration of bow section by qualified wreck divers only. Excellent external dive around gun turret.
Penetration of midships and stern restricted to qualified wreck divers only. Beware surges at openings during swell conditions.
Always beware currents and surges in swell conditions.

APPENDIX E

APPENDIX 1: WGN20060 [21655] SinkF69 Monitoring Report Requirement

Charitable Trust

1/4/2006

greater Wellington Regional Council

PO Box 11646

Wellington

Ref: WGN20060 [21655] SinkF69 Monitoring Report Requirement

Attn: Sean Lisle, Resource Advisor

Dear Sean,

In reference to your letter dated 17th March 2006 please find below a post storm monitoring report of the frigate Wellington in compliance with consent conditions.

On the 4th/5th March of this year the south coast of Wellington was struck by a 12.8m storm swell, at or near low tide at peak of storm. It was hoped some smaller storms would occur first so the ship had time to settle onto the seabed but this was not the case, with the first major swell peaking at 12.8m over two days of constant significant wave action. *(ref: Appendix 2: Baring Head wave recorder readings ; c/o Wellington Harbour Master.* We note that this is in contrast to the previous two storms which have occurred at or near high tide. The Waitangi Storm 2002 (13.2m) occurred at king high tide, resulting in coastal damage in a number of area's. There have been 3 storms of this scale during the last 5 years with the recent making 4. Previous historic wave data and impact analysis was provided by several sources during the resource consent.

State of Vessel

Pre storm F69, with her bow still sitting above the seabed, was restrained by two anchor chains connected to an 8 tonne mushroom anchor, which is today (post storm) fully embedded. During this swell the ship split into two initially, separating at the bow between the gun turret and bridge (50m), then three as its remaining mid and stern sections, whilst sliding in an anti clockwise direction pivoting on the stern, rudders and propeller drive shafts.

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This sideways slide caused the keel to collapse, undermining the large engine room and boiler room spaces breaking the rest of the ship in half. The sliding action has caused the lower deck (mainly stores and cooler spaces) and the next deck, accommodation and offices, to collapse after braking its keel as it slid sideways. The ship is now sitting on top of these two lower decks and has settled further onto the seabed, increasing the clearance of the vessel to the surface minimum depth [@chart datum] of 11.1m. This was formerly notified to mariners week commencing 16 th April. The upper portions of the mid section and stern section remain intact and easily divable. The flight deck and hanger are also intact as is the bridge, officer's quarters, operations and sonar control rooms of the vessel. These areas can still be penetrated by divers with relative safety at present. The majority of damage to the vessel has effectively happened in its lowest decks as a result of its sliding action along the seabed. As this has happened the bulk of the vessel has embedded itself into the sandy and light gravel seabed, within the consent area. The bow has separated at the known weak point in the Leander hull design as had occurred with WAIKATO. While WELLINGTON a batch III Leander was strengthened over WAIKATO, as was stated at the consent hearing, this strengthening was clearly insufficient to prevent separation under the prevailing conditions. The bow is still secured to the anchor and is basically in its original form and position, with the large opening where the tear occurred providing significantly better diver access and light thru the bow section. This section is still fully dive-able with significant sea weed and coralline growth occurring on its exterior with numerous fish species visible all over the structure. *(Ref F69 DVD post storm video and Police National Dive Squad review footage already delivered to GWRC, Harbours Dept and WCC).* One chain is taught and the other slack and lying on the seabed so at this stage, having obviously sustained the storm, the bow is well secured and based on other coastal wrecks referred to in the resource consent, would appear destined to slowly collapse onto the seabed.

Safety

Immediately post storm at the first opportunity to dive the vessel the trust investigated the ship and found that the ship no longer resembled the vessel layout map provided to the dive industry, enforcement, monitoring and rescue services. The trust notified the Harbour Master and requested that the ship be closed to divers, whilst Police National Dive Squad, making an exercise of mapping a shipwreck, provided a report on the state of the ship post storm. This included a written and video evidence report and was provided to harbours department, GWRC, WCC, TV1 and TV3. Recommendations to the dive industry includes a map recommending access only to bow with external diving of all other sections. A Dive Safety media release was also produced by Police and was emailed to all commercial dive operators as a result of input from the dive squad. (Attached Appendix A) Diving on wrecks has always been regarded as a specialty qualification and this has not changed with the current form of F69. External dives should only be undertaken by those holding an Open Water qualification. Those wishing to enter the ship must have undergone further recognised Wreck Diver training and qualification.

Debris

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The trust was notified of quantities of timber and cork washing onto nearby beaches at 10.00pm Saturday night of the storm by the Police Maritime Unit.

During the separation of the bow from the mid-section the freezer space was torn open, releasing timber and cork lining. Both of these float and were washed onto the beach. Along with this was a small amount of rubber pipe lagging from the same area. That evening and the following two days trust members and volunteers removed the bulk of timber, cork and lagging from the beaches to the local landfill. During the following week monitoring of the beaches was performed and some further small amounts were removed as it was found. Total debris amounted to three trailers in total. We note that very little timber remained on board F69 at time of sinking apart from the freezer space. With agreement of GWRC inspectors, this was left intact and on board and based on recovered material, is now completely gone from the ship. The following weeks the coast has had further swell action with 3 weeks of southerlies, peaking at 8 metres. Upon inspection of beaches post swell there has appeared no further flotsam from F69 and no further changes noted of the shipwrecks state or position.

Location of shipwreck post storm.

The Police National Dive Squad, during the post storm review, provided GPS marks for the three sections of the vessel. These have been provided to Adam Greenland, Senior Hydrographic Surveyor, LINZ Hydrographic Services by Mike Pryce, Wellington Harbourmaster, for notification on maritime charts.

The GPS marks are as follows;

Original bow:- 41 21 210 S 174 46 828 E (present position)

Aft end of bow:- 41 21 125S 174 46 807 E

Port forward corner of broken centre section:- 41 21 137 S 174 46 808 E

Bridge (now starboard, forward corner of broken centre section):- 41 21 148 S 174 46 787E

Port, forward corner of broken stern section:- 41 21 138 S 174 46 783 E

Original stern:- 21 145 S 174 46 767 E (present position)

There is some sections of steel debris from the ship on the seabed between the bow section and bridge as a consequence of the separation and these are already being covered by sand with any remaining structure above sand being quickly covered in marine growth and attracting fish. These appear well embedded and not considered a hazard for navigation, divers or marine life.

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We note that the ship still remains within the consent zone and is performing as intended as a reef and diver attraction.

The Future

As a result of the 12.8m storm and the more recent 8m swell, the bulk of the ship (mid and stern sections) is considered to be now locked onto the seabed with the collapse of the keel and lower decks. Instead of sitting on its angled keel pre storm, the ship now has a flat bottom with the lower deck fully embedded deep into the sandy seabed. Based on other local coastal wrecks we consider the ship to be on its downward journey, eventually to collapse deck on deck in its current position (ref the shipwrecks Devon and Yeung Penn). The bow section remains secured by the anchor and will be monitored after each storm for changes, as will the rest of the vessel. It is expected that the bow will also collapse downward, especially with the weight of the 45tonne gun turret now applying sideways pressure onto the starboard side. Once this occurs the turret will also become well locked onto the seabed with sand already finding its way into the interior. We note the bulk of damage occurred from sliding along the seabed causing the collapse of the keel, whereas little damage has occurred to the upper structure nearest the surface, where one would expect the major wave impact would occur. Thus, the bridge, officers quarters, sonar control room, operations room, hanger and upper decks are all in good condition. The ship has faired well and continues to look very ship like and inviting to divers.

In the advent of another similar storm exceeding 10m it is envisaged the ship will remain in its current position and slowly collapse the lower decks under the weight of the upper structure. This was projected during the RMA. The trust will continue to monitor the shipwreck in compliance to the consent and in

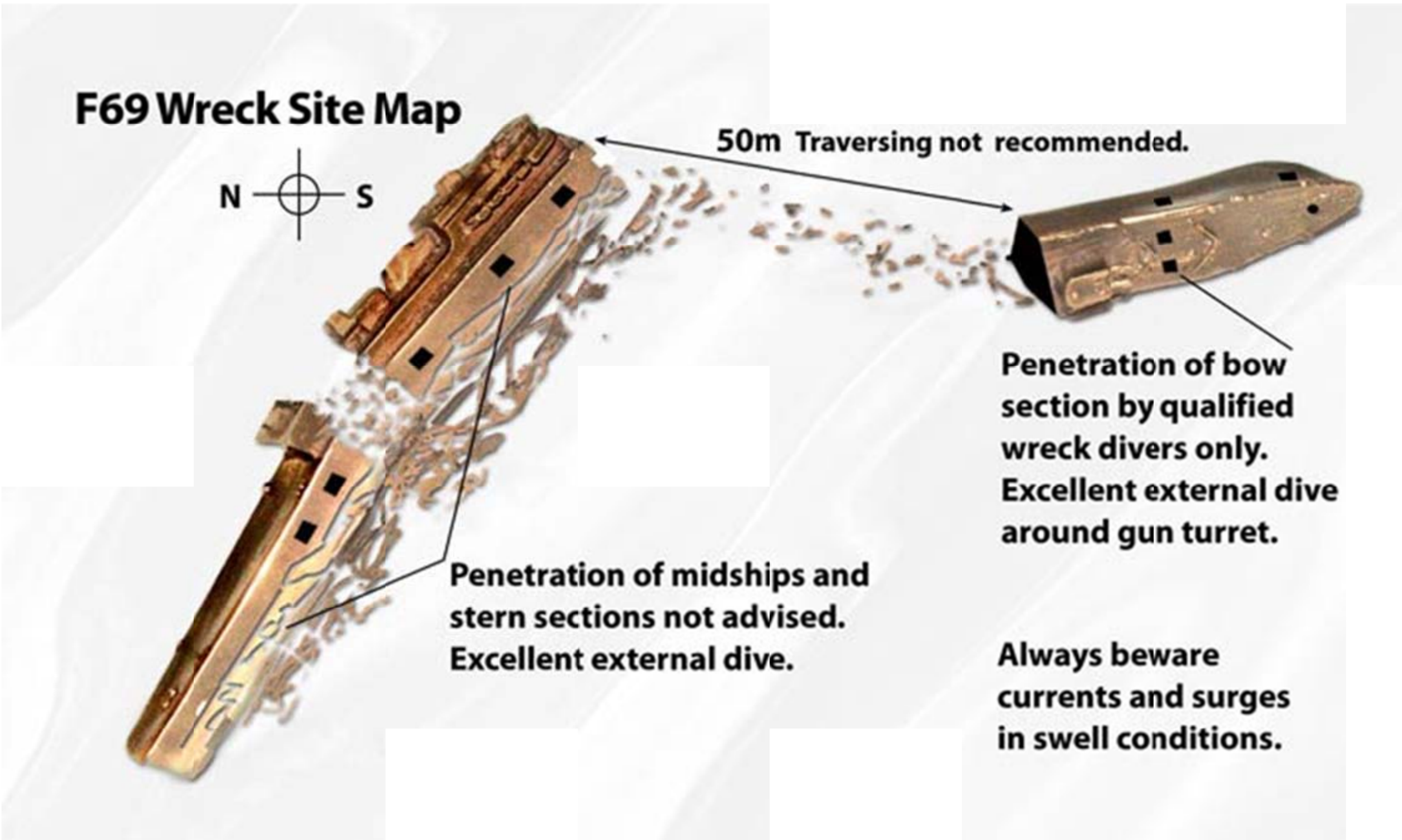
cooperation with the Harbours Department, GWRC, the NZ Police National Dive Squad and the dive industry.

Yours sincerely,

Marco Zeeman

Chairman

APPENDIX 2: F69 DIVE WRECK MAP



APPENDIX A

8 December 2003

Police urge recreational diving care this summer

Ensure your dive gear is regularly serviced, you're healthy and have the proper skills before entering the water – these are the key messages from police to recreational divers this summer.

Acting Senior Sergeant Bruce Adams, head of the Wellington based police national dive team, says divers are risking their lives through breaching simple dive preparation and survival skills.

"Too often divers die because they don't have the proper skills, equipment or physical fitness," he says. "Our waters provide a wonderful diving opportunity but the sport is very unforgiving if you don't know what you're doing."

Water Safety New Zealand statistics show that 90 people have drowned through diving accidents in the last ten years – 58 through scuba diving and 32 through snorkeling mishaps.

With summer holidays about to start, Senior Sergeant Adams hopes divers take the time to check their gear and themselves before taking the plunge.

The dive squad checklist centers on personal wellbeing, equipment, planning, buddy and boat support.

Personal wellbeing

- It's a good idea for recreational divers to visit your GP and have a medical check (annual medical clearances/examinations are required for commercial divers). It's also preferable your GP has specialist dive medicine training or an understanding of the dive environment. A list of appropriately trained doctors can be obtained from the website of the South Pacific Underwater Medicine (SPUMS) and are listed in every issue of Dive New Zealand. The website references are: www.spums.org.au and www.divenewzealand.com.
- If you're on medication, ask your GP first to see if this precludes you from diving.
- Maintain good health and get some form of exercise.
- If feeling unwell do not dive. **Both physically and mentally. The sport can be physically demanding but also has the potential to put you under some stress. Little events such as clearing a flooded mask are normally easily overcome**

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but when they combine with other events this puts some pressure on you to overcome, "STOP- REST- RELAX"

- If you haven't been diving for a while, start well within your confidence level. Do a refresher course or up-skill with a recognised training provider.
- If you are diving with someone who has not dived for some time, be aware of this and take his or her confidence level into account. Don't be pushy or overbearing.

Pair inexperienced divers with seasoned and adept divers.

- Do not dive if you have recently drunk alcohol.

Diving Equipment

- Regularly maintain and service your gear - it is your lifeline.
- **Ensure equipment functions correctly and you are familiar its operation, i.e. dive computers.**

 Cylinders require annual inspection. This not only helps prevent them from failing/exploding, but they can't be filled unless "in date".
 Expect filling stations to remove valves and inspect them if empty to make sure no water or debris is inside. **Do not breathe your cylinder empty at any stage.**
 Regulators should be serviced yearly. If there is any debris or discoloration on the filter this indicates its performance is likely to be affected and it needs servicing by a qualified technician.
 Check your buoyancy compensator device thoroughly. Ensure there is no perishing; all fastenings, zip-ties, cords and toggles are in place, and that all valves are functioning.
 Check all items for perishing, flat batteries or damage. Replace the items or have them serviced/repaired.
 Do not carry an excessive amount of weight and ensure the quick release mechanism is working. If in doubt seek advice from your local dive store. **You should be neutrally buoyant on the surface with your B.C.D fully deflated.**
 Thoroughly rinse all gear in fresh water after use.
"If you have any doubts about the state of your equipment, take it to your local dive store for inspection and advice," **Sergeant** Adams says. "The happier you are with your gear the more you will enjoy the dive.
"It's safer to listen to the advice you're given **by service technicians** and spend the money on maintenance than risk losing your life."

Plan Your Dive and Dive to Plan

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 Plan well and stick to the plan.
 Avoid rushing to start the dive. Give yourself time to plan, to get to your destination with time to spare, and to check your equipment and your dive partner before getting into the water.
 Set timings and depth, and stick to them.
 Religiously follow dive tables and maintain correct assent rates.
 Brief your boatman if you are using a boat.
 Diving with a partner is one of the safest practices you can carry out, but you must stay together. Be aware of each other all of the time, and not head off in separate directions to hunt crayfish or spear fish. Take turns following each other within arms reach.
 Stay within you and your buddy's confidence levels. Speak up if you are not comfortable or are unsure of the activity/location of the planned dive.
 Leave the seabed with sufficient air for the trip to the surface, decompression and some to spare. Don't breathe cylinders dry, even during safety stops. You should always have some reserve in the cylinder.
 Have a plan in place should something go wrong. Tell someone where and when you are going/returning. Plan for a diving emergency/illness, transport to hospital, first aid, communications with land or rescue agencies. Learn CPR.
 If you become uncomfortable or unwell during the dive, stop-rest-relax then return to the surface.

Free Diving

□ Have a "buddy" standing by using the 'one up one down' system.
□ Strenuous exercise will limit your bottom time.
□ End the dive when you feel uncomfortable.
□ Do not hyperventilate more than two or three times. Use slow shallow breaths.
□ Rest between dives for several minutes.
□ Use a well fitting 3mm wetsuit and weight yourself to be neutral at about 5m.
□ Join a club and get professional training.

Boating

□ Ensure you understand what the divers plan to do, and where and when they plan to surface.

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□ Ensure you are competent to drive/operate the vessel. Attend a course with Coastguard.
□ Ensure the boat has communications with land and others – a radio and a cellular phone – and that you know how to use them.
□ Ensure you have spare fuel, lifejackets, bailer, flares, oars or an auxiliary motor, anchor and line.
□ Have the vessel and motor serviced.
□ Check the weather.
□ Let someone know where and when you intend to go and return.
□ If you need to leave your anchor position to search for your missing diver, it's critical to leave your anchor with a buoy attached. Do not lift it.

"Make diving a safe and enjoyable experience for you, your family and friends," Senior Sergeant Adams says.

New Zealand Underwater and Water Safety New Zealand have excellent resources and safety advice, including several informative pamphlets.

To learn more, check these websites:
www.watersafety.org.nz or telephone (04) 801 9600.
www.nzunderwater.org.nz
www.divewreck.co.nz

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Appendix 2

Baring Head Wave recorder readings during storm 03/04 March 2006.
3rd March

Time	Max Wave height
9.30	4.369 metres
10.00	5.158m
10.30	4.964m
11.00	5.276m
11.30	6.707m
12.00	7.532m
12.30	6.895m
13.00	6.177m
13.30	7.044m
14.00	8.211m
14.30	10.288m
15.00	9.645m
15.30	8.585m

16.00 11.142m
17.00 9.37m
17.30 9.278m
18.00 9.008m
18.30 7.363m
19.00 8.470m
19.30 .021m
20.00 9.094m
4th March
Time Max Wave height
00.30 9.866m
1.00 11.127m
1.30 9.711m
2.00 11.602m
2.30 9.281m
3.00 9.244m
3.30 9.315m
4.00 8.328m
4.30 11.310m
5.30 12.870m
6.00 9.514m

APPENDIX F

Parks Victoria Warning re: ex-HMAS Canberra

Change of Conditions

Warning to recreational divers

The helicopter hanger on the port side of the ex-HMAS Canberra vessel has separated from the main super structure. As a result the frames and plating on the port side are moving 30mm vertically and 150mm horizontally which may pose a hazard to divers in this area as the structure may move unexpectedly.

In addtion, there are a large number of loose items in the lower deck and mid-ships areas of the vessel including lockers, cabinets, panelling and ducting. This may pose a danger to divers from items moving/falling and blocking access points especially on the lower starboard side of the vessel.

Divers are urged to take particular care in the lower deck and engine areas where sediment and loose items have restricted access at some exit/entry points.

It is strongly recommended that recreational divers stay away from these areas of the vessel to avoid the risk of personal injury.

Parks Victoria is currently in the process of addressing these issues and will provide further advice as soon as available.