NAVAL NUCLEAR BASES: THE COSTS TO THE CLYDE

NUCLEAR FREE SEAS

GREENPEACE

NAVAL NUCLEAR BASES - THE COSTS TO THE CLYDE

Greenpeace UK
30-31 Islington Green
London N1 8XE

Tel: 01 354 5100

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INTRODUCTION

This report is part of the Greenpeace Nuclear Free Seas Campaign. Previous publications have detailed the global inventory of the growing naval nuclear arsenals of the Soviet Union, China, France, the US and UK, the increasingly dangerous maritime strategies and operations at sea which mean that any nuclear war is likely to start at sea, and the UK's role in this naval nuclear arms race.

The purpose of this report is to bring to the Publics attention the environmental dangers that threaten the Clyde as the result of its role in the infrastructure of the arms race at sea, in supporting the operations of the nuclear powered and armed Navy's of the UK and US.

The Clyde military facilities consist of the Clyde Submarine Base (Faslane), the base for the Royal Navy's 10th Submarine Squadron, consisting of four Resolution class strategic submarines armed with 16 Polaris missiles, each with two nuclear warheads. The Coulport Royal Navy armament depot is a separate part of the base, where the Polaris missiles and warheads are loaded and unloaded and weapons stored and maintained. This is undergoing expansion to accommodate the Trident fleet from the mid 1990s. Holy Loch is the base for US Navy's strategic submarines of the 14th submarine squadron consisting, which consists of eight US strategic submarines armed with 16 Poseidon missiles, each with 10 nuclear warheads.

The report considers the likelihood of a serious accident involving a nuclear reactor or nuclear weapon on the Clyde, and criticises the inadequacies of the Clyde 'Public Safety Scheme' which is supposedly designed to cope with a nuclear reactor or other radiation accident. It considers the adequacy of the present monitoring of the radiation that comes with the presence of nuclear submarines in the Clyde.

This report also examines the justification for the continued use of Holy Loch by the US Navy. It finds that the original justification is increasingly disappearing, and warns that from the mid 1990's it could become a base for US Navy attack submarines. Many of which will carry the latest and most dangerous nuclear weapon of the arms race at sea - the nuclear Sea Launched Cruise Missile.

The eventual goal of Greenpeace's Nuclear Free Seas campaign is the multilateral, global elimination of nuclear weapons and nuclear reactors from the sea. In the interim a number of steps should be taken to improve the Clyde's potential to cope more effectively with environmental hazards and to increase awareness about the adverse effects of nuclear activities in the area.

These include increasing public knowledge about the probability and consequences of a serious accident to both a submarine nuclear reactor and a nuclear weapon on the Clyde; maximising the effectiveness of the Clyde Safety Scheme in the event of such an accident; increasing the radioactive monitoring in and around the Clyde; collecting data on the health of Navy and civilian personnel and their families and monitoring the local population for cancers that are found in association with radioactive discharges; and raising the question of whether the US Navy should maintain a base at Holy Loch after Poseidon missiles currently based there are withdrawn and after the likely START Agreement.

2. NAVAL NUCLEAR ACCIDENTS - ACCIDENTS INVOLVING NAVAL NUCLEAR REACTORS

There are three kinds of naval nuclear accidents which can lead to radioactive contamination: accidents involving naval reactors, accidents involving damage and destruction of naval nuclear weapons and those arising from the transportation of these weapons.

The Royal Navy currently has 19 Pressurized Water Reactors (PWRs) in its submarine fleet, by the end of the 1990's there will be 21, as well as 3 training and research reactors [1].

A nuclear powered submarine (and warships in the US Navy) uses conventional steam turbine machinery for propulsion. The supply of steam to drive the turbine comes from a nuclear reactor plant instead of an oil fired boiler. A nuclear reactor core is made up of fuel elements and control rods. Selected control rods are slowly withdrawn from the core until the process of the splitting of atoms in the fuel rods (nuclear fission) becomes self sustaining. When control rods are reinserted the reaction decreases. The emergency insertion of control rods when the core is dangerously overheating is called a reactor SCRAM.

This nuclear fission in the reactor produces heat which is transferred to circulating water (primary coolant) and thence to another water system (secondary coolant) via boilers to produce steam to drive the turbines and the propellers. This primary coolant water also functions to cool the reactor. The nuclear reactor and its associated plant are contained in a separate compartment within the submarine which is called the primary containment. The atomic chain reaction of fission produces by products, called 'fission products". These build up in the fuel the longer the fission continues and emit harmful radiation.

The Royal Navy's Nuclear Reactor Accident Scenarios

The Royal Navy provides an outline of two possible reactor accidents in the Clyde Public Safety Scheme. Both concern failures of the cooling system and barely merit three paragraphs [2].

One describes the possibility of a sudden and complete failure of the primary cooling water system. This involves the rupture of a major component of this system, such as a pipe and causes the loss of coolant water. If the reactor core can no longer be cooled, the fuel elements will eventually melt, leading to release of fission products into the reactor compartment (the primary containment). The worse accident of this type is termed by the Navy a Maximum Design Accident (MDA).

Then it states that "if following these events, the submarines primary containment (i.e. the vessel that surrounds the entire nuclear reactor) were itself to fail to some degree, fission products would become dispersed throughout the submarine". This compartment is penetrated by numerous pipes and cables which may develop leaks, therefore in the words of the Navy, "some minimal leakage is almost inevitable" into the submarine. In the Rosyth Safety Scheme, a slow release over 24 hours of a proportion of these fission products into the submarine, and thence to the atmosphere is described.

The second scenario is based on the occurrence of a more dramatic breach of the containment leading to a greater spread of radioactivity into the submarine (and hence to the atmosphere). This is the Primary Containment Failure Accident (PCFA). The Scheme then adds that the hull would contain the radioactivity as a 'secondary containment', but "there must always be a chance of an open hatchway or other external venting allowing a small proportion of the fission products to escape into the atmosphere where they will tend to form a cloud and be borne along on the prevailing wind" [3].

This is a situation which the Navy notes in

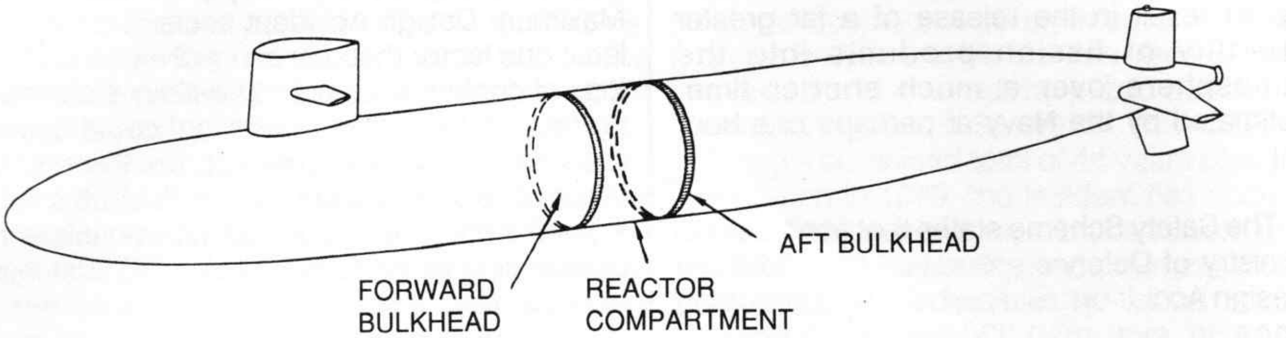

Figure 1. Typical Submarine with Reactor Compartment Identified

SCHEMATIC OF NUCLEAR PROPULSION PLANT

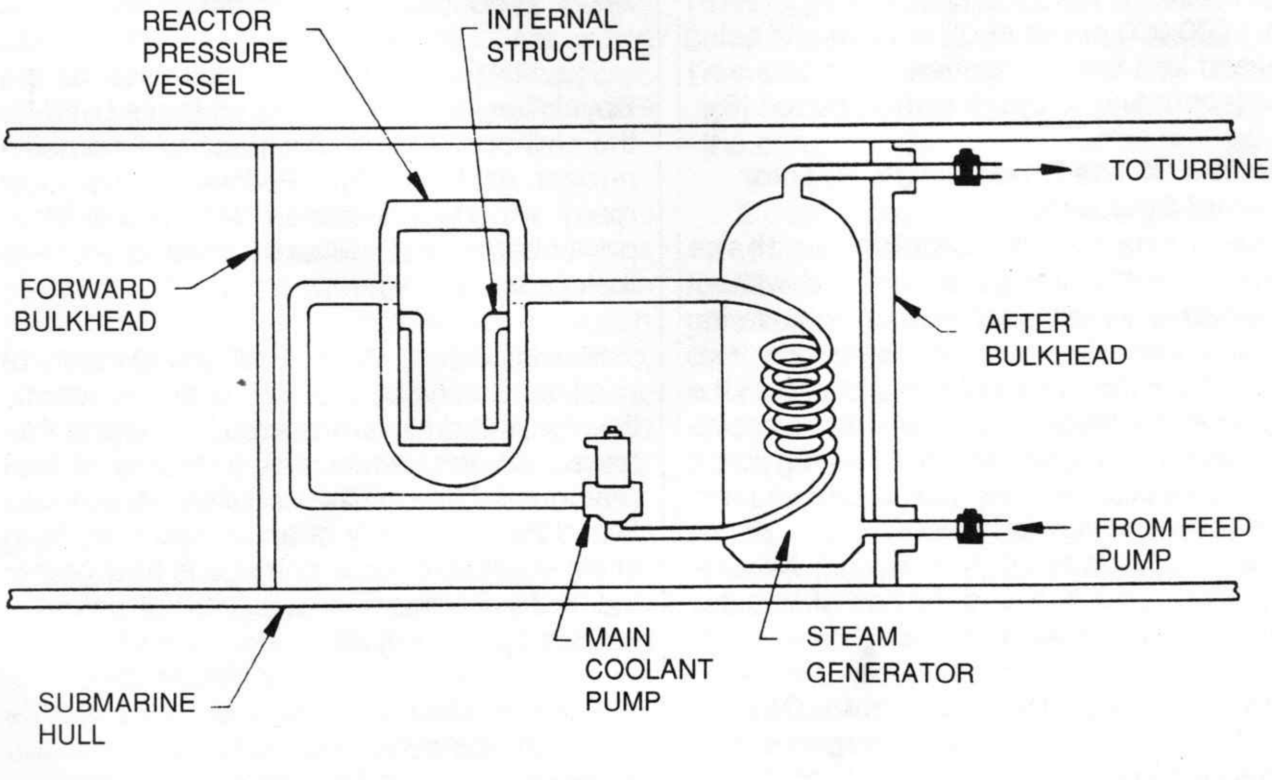

Figure 2. Nuclear Power Plant

Source ref. 106

the Rosyth Public Safety, (but not in the Clyde Scheme), could result from a severe collision - which can occur in harbour or at sea. This could cause a "sudden and complete failure of the primary coolant system concurrent with the breach of the primary containment". This would result in the release of a far greater quantity of fission products into the atmosphere over a much shorter time, estimated by the Navy at perhaps one hour [4]

The Safety Scheme states that according to Ministry of Defence estimates, the Maximum Design Accident has a probability of occurring once in every 10,000 years of reactor operation. The Navy estimates that it would result in the release of up to 1,000 curies of Iodine 131 and 100,000 curies of other fission products into the secondary containment, (the submarine itself). The Navy claim that a 'small proportion' of this is would be released into the atmosphere over a period of 24 hours [5].

The second, a Primary Containment Failure Accident, is estimated to occur once in every 1,000,000 years of reactor operation. This would result in 100,000 curies of Iodine 131 and 1,000,000 curies of other products being released into the atmosphere in as little as 1 hour (according to the Rosyth Scheme) [6].

Criticism Of The Royal Navy's Reactor Accident Scenarios

The fundamental criticism of these scenarios is that they are asserted without published, scientific, technical or engineering justifications. The reasons why only two accident scenarios are put forward, or how the probability statistics are derived, also remains unexplained. Since the methodology and actual calculations are not available, any independent review is impossible and hence public appraisal of the Royal Navy's assertions about the dangers of reactor accidents, cannot be carried out.

For example, the Maximum Design Accident very broadly describes the consequences of a loss of coolant, leading to overheating and melting of the reactor core. Yet one expert study describes four classes of accidents which can result in the melting of the core, of which the Royal Navy's loss of coolant accident is only one [7].

The description the Navy provides of the Maximum Design Accident scenario omits at least one factor that can be involved in such a loss of coolant accident. The Navy state that no 'atomic bomb like explosion' could occur in a pressurised water reactor, but the above study of nuclear power reactors illustrates that a combination of coolant circuit fracture and overheating of the core could lead to a 'steam explosion'.

According to this expert study, "The coolant is very hot (550 degrees Fahrenheit) and highly pressurized (2100 pounds per square inch) and so it will explode into steam if the reactor vessel or connecting piping should ever rupture" [8]. Such an explosion could result in a breach of the reactor vessel (primary containment), leading to a further loss of coolant and core meltdown. This would greatly accelerate the slow leaking through pipes and cables described by the Navy and lead to a more rapid release of fission products.

The statements of probability used by the Royal Navy are also similar to those used by the civil nuclear industry prior to Chernobyl nuclear accident [9]. Following Chernobyl many experts concerned with civil nuclear power began to significantly revise downward their probability figures.

Morris Rosen, Director of the Division of Nuclear Safety of the International Atomic Energy Authority, is on record as saying that based on the actual safety record of civil reactors, following Chernobyl and Three Mile Island the probability of an accident resulting in severe reactor core damage is now nearer the order of once in every 1,000 years of reactor operation [10].

It is not clear whether the Royal Navy's accident calculations acknowledge the increased hazards for submarine reactors of collision, grounding, fire, or the detonation of conventional explosives in weapons [11].

The fact that accidents can occur on submarines while they are in port was revealed by an incident on board the Royal Navy's nuclear powered Polaris submarine, the Resolution, on January 26th 1988. The Ministry of Defence eventually described this as 'a minor electrical malfunction' of unspecified nature [12]. It apparently resulted in the power supply to the pumps for reactor coolant water being cut off. Two back up pumps failed as did a further motor, alarms at the base sounded and heat built up in the reactor core: conditions that can lead to the meltdown of the core.

One nuclear expert, former US Navy nuclear engineer Richard Webb stated that based on the description of the incident, the submarine was perhaps 1 - 7 minutes from overheating and a runaway (unstoppable) meltdown. This could have involved a conventional steam explosion, and could have resulted in widespread contamination. This would have posed a serious environmental threat to the 13,000 people who live within five miles of Royal Navy's submarine base at Faslane [13]. According to local MP John Mc Fall, the Royal Navy had denied any such incident had taken place until the revelation in the newspapers [14].

There are further reasons why the Navy's descriptions of possible accidents do less than justice to the possibilities. It is not known whether they take into account such compounded causes of radiation hazard, such as the dangers of ship board fire, explosion of weapons in handling and collisions that could lead to a breach of reactor containment and submarine hull (see below).

In the light of this, it seems odd that the Navy can write in reference to reactor accidents in port that "should such an accident occur, the effect would, at worst, be a release over a 24 hour period of a radioactive cloud..". The Scheme adds "...it is against this background [a slow release of radioactivity over 24 hours] that the Clyde Public Safety Scheme has been prepared" [15].

Reactor Accident Risks - The Royal Navy's Known Operational Safety Record

Virtually nothing is known about the Royal Navy's operational safety record. The only documentation available has recently been revealed and entered the public domain and covers the years 1962 - 1979. This states that during a combined total of 44 years of reactor operation in 1979, "no incident has occurred which has caused a radiological hazard to the public" [16]. However, the documents do give information on certain kinds of reactor incidents that have occurred.

During the period 1962 - 1979 there were 712 "incidents", defined "as events requiring operation away from the norm and which include all occasions when emergence drills have been initiated". In 1979 the incident rate was about 100 per year with 14 submarines in operation, an average of seven per submarine with analysis showing 20% derived from operating error of Navy personnel [17]. Yet this record is far from complete, since it gives the consequences of the incident (such as a loss of power), but does not detail the nature and importance of any of the incidents - for example whether any of these incidents involved potential dangerous overheating of the core.

It does show that 106 emergency reactor shutdowns (SCRAM's) occurred between 1975 and 1979. A reactor is shutdown when the rate of fission in the core exceeds safe limits by overheating the core, and is normally done by an automatic system [18]. This total included 50 accidental reactor shutdowns (called 'spurious SCRAMs') when power was lost unexpectedly. Of these, 21 were attributed to the malfunction of the protection system (which is responsible for inserting the control rods if the core is overheating), and 29 to operating error of Navy personnel [19]. The Navy itself states that the resulting sudden loss of power at sea can threaten the safety of the submarine [20].

In the document the Navy also recognizes that "Fire has always been a major hazard in any warship packed with electrical equipment and employing oil and steam at high temperatures. In a submarine this situation is exacerbated by the contained atmosphere and even more cramped conditions" [21]. A fire causing burn injuries occurred on board the Royal Navy's nuclear powered submarine Conqueror in August 1987 in Devonport and a lesser fire struck this submarine in Gibraltar in May 1988 [22].

The document also states that "...no British nuclear submarine has been lost, although a major fire has required the lengthy withdrawal from service of one boat." [23]. If this indeed refers to a nuclear submarine, as is strongly suggested by its context, then research has found no apparent public record of the incident as described above. If a Royal Navy nuclear submarine has suffered such a 'major fire requiring lengthy withdrawal' prior to 1979, then this incident remains to be fully accounted for by the present government.

Two recent incidents, however, have reached the public domain. In 1980 the Dreadnought (now stored in Rosyth) suffered machinery damage and reportedly cracks in the reactors secondary cooling system [24]. Also on May 20th 1981 the submarine Valiant, now scheduled for decommissioning, returned to port after reportedly discovering a leak in some part of the reactor coolant system [25].

Globally, there are five nuclear submarines and about 20 naval nuclear weapons lying on the ocean floor due to US and Soviet accidents. Soviet accidents include at least one and perhaps two submarine reactor meltdowns [26]. According to Admiral J.D. Watkins, former Chief of US Naval Operations, "In the last ten years, they (the Soviet Navy) have had over 200 submarine accidents, some of which have been very serious." [27]. The most recent nuclear submarine loss was on the 3rd October 1986. A Soviet Yankee class submarine suffered an explosion and fire and sank with nuclear missiles and two nuclear reactors with a possible total inventory of radioactive fission products twenty times that released at Chernobyl.

Little is known about the impact of such an accident on the ocean environment in either deep water or the shallow coastal seas which are richest in marine life. In March 1986 the US Poseidon missile carrying submarine Nathaniel Green ran aground in the shallow Irish Sea. This caused damage so serious to the submarine that it was decided that it should be decommissioned, instead of another US Navy submarine [28].

The Consequences Of A Serious Accident Involving A Nuclear Submarine Reactor Or Naval Nuclear Weapon.

Independently assessing the probability and the consequences of a nuclear accident in a submarine nuclear reactor is made very difficult by the lack of publication of any detailed history of accidents in such reactors, or of any information concerning the operating characteristics of naval propulsion reactors.

Some studies have taken place in the United States using what detailed information exists on the history and technical details of US Navy submarines [29]. These have enabled 'informed judgments' to be made about the nature and contents of such reactors. The first UK nuclear powered submarine launched was the Dreadnought, which went critical (the reactor began to produce power) on 6th November 1962. This was powered by a Pressurised Water Reactor (PWR) propulsion system derived from the US Navy's Skipjack class of submarine [30]. Subsequent submarines were powered by PWR designed and developed in the UK but based on this US design.

Given this history it seems reasonable to assume for the purposes of this report that the structure and contents, particularly the amount of radioactive material that could be released (core inventory), are likely to be similar to those found in the US. It is therefore possible to refer to the US studies when considering the consequences of a serious accident on a Royal Navy submarine in the Clyde.

Existing Studies On Reactor Accidents

A US study of the consequences of an accident involving the meltdown of a naval propulsion nuclear reactor in San Francisco Bay has used the established methodology for civil nuclear power accidents employed by the US Nuclear Regulatory Commission (NRC). It utilised conservative assumptions which underestimate the effects of the accident. One example is that the study assumed that the reactor remains shut down for at least several days prior to the hypothetical accident, which eliminates most of the highly toxic iodines from consideration.

A reactor accident such as that involving a breach of the containment and a consequent escape of radioactivity into the atmosphere over a 4 hour period was assumed. The radioactive inventory released, it's distribution and consequent health impacts were computed for different weather factors. The population at risk were assumed to be the residential population in the path of the radioactive cloud and all exposed inhabitants are assumed to be adults. Again, this understated the actual impact of the accident modelled, because the work force population is greater than the number of residents and adults are less susceptible than children and infants to the effects of radiation.

The release of radioactivity (the fission products) would be in the form of gases and aerosols. It was assumed that the release occurs at ground level on a dry day in winter. The plume width increases steadily with distance from the damaged reactor, since the cloud expands steadily with distance. The San Francisco study was only carried out for a distance of 11 km from the source since that is the distance from the dock to the Pacific ocean, using the most frequently observed wind direction.

Radiation doses would have been received from the resulting radioactive cloud or plume in five ways; the plume itself would give off radiation; particles that have settled on the ground from the plume would emit radioactivity and particles from the plume could be inhaled - which is the major pathway for intake to the body. Also contamination can arise from particles that have settled on the ground and then have been re - suspended in the air; particles that have fallen directly onto the skin and contamination arising from eating and drinking affected food and water.

The results of ingestion by these methods would be 'prompt' casualties, those that die very soon after the accident and 'delayed' casualties. Delayed casualties are those people who develop non - fatal cancers and radiation linked sicknesses many years later. Radiation may also induce genetic changes in cell structures (genetic mutation) leading to birth defects in subsequent generations of children.

The San Francisco study showed that the calculated resulting exposures would massively exceed the US Nuclear Regulatory Commission limits. This would range, in the case of 'fallout' of Caesium 137, from one million times the allowable limit close to the reactor, to more than 100 times the limit 11 kilometers from the submarine. In the case of air concentrations of Iodine 131 the limits were exceeded by up to 2000 times.

Based on these exposures casualties from fatal cancers were computed. Assuming that people remain in the city for one day following the accident, the casualties would range from 5 to 1068 depending on the atmospheric conditions and risk factors used. If people remained in the vicinity for a week then the range would be from 174 to 1778 and for a year 225 to 2051. Additional yearly casualties would range from 61 to 659, declining to about half this number in 30 years.

Therefore, even under conservative assumptions used in the study of a meltdown of a naval nuclear reactor in San Francisco harbour, thousands of casualties could result unless the city was immediately evacuated and decontaminated prior to rehabilitation. Evacuation would have to be rapid (1 - 2 hours) to be effective.

A study comparing San Francisco, one of the most densely populated urban regions in the United States, and the Clyde would be necessary to gain an idea of the likely casualties caused by such an accident. At this stage detailed estimates of the effect on the Clyde are not possible given the lack of published information. However, with levels of fallout 11 kilometers from a nuclear submarine reactor meltdown being estimated at more than 100 times the officially allowed US levels, not only the nearby towns of Dunoon and Helensburgh but also the many communities on the Clyde and the suburbs of Glasgow would clearly need to consider having rapid evacuation plans.

For people to return, extensive decontamination would have to take place. Decontamination costs of large urban areas have been put by US Government studies at tens of billions of dollars. There is no legal precedent for assessing liability and indemnity for the cost of cleaning up after a military accident and hence it is not known how the costs could be paid [31].

What is evident is that far more public information and research is required to enable a clearer picture to emerge of the risks and consequences of an accident, such as a meltdown, in a nuclear submarine reactor near the Clyde.

Accidents Involving Naval Nuclear Weapons

A nuclear warhead consists of a conventional explosive element which triggers a nuclear explosion caused by the splitting (fission) of elements such as Plutonium (PU - 239) resulting in a huge release of energy that produces the devastation.

The Royal Navy arsenal of about 324 nuclear weapons consists of nuclear free fall bombs and depth bombs, known as 'tactical' weapons for nuclear war fighting at sea and long range 'strategic' weapons such as Polaris missiles. The Royal Navy operates four Polaris missile submarines from Faslane with 128 nuclear warheads and the up to 64 missiles are loaded and unloaded at Coulport. US Navy ships and submarines visit ports around the UK regularly and most are capable of carrying a variety of 'tactical' nuclear weapons. The total of eight US submarines operating from Holy Loch, Scotland, are armed with up to 128 Poseidon 'strategic' missiles with 1280 nuclear warheads [32].

Possible Kinds Of Naval Nuclear Weapons Accidents

The US military considers various nuclear accident scenarios plausible and has contingency plans to deal with them [33]. The one considered most likely by the US Department of Defense is the detonation of the conventional high explosive in the warhead. In the case of nuclear missiles this might be compounded by the explosion of the missile propellent [34]. This threatens the burning of the Plutonium, particles of which would be carried into the sky in a toxic radioactive cloud or 'plume', which can then be inhaled [35]. The dispersion of radiation in the atmosphere through this plume depends on various weather factors. The danger is exacerbated by the fact that Plutonium will burn at a lower temperature than those present in normal fires [36].

According to US Department of Defense experiments, such an accident could "...create a radiological (ie radioactive) cigar - shaped cloud extending from the accident scene for about 28 miles with a maximum width of about 2.5 miles" [37]. Such a detonation of the conventional explosive resulting in contamination has occurred. The two most serious accidents have involved crashes of US aircraft carrying nuclear weapons at Thule, Greenland in 1966 and Palomares, Spain, in 1968 leading to widespread radioactive contamination in both areas [38].

The most likely scenario for a naval nuclear weapons accident would be caused by a fuel or electrical fire on board a ship or submarine. This could also entail the ignition of the missile propellent, if present, and the high explosives in the nuclear warheads. On October 6th

1986 a Soviet Yankee class strategic missile submarine suffered an explosion and fire originating in one of its missiles, believed to have been caused by the ignition of liquid missile fuel [39].

The US Navy has recently provided limited information concerning the numbers of nuclear weapons 'accidents' and 'incidents' it has experienced. The definitions of 'accident' and 'incident' are based on the relative seriousness of the event [40]. By 1981 the US Department of Defense had provided a figure of 32 nuclear weapon 'accidents' [41. In 1983 it was revealed that between 233 to 563 unspecified US Navy nuclear weapons 'incidents' had occurred over the period 1965 to 1983, which included 62 'incidents' aboard surface ships in port [42. In 1986 more specific figures released by the US Navy showed 381 'incidents' and 3 'accidents' between 1965 and 1977 [43.

The Royal Navy And Nuclear Weapon Incidents

The UK government, in response to parliamentary questioning about nuclear weapons accidents, normally replies that no event has occurred resulting in radioactive contamination or danger to the public [44]. No listing of lesser events which the US Navy would define as an 'incident', has been forthcoming.

A report by the Bradford School of Peace Studies concerning nuclear weapons accidents comments that given the known US Navy record, "Unless the US Navy has been particularly careless and unlucky the evidence suggests the real number of nuclear weapons accidents and incidents involving all three US nuclear armed services.. and the other major nuclear powers - the Soviet Union, UK, France, China - over the entire period since 1945 is almost certainly very much greater than anyone outside the military has previously suspected," [45].

A simple numerical comparison with the US Navy's record raises the possibility that the Royal Navy is likely to have experienced some 'incidents' fitting the category used by the US Navy. The US Navy currently deploys and stores around 4285 naval nuclear weapons (with 9227 warheads) and the UK approximately 262 weapons (with a total of 324 warheads). A simple comparison, using the more precise figure of 381 US Navy 'incidents' recorded between 1965 - 1977, would suggest an expectation of up to 23 similar nuclear weapon 'incidents' having occurred within the Royal Navy during this period of 12 years [46].

Regarding the danger of ship board fires to nuclear weapons, a Defence Council Instruction revealed 312 fires recorded in Royal Navy ship and shore establishments in 1986 - 7, including a major fire on the nuclear weapons capable aircraft carrier Illustrious in the English channel in August 1986 [47]. The risk of naval operations was dramatically illustrated by a dangerous accident in 1976 when the US Navy destroyer Belknap collided with the aircraft carrier John F. Kennedy in the Mediterranean Sea. The resulting fire melted the Belknaps aluminum superstructure to the deck: both ships were capable of carrying nuclear weapons [48].

One particularly unstable and volatile US conventional explosive was known as LX09. US Navy Poseidon missile warheads probably contained this until well into the 1980's [49]. In 1977 a piece of this material exploded at a nuclear weapons assembly plant in Amarillo, Texas while being tapped into place with a rubber mallet. The resulting explosion killed 3 and hurled debris more than 300 feet [50].

The US Navy operates 8 Poseidon carrying submarines from Holy Loch, Scotland. On November 2nd 1981, at Holy Loch, a Poseidon missile being unloaded by crane from the submarine USS Holland, fell 17ft before being arrested by a safety device. In subsequent tests, samples of LXO9 exploded more than 50% of the time when a small weight was dropped on it from a height of 15 inches [51].

The US Department of Defense is gradually replacing such volatile and dangerous explosives with less volatile Insensitive High

Explosive (IHE). Nothing is known about whether this will effect high explosives in British nuclear weapons. It is known that this safer insensitive high explosive will not be fitted to the US Navy's latest Trident II (D - 5) strategic missile, which the UK is purchasing. This is to maximise the explosive power of the warheads.

Since most of the expenditure for Royal Navy's Trident II warheads is known to be taking place in the US, this raises the question of whether the Royal Navy's Trident II missile will also use the old less stable high explosive [52]. The US decision has been explained by a US Navy official using the argument that the missile fuel is in any case so volatile that "...in some kinds of accident situations the explosive force of that third stage (rocket propellent) would be sufficient to scatter plutonium around anyway." [53].

Nuclear weapons require servicing and maintenance like other weapons, this requires transportation across the country through heavily populated areas - this is also part of the risk of naval nuclear weapons. Special convoys make journeys every few weeks from bases or storage sites to Aldermaston Weapons Establishment, Berkshire for refurbishment. They are transported in a fully assembled form with a fire engine behind [54]. Police on the routes are known to have decontamination instructions [55].

There have been two road accidents involving the special weapons convoys that could have resulted in the explosion of the conventional explosive and radioactive contamination. On May 20th 1986, two vehicles taking Polaris missile warheads to Coulport collided with each other in the middle of the town of Helensburgh. On the 10th January 1987, a 20 ton vehicle of a nuclear weapons convoy skidded on icy roads, crashed into a field and overturned in Wiltshire. The type of convoy, the one mile cordon thrown around the vehicle and its presence on a route toward the Navy Ordnance Depot, Dean Hill near Salisbury - all suggested that naval nuclear depth bombs or bombs were being transported [56].

Existing Nuclear Weapon Accident Studies

Greenpeace has commissioned a study on the consequences of the most likely kind of naval nuclear weapons accident to affect a port. It assumes a fire occurs on a warship involving the ignition of high explosives in the nuclear weapon and the fragmentation of a single nuclear warhead which results in a breach of the hull of the ship and formation of a radioactive plume. It utilises similar conservative assumptions used in the reactor accident studies (see above). A range of casualty figures are computed depending on various atmospheric conditions.

The study carried out for Copenhagen in Denmark, found that the contamination caused by one nuclear warhead burning for three hours would result in up to 956 prompt cancer fatalities. This total does not include delayed non - fatal cancers and genetic birth defects. Again the costs for decontamination would range from between an estimated 15 and 150 billion US dollars [57].

3. THE RESPONSE TO NAVAL NUCLEAR ACCIDENTS - THE CLYDE PUBLIC SAFETY SCHEME

Description

A 'Public Safety Scheme' is published for each area with nuclear submarine bases, such as the Clyde, or which receives regular visits by nuclear submarines, such as Barry and Cardiff.

This is drawn up by the Navy in consultation with local authorities. It describes various measures to be taken in the event of a nuclear propulsion accident to protect personnel and the public and describes the procedures to implement them [58]

The body for liaison in relation to these plans is the Local Liaison Committee (LLC). The function of the LLC is described in the Clyde Public Safety Scheme as "reassuring local opinion on the hazards involved, of conveying to the public the significance of any accidents, and of creating administrative machinery for the protection of the population in the event of a serious accident". It adds "To these ends a Public Safety Scheme is prepared by Flag Officer Scotland in consultation with local authorities" [59].

The Clyde Safety Scheme describes two kinds of accidents leading to release of radiation into the environment. A range of measures are described for several zones of different distances from the centre of the accident. The action to be taken will depend on the levels of radiation recorded by the Navy after an accident. The assumption will be that a release has occurred, but derived on the Maximum Design Accident (see above) [60]

The measures described to "afford protection against the effects of radiation derived from the cloud", which are to be taken in these areas are: the administration of potassium iodide tablets to reduce the intake of highly radioactive iodine - 131 (which would be one of the fission products released by the accident) ;the evacuation of persons; and a ban on all consumption of food and drink which may have been contaminated by radioactive particles [61]

The Rosyth Safety Scheme states that which measures are implemented and at what distance from the accident, depends upon whether the radiation dose calculated from measurements by the Navy's mobile Naval Emergency Monitoring Teams (NEMT's) exceeds a predetermined level [62]. This is called an Emergency Action Guidance Level (EAGL). The Clyde Safety Scheme is more general and merely states that the measures taken "will depend on the kind of accident that has occurred, the size of atmospheric release, the local weather state and the prevailing wind direction and speed and number of people living at any given distance from the berth affected" [63]. This is established by the Navy for submarine accidents [64].

Different zones distinguish to what extent 'automatic measures' are expected by the Scheme to be implemented. These are based on the estimate of "radiation doses people in them could receive after a reactor accident". It is assumed that a Maximum Design Accident with a slow seepage of radioactivity has occurred [65].

1. 0 - 50m: (The Exclusion area) Within 50m of the hull of the nuclear submarine suffering the accident is known as the "dead zone", since there is no shelter from 'gammashine' (the gamma type radiation emanating from a reactor compartment of the submarine after an accident involving rupture or melting of fuel cladding) [66] Personnel on the base, or in the vicinity of special emergency berths, are to be rapidly evacuated and taken to a special centre in the base. In the Clyde, dosimeters would be carried and personnel would be assumed to have received a dangerous dose above the Emergency Guidance Level [67].

2. 0 - 550m: (The Evacuation Distance) Within 550m of the accident site is the buffer zone, beyond which the Navy states that a significant radiological hazard is unlikely. In this zone fission products do represent "a separate and distinct hazard to health". All non essential personnel will be evacuated. Those maintained in this area will use protective clothing and be given iodide tablets. The Navy claims that provided that instructions are followed, no people should exceed the estimated dangerous dose (EAGL).

3. Beyond 550m: (Outside the evacuation distance) Outside of 550m no immediate action will be taken. Monitoring for the levels of airborne radioactivity by mobile Naval Emergency Monitoring Teams will follow a pre - arranged plan. This will establish whether any of the three EAGL's is exceeded and thus whether sheltering, the distribution of iodide

tablets is necessary. Radio broadcasts may advise people to stay indoors with windows and doors closed and not to consume any exposed food or drink. Lastly evacuation might be necessary out to 1 - 2km until "levels of ground and building contamination can be reduced".

4. More than 10km is called the "No hazard distance", where it is considered that the probability of anyone exceeding an EAGL is so remote that no pre - planning is necessary. However radioactive Iodine 131 will be deposited on grassland and this can be concentrated in milk by cows and goats. A ban may be recommended on milk consumption in the affected areas out to 9km using a pre - written press release [68].

In the event of an accident the Commodore becomes the 'Naval Coordinating Authority' at Faslane. Monitoring of radiation levels is instigated, and the Navy may then declare an accident has occurred. This leads to the formation of a 'Local Action Committee' in Strathclyde. This consists of naval officers and representatives of the area civil organizations: the fire, police, health, transport, water and housing services [69]. The Scheme applies to emergency berths spread throughout the Clyde which could be used in the event of a submarine reactor accident.

When a decision is made by the Navy commanding officer, potassium iodide tablets will be distributed to select groups inside the 550m zone at the base or at an emergency berth. Simultaneously, bans on consumption of food may be announced in the media and special news release to all farmers and be visited and advised on production of milk.

If a decision is taken to evacuate outside the 550m zone, the Rosyth scheme states that police and other personnel will provide information and transportation to evacuation centres using school buses and other public transport. On the question of medical care for the general public, "It is not envisaged by the Royal Navy that any special medical care will be required for the civilian population other than the distribution of potassium iodide." [70].

Claims for injury damage or loss will be dealt with by the MoD under principles established by the Nuclear Installations Act of 1965. Claims against the US in the event of an accident involving a US reactor or weapon will be dealt with under special arrangements, in consultation with US authorities. These remain confidential. However, it is known that the US Department of Defense does not establish legal liability in advance of an accident [71].

Shortfalls In the Clyde Public Safety Scheme

There are three major shortfalls of the Clyde Public Safety Scheme. Firstly, no mention is made of an accident involving a nuclear weapon and the range of accidents considered for a submarine nuclear reactor are too narrow. Secondly, control of any emergency operation lies predominantly with the Navy and the Local Authorities role is far too limited. Thirdly, no provision is made for realistic testing of the Safety Scheme.

One of the aims of the Clyde Safety Scheme is to meet the terms of reference of the Local Liaison Committee: "To consider all situations in which the public may be placed at risk and to devise organizations to meet those hazards" [72]. Yet the 'range of accidents' referred to does not involve nuclear weapons accidents. The covering letter from the Navy in front of the 1983 the Clyde Scheme does say that the safety scheme is "for any other accident in the Clyde area which might lead to a spread of radioactive contamination" and that "accidents other than those involving nuclear reactors would be dealt with under the same arrangements" [73].

The phrase 'nuclear weapon' does not appear in the Clyde Safety Scheme. This is a serious omission for the Clyde, since Faslane is a base for 4 Royal Navy submarines with 16 Polaris missiles each with two nuclear warheads. Holy Loch is the base for 8 US

Navy submarines each of which can carry 16 Poseidon missiles with 10 warheads. It, and occasionally Faslane are also visited by US attack submarines which can carry nuclear anti - submarine missiles (SUBROC) and the Tomahawk Sea Launched Cruise Missile (SLCM).

With three US Navy submarines regularly moored in the Holy Loch (with four on patrol) and one Royal Navy Polaris submarine at Faslane (with two on patrol at sea), there are perhaps 64 nuclear weapons, with 544 nuclear warheads, regularly present in the Clyde (and not counting those under repair or storage). These are subject to fires and explosions which can give rise to radiation hazards (see above) [74].

As was noted in the section concerning the consequences of a serious accident in a submarine nuclear reactor, the Safety Scheme only considers and describes two related scenarios. These are the Maximum Design Accident and the Primary Containment Failure Accident. It is Ministry of Defence Policy to base the scheme on the calculated consequences of the less serious Maximum Design Accident.

The Clyde Safety Scheme is extremely sanguine about the area likely to affected by a nuclear accident. In the event of a Maximum Design Accident with the Navy's estimate of a 'slow seep' of radioactivity to the atmosphere, the Scheme states that "it is unlikely that a health hazard will exist beyond 550m from the vessel". The Rosyth Safety Scheme considering the same accident asserts that "The radiation levels necessary to produce this effect (thyroid cancer) are fairly high and are unlikely to occur in persons exposed to the cloud when they are at distances greater than 550m" [75].

The Clyde Scheme states baldly "Apart from a very small area in the vicinity of the South Gate, the 550m zone around the berths in the Clyde Submarine Base [Faslane] lie completely within the Naval Base Boundary" [76]. The Clyde Scheme does state that under the circumstance of the second kind of accident, the Primary Containment Failure Accident with its more rapid release of fission products, this "could result in a health hazard at distances up to 5 kilometers downwind" [77].

The Navy admits that because of the danger of 'gammashine' near the submarine "it may be some hours before monitoring teams can gather sufficient information to make possible a realistic appreciation of the course of an accident". It adds that as a result, 'safety planning...will concentrate on the protection of those in the 550m, area' within the base [78]. Consequently, it could be many hours before it was realized the accident was serious and measures such as distribution of potassium iodide and evacuation, were implemented for those beyond 550m.

The final statement in the Scheme concerning 'measures to be taken' beyond 550m, states that contamination from radioactive particles on the ground after the passing of the cloud "may indicate that evacuation of the general public from certain areas out to 1 to 2 kilometers is advisable until levels of ground and building contamination can be reduced" [79].

The basis of these calculations of likely hazards at certain distance are not provided by the Clyde Safety Scheme. The scheme says only that "The distances mentioned...are based on average radioactivity release and weather conditions" [80]. In response to an enquiry concerning the basis of the zones, the Ministry of Defence has replied that "The evacuation distance (550m) was decided on the basis of an analysis of the possible consequences of a nuclear submarine reactor accident, taking into account such factors as the design and size of the reactor and amount and types of radioactive material involved." [81].

Unfortunately the kinds of assumptions and calculations involved in this decisions are still not available. The Clyde Safety Scheme adds that these distances are to be used by civil authorities for emergency planning purposes.

This may be too conservative a basis on which to plan for possible nuclear accidents.

The primary terms of reference of the Clyde Local Liaison Committee is "to reassure the public on the hazards involved". Of secondary importance is the need "the convey to them [the Public] the significance of any accident" [82]. Concern about this emphasis is reinforced by the limited involvement of the Local Authority with the development, initiation or testing of the Safety Scheme.

An example of the dominance of the Navy in this process is the fact that "An emergency will be declared by, and ONLY on the authority of the Commodore Clyde" (original emphasis) [83]. Following this, the Local Action Committee and civil emergency organizations are mobilized on receipt of a message from the Navy [84]. The initiation of any measures under the emergency plans depends solely on an evaluation of the Naval Commodore of the area, and not with the decision or advice of the Local Authority [85]. This is illustrated by the fact that in the event of an accident the Navy "provides advice to the Local Authorities on all necessary countermeasures".

Concerning the monitoring of radiation levels after an accident the Naval Monitoring units report directly to the Commodore Clyde at Faslane. Naval units and Council personnel 'where available' are to be "prepared to assist [the Navy] subject to availability of equipment and qualified personnel", to assess the hazard at different distances [86]. Further, the Local Accident Committee is to "Be prepared to evacuate members of the general public from the area of hazard as advised by the Commodore Clyde" [87]. The dangers inherent in such control of the decision to initiate the emergency plans being vested so fully in the Navy, was made clear when no information was provided by the Navy to the Local Authority during the progress of the incident concerning the Polaris submarine Resolution. This occurred at Faslane in January 1988 and could have reportedly resulted in the meltdown of the reactor core.

There are no means provided for the Local Authority to independently assess the accident situation and they are not responsible for initiating the plans. This has parallels in the UK civil nuclear industry where responsibility lies with the controller of the nuclear power station. In Germany, by comparison, local authorities have access to monitoring systems and are responsible for independently initiating emergency plans for civil nuclear reactor accidents [88].

Another disquieting fact is that the press liaison is controlled by the Navy and all press statements must be approved by the Navy; "Initial local releases to the Press will be made by the Commodore Clyde,.." [89]. The Safety Scheme provides a series of pre - worded statements which are to be used by the authorities. These give an insight into the Navy's attitude about the possibility and consequences of a reactor accident, since it rather prejudges the situation. So confident are the Navy, that the pre - written press release for the local population states that "an accident has occurred...which has resulted in the release of a small quantity of radioactive products." [90].

The 1985 Combined Barry and Cardiff Special Safety Scheme is more candid about the reasoning behind this. It states that "The main aim must be the continual reassurance of the General Public and the allaying of fears and emotions that could be aggravated by sensationalist pronouncements by the media" [91].

Even if the Safety Scheme were substantially strengthened to meet the above criticisms, it would still need to tested to see if it would be effective. A comprehensive US Government (Congressional Accounting Office) report on the subject of emergency evacuation plans in the vicinity of nuclear facilities concluded that "problems found with plans that were tested indicate that an untested plan would probably be ineffective in an emergency situation". It recommended that "local emergency preparedness should be periodically tested in concert with the nearby nuclear facility" [92].

Nine exercises were held inside the perimeter of the Royal Navy's Coulport complex in 1983 - 4. The record suggests that during these exercises the civilian authorities were involved only in so far as they were kept informed of the progress of the exercises during the day. Instead, civilian authorities took part in two 'table top' exercises in 1984 [93]. In 1988 a parliamentary question was asked concerning the dates, names and locations of exercises held under the Clyde Scheme since 1979. The reply was 'it is not our practice to discuss details of nuclear accident response exercises' [94].

An important test of the Safety Scheme would be whether it includes adequate evacuation plans for those outside the current envisaged 'evacuation distance' of 550m. This question of is down played by the Royal Navy throughout the Safety Scheme. It states for example that "It is unlikely that evacuation of members of the civilian population will become necessary". Any request for evacuation is left to the Civil Authorities "should they consider it desirable" [95].

An example of much higher standards which perhaps should be considered in this regard, is that of civil nuclear emergency plans in the US. Although dealing with civil reactors with a larger quantity of dangerous fission products, the plans contain the minimum requirement that effective plans must exist to inform all people that a radiation hazard exists within a 10 mile (16km) evacuation distance from the accident within 15 minutes [96].

Another problem is that all emergency plans depend crucially on the response of a variety of personnel such as fireman, ambulance and bus drivers, policemen, physicians and professional and clerical staff. There is considerable evidence that many would understandably have other priorities before performing their duties following a serious nuclear accident, whether the Navy could prove that there was no radioactive threat beyond 550m or not. During the Three Mile Island accident for example, only 6 out of 70 doctors were present at one of the hospitals in the area, with a high absentee list of nurses and other staff [97].

The final problem to consider in the wake of a serious naval nuclear accident is the question of compensation. The Ministry of Defence has written 'in the unlikely case of an accident claims for compensation would be considered on their merits in the normal way' [98]. In the case of major accidents at civil nuclear reactors, under the Nuclear Installations Act, the nuclear industry has to provide £20 million to meet claims arising from third party claims. A further reserve of £210 million is guaranteed by the Government. Any claim in excess of this total of £230 million will only be met at the discretion of parliament [99].

The Clyde Safety Scheme is said to apply to all radiation emergencies in the Clyde, presumably this includes accidents on board US Navy Poseidon submarines in the Holy Loch. It is unclear what the process of consultation or the division of authority would be in the event of a reactor (or weapons accident) on board a US submarine. This, and the question of compensation being paid by the US after an accident is an added area of uncertainty and something that must be considered in looking at the costs to the Clyde. In response to a parliamentary question concerning these matters, the UK government has replied that 'there is very close cooperation on contingency planning' for nuclear accidents and the 'rules and responsibilities' (including the question of compensation) are governed by 'special arrangements,' which are classified [100].

In the light of a serious nuclear accident on the Clyde requiring evacuation, distribution of iodine pills and resulting in possible long term cancers, sums of this order will almost inevitable prove totally inadequate.

4. RADIATION FROM NORMAL ACTIVITIES OF NUCLEAR POWERED SUBMARINES

The section above has considered the potential for and the consequence of accidents on board nuclear powered submarines, and criticised some of the shortcomings of the 'Safety Schemes' supposedly designed to deal with such accidents.

The normal running of a nuclear reactor aboard a submarine also results in radioactivity being released. This occurs when the liquid primary coolant is discharged as the reactor is started up. This overflow is due to expansion of coolant water as the reactor reaches operating temperature. The principle source of radioactivity in liquid effluent is tiny amounts of corrosion and wear products from the metal surfaces of the reactor plant, which are carried by reactor coolant from reactor plant metal surfaces. The most predominant radionuclide is Cobalt 60 which loses half its radioactivity every 5.3 years.

In terms of personnel working with the reactor most radiation exposures is derived from inspection, maintenance and repair inside the reactor compartment after the reactor has been shutdown. Again the major source of radiation is Cobalt 60 deposited inside the piping systems [101].

Monitoring Radiation On The Clyde

The Royal Navy monitors the level of radioactivity on Faslane and Coulport, although no information is normally publicly available as to its findings. The US Navy monitors at Holy Loch. The Ministry of Agriculture, Fisheries and Food (MAFF) samples near Holy Loch and Faslane and Coulport in the latter two cases on behalf of departments of the Scottish Office [102]. Strathclyde regional council also monitors the area [103].

Greenpeace itself has commissioned a preliminary monitoring of 9 samples taken on the Clyde and other UK naval bases which accommodate nuclear submarines [104]. This was probably caused either by discharges from the nuclear waste treatment plant at the Clyde or directly from nuclear submarines due to primary coolant expansion on restart after refitting [105].

The existence of radioactivity at the Clyde has also been confirmed by the MAFF and Local Authority reports. The findings of all these reports show that the concentrations involved were always very low compared to the concentrations required to exceed, for example, the new National Radiological Protection Board (NRPB) annual dose limits [106].

Similar findings have been published in the United States. The US Navy carries out three monthly monitoring of harbors frequented by its nuclear powered ships. This consists of analyzing at least 5 water samples and between 20 and 120 sediment samples, supplemented by shoreline surveys, marine life samples and effluent monitoring. The samples are taken in areas where nuclear powered ships berth and from upstream and downstream locations. The US Navy also monitors foreign harbors frequented by the US Naval nuclear - powered ships [107].

The US Navy concludes that its nuclear powered vessels have had "no significant or discernable effect on the quality of the environment" [108]. The Ministry of Defence is equally adamant that "...there has never been an incident on board a Royal Navy nuclear submarine which has resulted in a radioactive hazard to any member of the crew or to the public or the environment" [109].

Although these findings might appear to allay fears, Greenpeace's fundamental objection to radiological discharges either from military or civil nuclear reactors are based on the premise that, in the words of the US Navy, 'any exposure, no matter how small, involves some risk' [110].

Such opposition is strengthened by the fact that where the Clyde is concerned this 'risk' is experienced in an area where a high incidence of leukaemia has been reported. The US Navy itself has had 196 claims filed for injury from radiation associated with naval nuclear propulsion units. Eight claims in which radiation was an alleged causal agent have been awarded, although the US Navy considers that all eight awards have been 'unjustified' [111].

Greenpeace has consistently advocated the need to adapt a precautionary approach to pollution including the reduction and elimination as soon as possible of any radioactive discharge.

This approach has been strengthened by the recent findings of the Committee on the Medical Aspects of Radiation in the Environment (CoMARE). The head of the Committee Professor Martin Bobrow when discussing its findings, concerning radioactive discharges from Dounreay and Sellafield and local leukaemia in the under 25 age group stated 'To me it seems that the burden of proof has shifted, the leukaemia cases must be assumed to be connected with the nuclear plants until proven otherwise' [112].

*

RADIATION AND HEALTH

What Is Radioactivity ?

All matter whether it is liquid, gas or solid, is composed of minute atoms. An atom is made up of even smaller particles; a nucleus, itself composed of protons and neutrons, surrounded by a cloud of electrons. The protons are positively charged, the electrons negatively charged - so that the atom as a whole is, in its normal state, electrically neutral. The electrons are responsible for the chemical behaviour of the atom.

. The number of protons in the nucleus is called the Atomic Number and it determines which element an atom belongs to. For example, the Atomic Number of Iodine is 53 - so all atoms containing 53 protons are Iodine atoms. But the number of neutrons which may be associated with these 53 protons can vary, thus giving rise to different forms of Iodine, know as isotopes. Any given isotope is identified by its Mass Number which is simple the total number of protons and neutrons in its nucleus. Therefore Iodine 127 has 53 protons and 74 neutrons.

Some combinations of protons and neutrons give stable isotopes, (e.g. Iodine 127), while others are unstable, these are termed radioisotopes. Radioisotopes become stable by emitting a form of energy called radiation. This process is known as Radioactive Decay.

Radioisotopes decay at a constant rate known as the half - life, being the time taken for half of the atoms of the isotope originally present to decay. For example, radioisotope Iodine 131 has a half - life of 8 days: which means that after that time half of the quantity of radiation originally present has disappeared. After a further 8 days half of what remained has decayed, i.e. one quarter of the original still remains. Half - lives can vary, according to the isotope, from seconds to millions of years. The half - life of Plutonium 239 is 24,000 years.

Ionization

Radiation given off by radioactive isotopes is capable of transferring some of its energy to the electrons surrounding the nuclei of atoms of ordinary matter. These energetic electrons break away from their atoms to become free electrons; this process is known as ionization. It is this ionising effect of radiation which causes biological damage.

There are three types of ionising radiation:

Alpha Particles - Usually given off by the nuclei with large number of electrons (heavier) radioisotopes such as Radium and Plutonium. They are stopped by the dead outer layer of our skin, but there is a major health hazard if isotopes giving off alpha particles are taken into the body by ingestion or inhalation, where they lodge in soft tissue such as the lung. In such circumstances Alpha particles are approximately 20 times more biologically damaging than the same dose of beta or gamma rays.

Beta Particles - These are high speed electrons emitted from the nuclei of many natural and man made radioisotopes. Most beta rays are not capable of penetrating the skin. They are less biologically damaging than alpha rays but are also a hazard if isotopes emitting them are eaten or inhaled. Some beta emitting isotopes give off gamma rays as well.

Gamma Rays - These are true electromagnetic rays (like light or radio waves). They are similar to x - rays but usually of a higher energy. They are given off by many, but not all, radioisotopes. This form of radiation is very penetrating, and can only be stopped by a large thickness of concrete or lead etc. X - rays can penetrate the whole body and are the dominant form of external radiation. As in the case of alpha and beta emitting isotopes, gamma emitting isotopes are even more of a hazard if ingested or inhaled.

Sources Of Radiation

Radiation either comes from natural background radiation or artificial sources.

(i) Natural background radiation comes from cosmic rays from outer space and certain radioactive rock strata. There have been some marked health effects found in areas where there is a high naturally occurring level of radioactivity.

(ii) Artificial Radiation includes medical x - rays, fallout from nuclear weapons tests and discharges from the nuclear power industry and nuclear propelled submarines.

How Is Radiation Measured ?

The measurements by which radiation is normally measured are called bequerels and sieverts.

Becquerel (Bq)

The activity of a radionuclide is the number of nuclei decaying per second. One becquerel is equal to just one decay per second.

(Previously this activity was measured by a unit known as Curie = to 3.7×10^{10} decays per second in one gram of radium).

Sievert (Sv)

The Sievert is the name given to the effect of the amount of radiation received by a person. It takes into account that some parts of the body are more easily harmed than others and that some forms of radiation are more damaging. One milli - Sievert (mSv) is one thousandth of a Sievert.

How Does Radiation Affect Living Things?

It is generally accepted by scientists that even a very small dose of radiation can potentially cause injury to living cells. Experts disagree about the amount of damage which can be caused by small doses of radiation.

When ionising radiation passes through a living cell, it can lead to death of the cell, or disruption of its functioning. Irradiating a cell may affect the mechanism which controls its division so that it divides in an uncontrolled manner to form a growth known as cancer. It can also lead to mutation of the cell's genetic material, DNA. If this occurs in the sex cells, the sperm or eggs, the result may be a foetal abnormality which will only show up in later generations. Very low doses of radiation can also cause cataracts, skin damage and premature ageing.

The more serious effects of radiation have been widely publicised after the Nagasaki and Hiroshima bombings and more recently after the Chernobyl accident. The effects on human health of these events are still being analyzed. In 1987 the National Radiological Protection Board (NRPB), revised their radiation dose recommendations following recent new health studies of survivors of the Nagasaki and Hiroshima bombings. The recommendations for nuclear installations workers was revised downward by 70 percent and for members of the public by 90 percent [113]. These NRPB recommendations are based on research carried out on populations who had received a very high and instant dose of radiation; what is harder to ascertain is the effect of much smaller doses of radiation received over long periods of time, therefore it is vital that further research should be done on the effects of low level radiation.

Health Studies

There have been a number of studies carried out which have shown clusters or high instances of cancers around nuclear installations. Particularly noticeable are the increases in leukaemia in young children and increases in cancers of the bone marrow and lymph, such as multiple myeloma and Hodgkin's disease.

In 1987 the Office of Population Censuses and Surveys published a study of cancer incidence and mortality in the vicinity of nuclear installations in England and Wales for the period of 1959 - 1980. This study shows an increased incidence of leukaemia in the 0 - 24 age group and multiple myeloma and Hodgkin's disease in the 25 - 74 age group [114].

Most recently, on June 8th 1988, the Committee on Medical Aspects of Radiation in the Environment (CoMARE) published a report following investigations into leukaemia instances around Dounreay reprocessing plant in Scotland. CoMARE was set up in 1985 as a result of recommendations by Sir Douglas Black's Inquiry into the high incidence of leukaemia around Sellafield reprocessing plant in Cumbria.

The CoMARE researchers found six cases of childhood leukaemia registered around Dounreay between 1979 and 1984, when only one would have been expected. The report pointed to the plant as being 'the most likely cause of higher than expected rate of leukaemia among children living nearby'. One committee member, Dr Thomas Weldon, insisted that "On the balance of probabilities we think it is most likely that Dounreay and, by implication Sellafield, are to blame for the excesses of leukaemia" [115].

Roman et al carried out a study into the incidence of leukaemia around the Atomic Weapons Research Establishment at Aldermaston and the Royal Ordnance Factory at Burghfield in Berkshire. When the data for the two districts were combined they found a significant increase in leukaemia in the 0 - 4 age group (53 observed, as against 34 expected) [116].

Local Health Statistics Around The Naval Nuclear Installations Of The Clyde.

High levels of nuclear waste were discovered in the loch side mud flat at Holy Loch in 1965, 4 years after the US Polaris submarines arrived. Despite assurances from the US Navy that this would never happen again, in 1978 another increase in levels of radioactive Cobalt 6O was found.

During their investigation of the area in 1985 Yorkshire TV uncovered several cases of cancer around the Holy Loch. At Kilmim which only has a population of 318, 3 cases of cancer were detected. One of the victims was a 3 year old boy with an extremely rare form of cancer occurring once only in every million children [117].

An unusual pattern of cancer was also discovered at Dunoon. Yorkshire TV detected 12 cases of cancer in young children, making the death rate from cancer in the under 25 year olds for the past 15 years 3 times the Scottish average. The leukaemia death rate around Holy Loch was more than 5 times higher than would have been expected [118].

Table 1 Incidence of Under Twenty Five Leukaemia in Holy Loch within 12.5 km of Holy Loch submarine base.

1968 - 73		1974 - 78		1979 - 1984	
O	E	O	E	O	E
8	5.03	5	4.66	4	4.48

Table 2 Incidence of Under Twenty Five Non Hodgkin's Lymphoma, Acute Lymphoblastic Leukaemia and Acute Myeloid Leukaemia within 6.25 km of Holy Loch submarine base.

1968 - 73		1974 - 78		1979 - 1984	
O	E	O	E	O	E
1	0.89	2	0.82	2	0.89

O = Observed E = Expected

Table 3 Under Twenty Five Deaths From Leukaemia at Holy Loch (Dunoon and Strone) 1969 - 1983 ? [119].

Observed....5	Expected....0.95

Faslane

Faslane is not covered in the Scottish Health Information Services analysis. However, in a submission to the Black inquiry there was a significant raised level of under 25 myeloid leukaemia in the Clyde estuary during the period 1968 - 74, (9 observed when about 3 would have been expected) [120].

The Royal Navy has admitted that between 1972 and 1975 there were 4 babies born to families of submariners, who had served on board the nuclear powered and armed submarine HMS Resolution, who had hair lips and cleft palates. To have occurred at an average rate, each of the 300 crew would have had to have fathered 13 to 14 children over three years, this is a figure 40 times the expected average. George Younger, Defence Minister has dismissed these extremely unusual health instances as 'a very sad coincidence' [121].

According to Shirley Ratcliffe experimental evidence in mice shows that a small dose of radiation to the father can cause genetic defects in the offspring. These defects have been shown to include hair lips and cleft palates [122].

What Needs To Be Done

The effects of low level radiation are difficult to detect. Some of the genetic effects and cancers do not occur for several years after the initial contact with radiation. For this reason it is impossible to say categorically that the incidence of cancers found on the Clyde are caused by radiation. The fact that many studies have been carried out which do demonstrate localised clusters of leukaemia and lymphatic cancers makes it imperative that more research should be carried out into the effects of low level radiation.

6. CONCLUSION AND RECOMMENDATIONS

This report has shown that at the present time it is not possible to make an accurate assessment of the probability and effects of a serious nuclear accident in a naval reactor or nuclear weapon on the Clyde. The reason for this is not that such accidents cannot occur, but that their effects cannot be predicted because of the large gaps in the relevant published documentation. US studies however, have shown that the effects of a major naval nuclear accident can be calculated and that they are extremely grave, resulting in the need for large scale evacuation and hundreds of cancers.

The present Clyde Safety Scheme which is supposed to provide adequate protection in the event of a nuclear accident is based on an incomplete range of possible nuclear reactor accident scenarios. It also ignores the need to take into account the effects of an accident involving a nuclear weapon on the Clyde. The Safety Schemes analysis of what would be required to cope with the problems posed by accidents is complacent and has never been adequately tested.

The health studies in the areas around the Clyde of cancers for those under 25 which can be associated with radiation, give considerable cause for concern, as do published health records of workers. The levels of radiation produced by the nuclear submarines on the Clyde need more comprehensive monitoring and their findings more public distribution. A thorough and continuous checking of health statistics for those cancers which have been associated with radiation discharges is also required, as are comprehensive preventive health measures for dockyard personnel and their families.

It must be stressed that all the recommendations of this report are only seen by Greenpeace as interim steps. If the variety of information asked for by this report is made available, it will provide a basis for a fuller analysis of the risks to be presented to the public. This will increase awareness about the dangers inherent in having floating nuclear reactors and nuclear weapons on the Clyde. It is believed that ultimately this will add to the growing international desire to rid the world of naval weapons and reactors, in order to arrive at the eventual goal of a Nuclear Free Seas.

Recommendations

Naval Nuclear Accidents - Risks and Consequences

1.The Royal Navy should publish the details of the basis for its estimates of the probability of nuclear reactor accidents on the Clyde.

2.A full range of accident scenarios should be published by the Royal Navy both for nuclear reactors and nuclear weapons. These should make explicit the assumptions and calculations upon which they are based, and clearly demonstrate the resulting consequences.

3.The details of the structure and core inventory of the Royal Navy's nuclear reactors weapons should be published, since this is a prerequisite for an effective evaluation of the levels of potential contamination which might result from any of the accident scenarios.

4.The radiological inventory of the Royal Navy's nuclear weapons should be published, since this is a prerequisite for an effective evaluation of the levels of potential contamination which might result from any one of the accident scenarios.

5.The broader environmental impact of a reactor or weapons accident should be analyzed, including the impact of such an accident on terrestrial and aquatic environments and water supply.

Emergency Plans

1.The Clyde Safety Scheme should be revised in order to cope with a major naval nuclear accident rather than the very limited accident at present catered for.

2.The Local Authorities should have a much more active role in the planning, initiation and testing of the Clyde Safety Scheme. At present the role of the Royal Navy in devising and implementing the scheme is too dominant.

3.The Clyde Safety Scheme should be periodically tested. A US Government report on emergency plans near nuclear facilities concluded: 'Problems found with plans that were tested indicate that an untested plan would probably be ineffective in an emergency situation' and that 'local emergency preparedness should be periodically tested in concert with the nearby nuclear facility' [123].

4.An assessment should be made of the likely economic impact on the Clyde and the neighboring areas of a serious naval nuclear accident including the cost of decontamination. A detailed procedure for calculating and disbursing compensation should be drawn up, and the adequacy of the present Government 'insurance' against such an accident critically reviewed.

Monitoring Nuclear Submarines In Port

1.Details of the ways in which the normal running of submarine nuclear reactors involve discharges of radioactive effluent and the quantities involved should be made public in order to facilitate a more effective monitoring programme on the Clyde.

2.The US Navy takes a wide range of samples quarterly and publishes its findings in considerable detail [124]. The Royal Navy and the local authority should each carry out an equally comprehensive programme of monitoring and publish their findings separately.

3.Any such publications should be written in so far as is possible in non technical language, with the range of medical opinion concerning the medical and environmental effects of low level radiation made clear.

Health

1.Regular health studies of the naval and civilian personnel and their families should be carried out and published. These should include adequate measures such as body scanning.

2.There is inevitably a turnover of submarines and workers at the dockyard, studies should therefore be extended to personnel and their families who have moved away, retired or changed employment.

3.A constant appraisal of the health of the local population around the Clyde should be carried out. Particular attention should be paid to unusual leukaemia rates and other health conditions known or suspected to be connected with radiation.

Employment

1.A study should be carried out on alternative sources of work at the Clyde for those whose employment at present depends on the refitting of nuclear powered submarines.

THE FUTURE OF THE HOLY LOCH - A US NAVY NUCLEAR BASE

1. SUMMARY

In 1961 the US Navy began using Holy Loch in the Firth of Clyde Scotland, as a 'forward base' for submarines armed with its first long range submarine launched missile, the Polaris. Its limited range of less than 1,500 miles was the reason given for having a European base within easier striking distance of the Soviet Union.

Between 1971 and 1977 Polaris was replaced by the Poseidon missile, which has a range of 3,200 miles. This brought the Soviet Union more within range of Poseidon submarines in the mid-Atlantic and diminished the original justification for forward basing. In 1979 the US Navy began deploying the Trident I missile which has a range of 4,559 miles. This and a even longer range Trident II missile (at 6,900 miles), is due to replace the last Poseidon carrying submarine in 1999. This will totally remove the original military justification for the use of Holy Loch as a US Navy strategic missile base. The decommissioning of Poseidon submarines could be accelerated should a Strategic Arms Reduction Talks (START) Agreement be reached.

However, recent statements from the US and UK governments show that the base could remain open for other purposes. The US Navy's two other two strategic nuclear bases at Rota in Spain and Guam in the Pacific, ceased to be used for such submarines in 1979, they are used instead to support attack (hunter killer) submarines. Another base in La Maddalena on the Italian island of Sardinia, is used by attack submarines armed with nuclear Tomahawk Sea Launched Cruise Missiles (SLCMs). This provides a model for the possible future use of Holy Loch after Poseidon.

The SLCM is the maritime equivalent of the cruise missiles to be eliminated by the Intermediate Nuclear Forces (INF) Treaty. US (and now Soviet) SLCMs are a dangerous new way of waging nuclear war on land from above and below the oceans and are the latest and most dangerous creation of the arms race at sea. Holy Loch has itself been visited by US attack submarines, some of which have already been made capable of carrying sea launched cruise missiles.

There are several reasons why SLCM carrying submarines are likely to come to Holy Loch with increasing frequency, and why the US Navy might wish to adapt the base to support attack submarines.

The first is the US Navy's 'offensive maritime strategy' which has been introduced during the Reagan administration and is supported by NATO. This calls for rapid deployment of attack submarines up to the Kola Peninsula, near Norway during times of crisis. In peacetime this has resulted in the increased operation of attack submarines in the Eastern Atlantic, Norwegian Sea and Arctic in the 1980's. Holy Loch is the nearest existing forward submarine base to the Soviet Navy's main bases in the Kola Peninsula.

The second is that the US plans to deploy more than 375 nuclear armed SLCMs by 1994 on in its Atlantic fleet, many of which will be carried by roughly 60% of the attack submarines at this time. In addition, NATO has plans to bring some of these US Navy nuclear SLCMs under its own control when in European waters, and Holy Loch would play a vital role in facilitating this strategy. NATO is planning this as part of a package of 'adjustments' and 'modernization' plans in order to compensate for the nuclear weapons removed under the Intermediate Nuclear Forces (INF) Treaty.

Finally, recent public statements by the UK

government have confirmed their willingness to allow the US Navy to use Holy Loch after Poseidon has been decommissioned for 'whatever other purpose..when they have decided' and for 'as long as they (the US) need it'. This attitude should not be allowed to deflect concern about the future of Holy Loch, which should be a topic of widespread public and parliamentary debate.

2. HOLY LOCH, SCOTLAND 'BALLISTIC MISSILE REFIT SITE/ NO 1', SUBMARINE SQUADRON 14, US NAVY.

Holy Loch has been a US Navy base since March 1961 as part of a deal between the US and UK for the UK to acquire the US Skybolt nuclear missile (later cancelled in favour of the Polaris submarine launched missile). As early as 1960 the US approached the UK concerning the possibility of establishing a base in the for submarines with long range strategic missiles.

The new submarine based leg of US nuclear forces required bases to be well within range of the Soviet Union to launch an attack against the maximum range of targets. Countries even closer to the Soviet Union, such as Norway, Denmark (or Japan in the Pacific) had non-nuclear policies that prohibited the stationing of nuclear weapons on their territory in peacetime. Since the UK already had US nuclear weapons, the UK and Holy Loch were the logical choice in the Atlantic.

At present eight US Navy submarines of the 14th Submarine Squadron (SUBRON 14) are based there and are armed with Poseidon strategic missiles. This represents just under one quarter of the US Navy's strategic submarine fleet. Holy Loch is now the only base for strategic missile submarines maintained by any nuclear power on foreign soil in the world. Similar US Navy bases at Rota in Spain and Guam in the Pacific ceased being used for such submarines in 1979.

The squadron at Holy Loch consists of three submarines of the Lafayette class, one of the James Madison class and four of the Benjamin Franklin class. The submarines official home port is Groton Connecticut, USA. Each of them return to the US every 6 years for an overhaul which lasts 16 months. Holy Loch is called by the US Navy, 'Fleet Ballistic Missile Refit Site/No.1' [1].

Each submarine carries 16 Poseidon (C-3) Submarine Launched Ballistic Missiles (SLBM's) and each missile can deliver 10 nuclear warheads. The Poseidon missile nuclear warhead has an explosive power of 40 kilotons (40 thousand tons of TNT), around 3-4 times as powerful as the bomb dropped on Hiroshima [2]. There are sometimes three submarines at anchor in the Holy Loch, between them they would have the capability to deliver the equivalent of 1,600 Hiroshima bombs on Soviet territory [3].

Two or three of the submarines are present in Holy Loch on average at any one time. The rest of the squadron are on 'deterrent patrol'. The submarines spend an average of half their time at sea. These patrols last 68 days and cover the North Atlantic, Arctic and Mediterranean Sea. This is followed by a 32 day 'refit' period in Holy Loch, which normally entails re-provisioning, repairs and crew exchange [4]. Each submarine has two crews, and the replacement crew are flown in to Prestwick airport from the US [5].

The major floating component of the Holy Loch base consists of the submarine tender USS Simon Lake. This was deployed in August 1987 and is essentially a floating barge with large cranes. On each return of a submarine to Holy Loch, two of its Poseidon missiles are removed for overhaul and repair while the submarine is moored next to the Simon Lake. This ship can service and store 20 Poseidon missiles. Alongside the Simon Lake is the USS Alamos, a floating dry dock

1000 feet long with a lifting capacity of 40,000 tons.

There are also harbour tugs and support vessels, and various barges - which may contain some low level radioactive waste. The base is supplied by a monthly supply ship, which also carries overhauled Poseidon missiles and other conventional submarine weapons from the US. There is also a growing complex of shore based administrative and support facilities [6].

3. THE DISAPPEARING MILITARY JUSTIFICATION FOR HOLY LOCH

1. The Increasing Range Of US Navy Missiles: Polaris, Poseidon, Trident I, Trident II.

The prime military justification given for the continued use of Holy Loch by the US Navy is becoming increasingly untenable. In the early 1960s it was stated that the base was needed for 'forward basing' of submarines armed with the US Navy's first strategic missile: the Polaris. The Polaris (A-2) missile which arrived in March 1961, had a range of less than 1,700 miles, which required patrols to take place in the Eastern Atlantic in order to be within range of the Soviet Union. If based in Scotland, the submarines would not have to spend time travelling across the Atlantic to bases in the US before and after each patrol. Therefore, a 'forward base' at Holy Loch allowed US Navy submarines to cruise within range of the Soviet Union for the maximum period of time [7].

Between 1971 and 1977 the Polaris missile which first arrived at Holy Loch, was gradually replaced by the new longer range Poseidon (C-3) missile. The Polaris had a range of 1,500 miles, and the Poseidon a range of up to 3,200 miles [8]. This doubling of range brought the Soviet Union within reach of US Poseidon armed submarines patrolling in the mid-Atlantic. They could therefore be based in the US instead of Scotland. There are in fact are eight similar Poseidon submarines based at Charleston, South Carolina. Therefore, by 1977 the military justification used for 'forward basing' US Navy submarines at Holy Loch was already diminished.

The Poseidon missiles currently based at Holy Loch are themselves due for retirement. In October 1979 they began to be replaced by an even longer range missile, the Trident I (C-4) [9]. The Trident I missile has a third more range than Poseidon, at 4,599 miles. In addition, according to the US Navy the new Ohio class submarines which carry Trident I, are able to remain on patrol for 21% longer than Poseidon submarines and increase the patrol areas by 10-20 times [10]. These trends mean that the original justification for the basing of strategic submarines at Holy Loch is increasingly disappearing.

In 1981 the US Navy itself stated in Congressional testimony that the Trident I missile 'eliminates the need for overseas basing' [11]. Indeed, it was the appearance of the longer range Trident I, in combination with changing political circumstances in Spain after the death of Franco in 1975, which resulted in the withdrawal of a similar Poseidon squadron from the base at Rota in 1979, under the terms of the 1976 US-Spanish Defence Agreement. A similar decision was made concerning the squadron at the US island territory of Guam in the Pacific for economic reasons.

In early 1977 the US Navy's highest commander, the Chief of Naval Operations (CNO) testified before the US Congress that he had ordered a study to 'find permanent sites for relocation of Poseidon SSBN's' from both Rota and Holy Loch [10]. However, Holy Loch still remains the only US strategic submarine nuclear weapons base left outside of the continental United States.

The US Navy will soon deploy the Trident II (D-5) missile, which is presently scheduled to enter service in December 1989. The Trident II will be carried exclusively by the latest submarine, the huge Ohio class, which will have 24, instead of 16, missile tubes. Trident

II will have a range of up to 6,900 miles depending on the number of warheads carried (between 8 and 15). Under the START negotiations Trident II will now be counted with 8 warheads, allowing maximum range. By the end of the century the US Navy plans to replace all other strategic submarines with at least 20 Ohio class submarines armed with the Trident II. These submarines will be based at Bangor, Washington State and Kings Bay, Georgia [12].

It is thought highly unlikely that the US Navy sees any military, economic or political rationale for using Holy Loch as a forward base for the Ohio class submarines with Trident II missiles [13].

2. Plans For Decommissioning Holy Lochs Poseidon Submarines

The US Navy's past position on the future of Holy Loch is typified by a statement from the naval attache at the London Embassy. He stated in 1983 that 'Holy Loch will continue to be needed for valuable basing support until the end of the century' [14]. This policy was confirmed by the US Navy in early 1986, when it was stated that the decommissioning of the 16 submarines which currently carry Poseidon missiles, was to begin in 1993 and to be completed by the end of 1999 [15].

This schedule may now have been brought forward however. In 1988 the Navy revealed that the Poseidon submarine USS Andrew Jackson, based at Holy Loch, is to be decommissioned in late 1988. This is instead of a planned 6 yearly overhaul and is the result of funding constraints imposed by the US Congress. Another Poseidon carrying submarine, the USS John Adams (based in Charleston, South Carolina) will also be decommissioned in 1989 ahead of schedule, as a cost cutting measure by the US Navy [16]. These decisions come 4-5 years ahead of the US Navy's previous plans for decommissioning. As a result, the last Poseidon submarine may now be decommissioned considerably before 1999 [17].

3. The Impact Of A Strategic Arms Reduction Talks (START) Agreement On Holy Loch's Poseidon Submarines.

The time scale for the decommissioning of Poseidon submarines may be more dramatically accelerated by a Strategic Arms Reduction Talks (START) Treaty. The START agreement is expected to result in a cut of roughly 30 - 35% in the total number of US and Soviet nuclear warheads on 'strategic' (long range) nuclear weapons (but not the 50% as is often claimed). The treaty will have a timetable for complying with the agreed reduction in the number of nuclear warheads. The latest timetable proposed by the Soviet Union is 5 years and by the US 7 years [18].

If the outstanding problems of the present draft Treaty are resolved, and the Treaty is accepted by the new President, a START agreement could conceivably be signed and ratified by the end of 1989. Assuming this date the US Navy would have to meet submarine launched limits by late 1995. The systems which will be dismantled to bring the US under the warhead limits will be the oldest, such as the Poseidon missile.

The US Navy currently deploys 5632 strategic missile warheads on 36 submarines, 16 of which are Poseidon carriers. A conservative estimate of the reduction in warhead numbers of 35% under START would require the elimination of roughly 1878 warheads. This reduction alone would necessitate the decommissioning of 12 of the 16 Poseidon submarines to bring the US under the Treaty limits by as 1995 [19]. The remaining four Poseidon submarines could also be accounted for as they are replaced by the Trident II carrying Ohio class. The first of the Ohio class will become operational in December 1989, with six more submarines presently under construction [20].

Given the above, as early as 1995 - 6 could begin the crucial period when a decision should be expected from the US and UK governments as to the future of Holy Loch. It should be expected that the US Navy would announce its intention to leave Holy Loch as soon as all the Poseidon submarines are decommissioned, or when there are too few submarines remaining to make the operation of the base worthwhile.

4. FUTURE US NAVY PLANS FOR HOLY LOCH AFTER POSEIDON

1. Supporting Trident I Missile Armed Submarines

The Trident I missile has been carried on some of the same classes of submarines which carry the Poseidon missile [21]. By December 1987, twelve James Madison and Benjamin Franklin class submarines had been converted to carry Trident I. These are based at Kings Bay, Georgia. It is therefore impossible to tell by looking if Trident I submarines use Holy Loch, since they are visually indistinguishable from similar Poseidon carrying submarines [22].

The ability of Holy Loch to support Trident I was increased in August 1987 by the replacement of the submarine tender USS Hunley with the USS Simon Lake. The Simon Lake has the capacity to service Trident I as well as Poseidon missiles [23]. This suggests that Trident I submarines could have, or will be able, to make use of the facilities at Holy Loch when required to by the US Navy.

The UK government stated on 19th November 1986 that "The question of the use of Holy Loch by Trident carrying submarines has not arisen" [24]. This answer may refer to the concept of formal basing of Trident I submarines at Holy Loch by the US Navy. If so, this statement could still allow for occasional visits by Trident I submarines for repairs or emergencies. This would supplement the declining use of Holy Loch by Poseidon submarines.

However this function would not on its own be an adequate justification for the maintenance of a base at Holy Loch beyond the decommissioning of Poseidon submarines. The question that should be increasingly asked in the coming years, is why the US Navy is persisting in using Holy Loch for an decreasingly important part of its sea based nuclear forces.

2. A Forward Base For Attack Submarines Armed With Sea Launched Cruise Missiles

There is one far more plausible option for the continued use of Holy Loch by the US Navy, rather than basing or supporting the long range Trident I missile submarines. This would be to maintain facilities at Holy Loch in order to support the operation of US nuclear powered attack submarines operating in the Atlantic.

Holy Loch would provide a forward base, strategically located for rapid deployment of attack submarines into the North Atlantic, Norwegian, Arctic and Barents Seas (called Northern Waters) against the Soviet Navy. Such a shift of operations northward has followed the new emphasis on 'forward operations' - required under the US Navy's 'offensive maritime strategy' which has been developed in the 1980's [45].

This controversial Maritime Strategy has been widely criticized as planning to carry out an early forward movement of naval forces in a crisis toward the Soviet Union that could increase tension. The planned attacks of the Maritime Strategy, once ships and submarines are forward, against Soviet naval and air bases and Soviet strategic submarines at sea, threaten the outbreak of war, and if carried out - the escalation to nuclear war [46]. This strategy requires an early forward movement of US Navy (and Royal Navy) attack submarines in a crisis or war, followed by aircraft carrier battle groups, towards the main bases of the major Soviet Northern Fleet on the Kola Peninsula bordering Norway [47].

This first phase of the Maritime Strategy has been described by US Admiral Nils Thunman

The Danger of the Sea-Launched Cruise Missile

The US Navy's nuclear armed Tomahawk Sea Launched Cruise Missile (SLCM) is a small (18ft) pilotless guided missile that can be launched from attack submarines and ships. It flies at sub-sonic speed within the atmosphere at low level, partly guided by a complex computer which compares the ground to an internal mapping system. It can deliver a nuclear warhead with an explosive power up to 150kt (equivalent to 150,000 tons of TNT or 15 Hiroshima bombs), over 1,550 miles to within 90ft of a target. It is designed to destroy land targets such as airfields, naval ports, and military command centres [25].

The US Navy began deploying the nuclear Tomahawk SLCM in June 1984. The Soviets have two equivalent missiles, the SS-NX-21 and SS-NX-24. The first of the SS-NX-21 (code name Sampson), was deployed at the end of 1987 in a submarine of the Northern Fleet, based on the Kola Peninsula near Norway [26].

The US SLCM, and its Soviet equivalents, are a new way to threaten and wage nuclear war on land from above and beneath the oceans - the most recent and dangerous offensive weapon of the arms race at sea.

Compensating For The Intermediate Nuclear Forces Treaty

This Sea Launched Cruise Missile is almost identical to the US Air Force Ground Launched Cruise Missile (GLCM) deployed in Europe in 1983. This is to be completely eliminated under the Intermediate Nuclear Forces (INF) Agreement which was signed in December 7th 1987. By early 1992 the INF Agreement will include the final worldwide elimination of the 256 US GLCMs that were operational in Europe at the time the Treaty was signed (the Soviet equivalent is also eliminated but was not operational at this time). Yet just when GLCMs must be finally eliminated under the INF Treaty, the US Navy plans to be able to put around 25 submarines and 42 ships of the Atlantic Fleet armed with approximately 378 nuclear cruise missiles into the waters around Europe [27]. As of December 1987 there were an estimated 30 nuclear Tomahawk estimated on Atlantic Fleet submarines alone.

Under the INF Treaty the Soviet Union will stop testing and eliminate its as yet undeployed Ground Launched Cruise Missile (the SS-CX-4). For their part however, the Soviet Navy deployed the first of its equivalent nuclear land attack SLCMs (the SS-NX-21 'Sampson') around the time of the signing of the INF agreement in late 1987 [28].

Another irony concerning the INF is the fact that in March 1987 US Reagan Administration officials acknowledged that under the then prospective INF Treaty it had been agreed not to destroy the nuclear warheads [29]. At the same time it was reported that the US Navy had shown interest in GLCM parts in order to save money for its own SLCM programme [30]. Although the SLCM warhead is produced by a different contractor, many warhead components will be returned to the US stockpile (similar considerations may also apply to the Soviet side) [31]. There is therefore the disturbing possibility that some of these components will be used in the most logical candidates: the Tomahawk SLCM.

The SLCM - Delaying The Strategic Arms Reduction Talks

Since the INF negotiations were confined to land based weapons, the sea based SLCMs were not on the agenda even though they are virtually identical to the Ground Launched Cruise Missile (GLCM). Because of its long range, however, SLCMs have been classed as a strategic weapon and hence included in the START talks. As early as 1978 the US Governments Arms Control and Disarmament Agency conceded that 'verifying the number of [nuclear SLCMs] deployed [on ships and submarines] would be difficult' [36].

This difficulty is due to the fact that all SLCMs are not to be eliminated, which means there is the problem of distinguishing between nuclear and non-nuclear SLCMs, and because of the ease with which they can be concealed. This makes necessary a strict verification regime including 'on site inspection' on demand of submarines and ships, to confirm that START nuclear warhead limits for SLCMs are being adhered too.

The problem of agreement on how this is to be achieved has been a major cause of delaying for the entire START negotiations. On April 5th 1988, the chief Soviet START negotiator Victor Karpov stated that this is primary issue delaying the completion of the agreement [37]. US negotiators have confirmed it is one of three key problems delaying START (along with verifying mobile land based missiles, and the number of cruise missiles carried by air force bombers) [38]. If a START agreement were to be signed it appears that it could now allow as many as 400 nuclear SLCMs on each side[39].

The SLCM Threat - First Strike, Nuclear War Fighting And The Nuclear Weapon For After World War III.

The US and Soviet SLCMs have been described as the most versatile weapons in the nuclear arsenals. The US SLCM is known to have long range 'strategic' and more regional 'theatre' nuclear war fighting roles [40].

The Tomahawk SLCM is primarily a 'theatre strike' weapon to be used to fight a 'limited nuclear war' between NATO and the Warsaw Pact. In theory it would be used to fight and terminate a nuclear war, before it escalated to the point where long range strategic weapons were brought into use. SLCMs are thus seen as a new way of waging controlled and limited nuclear war on land from European waters, 'without resort to [US] central strategic [nuclear weapon] systems'. As such these new US and Soviet missiles are dangerously de-stabilizing, since they will encourage the dangerous notion, developed in Soviet and US nuclear war plans, that a 'limited nuclear war' could be fought and won [41].

The US Navy has described the military virtue of "covert, forward deployed submarines [armed with SLCMs]" as presenting to the Soviets "a formidable threat" and "conveying to the Soviet Union that its territory is not a sanctuary" [42]. Yet this threat could be very de-stabilizing in a superpower crisis and encourage one side to strike first with its nuclear weapons.

This is because although the SLCM flies at a lower speed than a ballistic missile, (such as a Poseidon) it is difficult to detect because of its low altitude and small radar cross section. SLCMs can also have short flight times and therefore would provide little warning of attack. A SLCM launched from a submerged submarine 140 miles away from the coast, could hit a coastal air or naval base in as little as 15 minutes: faster than a strategic missile. This threat is de-stabilizing, since the fear of a surprise 'first strike' which included SLCMs, in a crisis or during a an escalating conventional war, could force one side to pre-empt that danger by launching its nuclear weapons first [43].

The US Navy's SLCM also has a bizarre 'strategic' function. Some SLCMs are to form part of a reserve arsenal for after a global strategic nuclear war - a "strategic reserve force". Admiral Kelso, Director of the US Navy's Strategic Submarine Division, explained to Congress in 1981 that some SLCMs would be held back during a nuclear war. The purpose of this is so that "the United States would, in a post nuclear exchange environment [after a general nuclear war], retain a measure of coercive power." [44]

(Deputy Chief of Naval Operations For Submarine Warfare) in 1985; "The Maritime Strategy calls for the majority of our nuclear attack submarines, or SSNs, ..., to go forward immediately at the beginning of any hostilities with the Soviets to sink his fleet, bottle up his massive submarine force, and now with the advent of the Tomahawk cruise missile, to attack his land bases".

He told another Congressional Committee, "During the deterrence or transition to war phase [of the Maritime Strategy], we will see forward global movement of our Navy, and our SSN's role in that movement is to go deep into the sea control areas of the Soviet Union". This surge forward is likely to happen in the "pre-conflict period", that is in a crisis or during a time of tension [48].

At present, many submarines of the US Navy's Atlantic attack submarine fleet taking part in executing such a strategy during a crisis or war, would have to transit the Atlantic - taking several days. Such a 'surge' operation was practiced by the US Navy with 44 attack submarines with a 'full weapons load' from US Atlantic coast bases after only 24 hours notice in April 1985 [49].

However, having attack submarines being able to regularly call at Holy Loch for 32 day re-provisioning repair and crew rests, would allow the US Navy to have more submarines to spending more time on patrol in Northern Waters. This is because they would no longer have to return to the US for this purpose. The above, could be the kind of military justification advanced by the US Navy for the continued use of Holy Loch after Poseidon submarines are gradually decommissioned.

3. Sea Launched Cruise Missiles (SLCM) - Circumventing and Devaluing The INF Agreement

As has been stated, a decision could be expected concerning the future of Holy Loch from the mid 1990s, based on the lifespan of the Poseidon submarines. By chance however, this timetable coincides with the expected dates by which the US Navy plans to have deployed 758 nuclear land attack Sea Launched Cruise Missiles (SLCMs) among 60% of its attack submarines and one third of its ships. If Holy Loch becomes a base supporting attack submarines, then the majority will be carrying the Sea Launched Cruise Missiles by the mid to late 1990's, and eventually virtually all US Navy attack submarines are planned to carry nuclear and/or non nuclear SLCM's by the end of the century [50].

The SLCM is almost identical to the Ground Launched Cruise Missile (GLCM) now to be eliminated under the INF agreement. By early 1992 the INF Agreement will include the final worldwide elimination of the 256 US GLCMs currently deployed [51]. Therefore, just when GLCMs must be finally eliminated under the INF Treaty, the US Navy plans to be able to put around 25 attack submarines (each of which could carry 3 nuclear Tomahawk SLCM's) and 42 ships of the Atlantic Fleet armed with approximately 370 nuclear cruise missiles into the waters around Europe.

By 1994 the US Navy plans to have a total of 3994 nuclear and non nuclear Tomahawk missiles deployed on 140 ships and submarines in the Atlantic and Pacific Fleets. This will include 3401 for attacking land targets from the sea - 758 of which will be armed with a nuclear warhead, with roughly 360 in the Atlantic [52]. The SLCM will multiply the offensive, land attack capability of the US Navy from its present 15 aircraft carriers, to 195 different SLCM carrying ships and submarines [53].

The impetus for the use of Holy Loch by US attack submarines will be increased by the fact that NATO has responded to the INF Treaty by discussing 'compensatory adjustments' or 'modernization' of its remaining nuclear forces. This is because among the 'adjustments considered' is the placing of some US Navy cruise missiles - whose use in wartime would presently be a decision formally only made by the US - more directly under the command of NATO and its multilateral decision making for the use of nuclear weapons.

NATO's secret High Level Group met in New Mexico in April 1987 to consider such 'adjustments' to NATO's nuclear forces after the then prospective INF Treaty. It was reported that US proposals did not include making SLCMs available to NATO, but European representatives argued that this held back the most convincing substitute system for the GLCM and Pershing II missiles which were to be removed [54].

Yet the High Level Groups recommendations presented to the Nuclear Planning Group in May and November 1987, reportedly did call for the assignment of the some SLCMs to NATO command. At the May meeting UK Defence Minister George Younger publicly supported the assignment of the US Navy Sea Launched Cruise Missile to NATO control [55].

West Germans officials in July 1987, reflecting increased opposition to upgraded nuclear weaponry on German soil, have also said for 'modernization' after INF, their government favoured SLCMs instead of a politically difficult land based nuclear Lance missile replacement based in Germany [56]. On March 1st 1988, there was a further report of a proposal existing which would arrange for the command of SLCMs on US submarines and ships to be reassigned from the US to the NATO wide command structure when the vessels pass into and through certain waters adjacent to Europe [57].

Holy Loch would facilitate the US Navy taking on this extra naval mission, by allowing an increased intensity of attack submarines in the Eastern Atlantic and Northern Waters.

6. MODELS FOR THE FUTURE USE OF HOLY LOCH - THE US NAVY BASES AT LA MADDALENA, ITALY; GUAM IN THE PACIFIC AND ROTA, SPAIN.

There are precedents for such forward basing to support nuclear armed attack submarines. These are to be found at three overseas bases of the US Navy: Rota in Spain, La Maddalena in Italy and Guam in the Pacific.

The US Navy used to maintain a strategic missile submarine base similar to Holy Loch at the major civilian and military port of Rota in Spain. It withdrew its strategic submarines from this base in 1979. However, the US Navy still maintains support facilities for regular visits by attack submarines and ships of the US Navy's 6th Fleet operating in the Mediterranean. The US Navy also withdrew strategic submarines from its Pacific base in Guam in 1979. But here too it maintains a support base at Apra harbour for supporting attack submarines operating in the Pacific. At Apra harbour there is the submarine tender ship Proteus an ammunition ship and a ship repair facility [58].

At the US Navy base of La Maddalena on the Italian island of Sardinia, there is the major 6th Fleet submarine 'refit and training group'. This is the centre of support for attack submarines operating in the Mediterranean and is the site of the floating submarine tender ship, the USS Orion [59]. The Orion is permanently moored in the bay and provides services for different attack submarines which call in during long deployments in the Mediterranean. The Orion had 23 such attack submarine visits in 1987, (17 of which involved work carried out on their nuclear propulsion units) [60].

It has recently been confirmed that in March 1983 the Orion was modified and certified as a "Tomahawk [SLCM] stowage and maintenance transfer facility". Further modifications were made in May 1985 to complete its ability to handle, store and repair SLCMs [51]. In 1986, twenty Tomahawk missiles (probably nuclear and conventional) were transferred to attack submarines moored alongside the Orion, and in 1987 fourteen such missiles were transferred.

Between January and April 1985, the tender USS Fulton was overhauled in the US in readiness for "a complete transfer and retransfer of all Orions ordnance (both nuclear and conventional)" [61]. The impending arrival of the Fulton in Italy focused attention on La Maddalena as an SLCM base. On the 6th November 1985 the City Council of La Maddalena unanimously voted for the US Navy to vacate the base. The response of the US Embassy at the time, however, was to state in a letter to the local press that worries that cruise missiles would be deployed at La Maddalena "is a question of presumption absolutely devoid of foundation".

Thus the US Navy has maintained facilities for attack submarines at two former strategic submarine bases at Rota in the Mediterranean and Guam in the Pacific, and services and stores SLCMs at La Maddalena in Italy. The only key ocean area close to Soviet naval bases, which does not have a support base for attack submarines, is the Eastern Atlantic. Holy Loch in Scotland would be the obvious candidate for fulfilling this role.

7. THE RECENT AND FUTURE USE OF HOLY LOCH BY US NAVY ATTACK SUBMARINES

1. Recent Use Of Holy Loch By US Attack Submarines - New Information

US Navy (and Soviet) submarines do not carry numbers in order that they cannot be identified or named. However, UK Armed Forces Minister John Stanley confirmed in November 1986, that US Navy attack submarines have made some use of facilities at Holy Loch for several years. He later confirmed that these have included Los Angeles and Sturgeon class submarines [62]. These are the classes capable of carrying nuclear Tomahawk SLCMs. In October 1987 two SLCM capable submarines were identified and photographed while moored alongside the tender Simon Lake at Holy Loch [63].

The UK government is not normally so forthcoming and has stated that records of visits to Holy Loch by US vessels are not kept. In December 1987 the UK Minister of Defence was asked to list all visits on a temporary basis to Holy Loch during the last six months involving "US...personnel or equipment not normally based there..", (which would include attack submarines). The reply was that "The use of Holy Loch is covered by confidential agreements between the US and UK...within those agreements such visits are a matter for the US Government", and no figures were provided [64]. On the only occasion the UK government has provided a list of port visits by US Navy ships and submarines it included names of and dates of visits to five UK ports, but excluded Holy Loch [65].

New information has been acquired by the Institute of Policy Studies in Washington DC from the US Navy through the US Freedom of Information Act. For the first time they have been able to ascertain the names and dates of port visits by US Navy attack submarines to UK ports in 1984 and 1985 [66]. Since the first nuclear Tomahawk SLCM was not deployed until June 1984, the submarines mentioned are unlikely to have been equipped to carry SLCMs during this period. However, because attack submarines are increasingly armed with SLCMs, the US Navy is now contesting several requests for the further release of information showing US Navy port visits for 1986 and 1987 [67].

The figures so far provided show that in 1984 the Royal Navy Polaris Missile base at Faslane, close to Holy Loch, had visits from the attack submarines USS Skipjack (SSN 585) and USS Sturgeon (SSN 637) for a total of nine days. The USS Sturgeon is of the class capable of carrying Tomahawk SLCMs. Holy Loch had visits from the attack submarines

USS Sunfish (SSN 649) and Sand Lance (SSN 660) for a total of eight days (neither of which have or will carry SLCMs but carry the nuclear SUBROC anti-submarine missile).

In 1985 the USS Archerfish (SSN 678) and Groton (SSN 694) visited Faslane, the USS Groton is SLCM capable. The USS Whale (SSN 638), and Baltimore (SSN 704) visited Holy Loch and both these submarines are also Tomahawk SLCM capable. The Baltimore has been confirmed as definitely 'certified' to carry the Tomahawk SLCM and was present for 18 days. (The term 'Certified' denotes the holding of a US Navy 'Naval Technical Proficiency Inspection Certificate'. This is gained by inspection every 18 months and confirms that the naval unit is prepared to conduct its nuclear mission).

The work of installing systems for nuclear and conventional Tomahawk SLCMs on the Baltimore leading to its certification was completed in June 1986. This work would have started in late 1985, soon after the date it left Holy Loch [68]. Holy Loch was also visited by the SUBROC capable attack submarine USS Bluefish (SSN 675) for an unusually long period of a total of 54 days.

2. The Official Positions Of The UK And US Governments On The Future Of Holy Loch

Both the US and UK governments have avoided making any statements as to what future use the US Navy might make of Holy Loch after the current Poseidon force based there is decommissioned.

The use of Holy Loch is known to be covered by 'confidential agreements' between the US and UK and any discussions on the future of Holy Loch are secret. For example, when asked if the UK government had received any request or notification from the US relating to replenishment or servicing of Tomahawk cruise missiles at Holy Loch, the Ministry of Defence stated "Any discussions of this nature would be confidential between the two governments" [69]

On the 23rd October 1986 the Minister of State for Armed Forces John Stanley, stated that there was 'no truth whatsoever' in rumours that the US Navy intended to withdraw from Holy Loch [70]. This was confirmed by the minister of defence George Younger, soon after a meeting with US Secretary of Defence Casper Weinberger at Gleneagles in October 1986, when he stated in an interview "...as long as they (the US) need it they can have it". Mr Younger was then asked how long he would expect the base to continue. He replied, "...there's no limit on that. In fact Mr Weinberger,...made it clear to us that as far as the United States are concerned they'd like it to continue into the future".

Reminded that Poseidon would be retired by 1999 he responded, "it is the case that the particular submarine, the Poseidon submarine, will become obsolete some time in the next few years hence. But that does not mean, and Mr Weinberger made this clear, that the base goes. The base will be needed for whatever other purpose, and they will no doubt let us know in due course when they have decided what that will be' [71].

All this strongly suggests that the US had expressed interest in keeping the base beyond the end of the life of the Poseidon submarines and that the UK government was willing to sanction this 'for whatever other purpose'. Again, in November 1986 a parliamentary question received the reply that the "the US Defence Secretary has made it clear that the US Navy has no plans to withdraw from the Holy Loch" [72].

The US Navy too has not confirmed its intentions. In the only recent testimony by the US Navy to the US Congress concerning Holy Loch in early March 1986, the US Navy representative was asked whether a study was under way "to change that facility [Holy Loch] from a ballistic missile submarine facility to an attack submarine facility". The answer was that no firm decision had then been made "I am not personally aware of any study underway. I know there is no decision at the moment to do that [change the facility to attack submarines]" [73].

It is not known whether discussions between the UK and US governments concerning the future of Holy Loch have been underway since this time. On May 28th 1988 George Younger stated that there had been no change in the 'practice or status' of Holy Loch, but the UK government 'would expect to be consulted' by the US authorities if they proposed to base 'a new class of weapon' in Britain - this would include the basing of Tomahawk SLCMs. He apparently recognized this as involving a 'new principle' [74].

It seems therefore, that the government does not regard the continuing visits by different US Navy attack submarines in the Atlantic Fleet, (rather than the presence of the same eight Poseidon submarines as at present) as involving a 'new principle' at Holy Loch. There could be therefore be some confusion over whether this - or the presence in the future of some SLCM's on an attack submarine tender at Holy Loch similar to the situation at La Maddalena, Sardinia - would constitute the 'basing' of a new nuclear weapon at Holy Loch.

This kind of uncertainty should not be allowed to obfuscate the significance of a such of a change at Holy Loch, nor should it be allowed to deflect informed public and parliamentary debate about whether such a development is justified.

8. RECOMMENDATIONS

This report has argued that once the Poseidon missile submarines at the US Navy base at Holy Loch are decommissioned - which is expected to occur by 1999 at the latest - it is possible that the US Navy will want to maintain these facilities to support attack (hunter killer) submarines operating in northern waters. Many of these submarines will carry nuclear weapons, including the Tomahawk Sea Launched Cruise Missile (SLCM).

There are several military justifications which are likely to be advanced for the continued use of Holy Loch by the US Navy's attack submarine. However, these would no longer apply if certain measures were taken to reduce the mutual threats that exists between the superpowers at sea, and hence the danger of nuclear war. These initiatives should have the active support of the UK government, and the future of Holy Loch should be allowed to become the subject of informed public and parliamentary debate.

The US Navy should abandon its offensive 'maritime strategy' and the Soviet Navy should halt their more aggressive naval exercises designed to counter this strategy. If the US and Soviet Union instead adopted a defensive posture, confidence would be enhanced and then there would be no need for the US Navy to use Holy Loch for attack submarines. This should form part of a whole range of disarmament and confidence building measures at sea, designed to reduce the risk of war.

The Strategic Arms Reduction Talks (START) should eliminate all US and Soviet SLCMs, since these are very de - stabilizing weapons designed for waging war on land from the sea, which possess the potential for use as a 'first strike' weapon. Indeed, President Reagan's chief arms control negotiator Paul Nitze has proposed just this - along with the elimination of other 'tactical' naval nuclear weapons designed for war fighting at sea. He proposed this in order to remove the problem of having to distinguish between nuclear and non nuclear SLCMs [75]. This has been a key issue delaying the conclusion of a START agreement between the US and the Soviet Union.

Finally, a defensive naval strategy could be enhanced by addressing the fundamental threat presented by nuclear powered and nuclear armed submarines. These include the difficulty of detecting them, their ability to operate for very long periods without surfacing and hence their capacity to lurk unseen off their enemies coasts.

The security of both sides could be increased if the number of nuclear powered and armed submarines were reduced and eventually eliminated. This would leave the less potent diesel powered submarines armed with non-nuclear weapons. These are both more suitable for defense rather than attack and do not pose the serious environmental threats of their nuclear powered counterparts.

NOTES FOR PART I

1. The fleet of 'hunter killer' submarines is assumed to be under expansion from 12 in 1979 to 17 boats in the 1990's. 'The Way Forward', Cmnd 8288, HMSO 1982.
2. 'The Types of Reactor Accident and Their Possible Developments' in 'The Clyde Area Public Safety Scheme' (CLYDEPUBSAFE) (hence CLYDEPUBSAFE), Flag Officer Scotland and Northern Ireland, Maritime Headquarters, Pitreavie, Revised 1983, pg 1-3 paras 1.6 to 1.8.

   In the Clyde Public Safety Scheme a reactor accident is defined as 'an unexpected event involving a nuclear reactor plant which is likely to lead to or has resulted in radiological hazard external to the reactor plant".
3. CLYDEPUBSAFE, ibid, pg 1.3 para 1.8.
4. The Rosyth Public Safety Scheme, (hence ROSPUBSAFE) Flag Officer Scotland and Northern Ireland, Maritime Headquarters Pitreavie, February 1984, pg 1.1 - 1.3.
5. CLYDEPUBSAFE, ibid, pg 2-3 para 2.7
6. ROSPUBSAFE, ibid, pg 1.3 paras 1.5.2-1.5.4. A curie is the a unit which expresses a certain number (3.7 x 10^{10})
7. Richard Webb, 'The Accident Hazards of Nuclear Power Plants', Harper and Row, 1979, pg 20. These are Loss of Coolant Accident (LOCA) (which is similar to the Royal Navy's first scenario, the Maximum Design Accident); the spontaneous reactor vessel rupture accident, (which seems similar to the Navy's second scenario, the Primary Containment Failure Accident); third, the Power Cooling Mismatch Accident (PCMA) and fourth the Power Excursion Accident (PEA).
8. Richard E. Webb, ibid, pg 7.
9. 'Chernobyl - Level Nuclear Accident Could Happen Every 5 Years', The Guardian, September 22nd, 1986.
10. 'Reactor Safety Called Unacceptable', The Toronto Star, Wednesday June 17th 1987, citing statements made at a meeting of the Canadian Nuclear Association (CNA).
11. Professor J. Edwards and Commander K.F. Tucker, 'Royal Navy Requirements And Achievements In Nuclear Training', The Journal of Naval Science, Greenwich Naval College, London 1978, Vol 4 No 3, 1978 pg 163-4. 'Submarine propulsion systems, because of their size, mobility and the hostile environment in which they must operate, are exposed to substantially greater risks that land - based nuclear power stations; accident situations are appreciably more numerous because of the possibilities of collision, fire, sinking, grounding and stranding, sea effects and so on.."
12. Hansard Official Report, Answer given by Armed Forces Minister Ian Stewart to question by Mr Foulkes, Vol 127 No 97, pg 738, col 2.
13. 'N-sub minutes from disaster', The Observer, Sunday 14th February 1988, pg 1.
14. 'MP demands inquiry into submarine incident', The Irish Times, Monday February 15th, 1988.

15 CLYDEPUBSAFE, ibid, pg 2-3 para 2.7.

16. Captain J. Jacobsen, RN and Commander A. E. Palmer, 'The Safe Operation Of Nuclear Submarines', Journal of Naval Science, April 1979, Vol 5 No.2, Greenwich Naval College, pg 83.
17. Professor J. Edwards and Commander K.F. Tucker, 'Royal Navy Requirements and Achievements in Nuclear Training', Journal of Naval Science, ibid, Vol 4, No 4, 1979, pg 207.
18. Richard Webb, ibid, pg 18.
19. Captain J. Jacobsen, RN and Commander A. E. Palmer, 'The Safe Operation Of Nuclear Submarines', ibid, pg 84. The Royal Navy refers to 'spurious scrams' as a 'reactor shutdown which can only be attributed to an irresponsible malfunction of the Reactor Protection System", at this time this was occurring once every 3 and a half reactor years.
20. The Journal of Naval Science, Vol 5 No 2, ibid, pg 85.
21. Captain J. Jacobsen RN and Commander A. E. Palmer, ibid, pg 72.
22. The Guardian, 8th August, 1987.
23. Professor J. Edwards and Commander K.F. Tucker, The Journal of Naval Science ibid, pg 207.
24. Eric Groves, 'Vanguard to Trident:British Naval Policy since World War II', US Naval Institute Press, London 1987, pg 353.
25. 'Chronology of Events 1981', Naval Proceedings, May Review Issue, US Naval Institute, Annapolis, Maryland.
26. Jan S. Breemer, 'Soviet Submarines Accidents Background and Chronology', Navy International, May 1986, Vol 91 No 5, pg 312.
27. US House Armed Services Committee (HASC), FY 1986, Department of Defense, Part 2, pg 928.
28. Shaun Gregory and Alistair Edwards, 'A Handbook of Nuclear Weapons Accidents', Peace Research Report Number 20, School of Peace Studies, University of Bradford, January 1988. Most of the information on accidents and incidents is drawn from this report with due acknowledgment, using original sources for the purpose of illustration.

29. W. Jackson Davies, PhD, 'Meltdown of a Naval Propulsion Nuclear Reactor: A Site Specific Analysis for the San Francisco Bay Region', Commissioned by Greenpeace, October 1987. All following information is drawn from this report.

30. Journal of Naval Science, ibid. passim.

31. Jackson Davies Phd, ibid, pg 164-5.

32. Joshua Handler and William M. Arkin, ibid. pgs 146 and 7.

33. The US military recognizes and plans for such possibilities, and radioactive contamination has occurred in the past. The US Defense Nuclear Agency (DNA) has said: 'The United States has never had an accident with a nuclear weapon which resulted in a nuclear (explosive) yield. Accidents have occurred, however, which released radioactive contamination because of fire or high explosive detonations' ; Nuclear Weapons Accidents Response Procedures (NARP) Manual, Defense Nuclear Agency, No. 5100.1, July 1984, Washington DC.

34. 'Nuclear Weapons Surety', US Department of Defense/ Department of Energy, Joint Report by the US Department of Defense and US Department of Energy, Washington DC 1984.

'Nuclear Accident Contamination Control', US Army Field Manual FM3-15, 28th November 1975, pg 6, states: 'The high explosive contained in most nuclear weapons constitutes a major hazard in a nuclear weapons accident.' and 'Detonation of the high explosives component may pulverize plutonium into minute, invisible particles that are dispersed in smoke and dust which can cause contamination over a large area".

35. Jackson Davies, ibid, and US Army Field Manual, ibid, pg 6. According to the US Department of Defense, 'When associated with fire, plutonium may burn, producing radioactive plutonium oxide particles.'

36. Shaun Gregory and Alistair Edwards, ibid, pg 168.

37. 'Areas around Nuclear Facilities Should Be Better Prepared for Radiological Emergencies', GAO Report to US Congress, EMD-78-110 ,30th March 1979 pg 23, US General Accounting Office, Washington DC.

38. Shaun Gregory and Alistair Edwards, ibid, pg 127 and 130.

39. Norman Polmar, 'Death of a Yankee', US Naval Institute Proceedings, Annapolis, Maryland, December 1986, pg 88.

40. The US Navy complies with standard US Department of Defense terminology in its broad definitions of nuclear weapons accidents and incidents. Here an Accident (code name Broken Arrow) is 'An unexpected event involving nuclear weapons..that results in any of the following situations...nuclear detonation, non nuclear detonation or burning of a nuclear weapon or radiological nuclear weapon component, radioactive contamination...seizure, theft..public hazard actual or implied"

An Incident (code name Bent Spear) is '..results in evident damage to a nuclear weapon or radiological nuclear weapon component to the extent that major rework..replacement or examination..is required, requires immediate action in the interest of safety or nuclear weapon security..could lead to a nuclear accident and requires that high officials..be informed..or take action"

Source: '1987 Nuclear Accident Response Capability Listing', Joint Nuclear Accident Coordinating Center, Field Command, Defense Nuclear Agency, (DNA), No. 5100.52.IL. Obtained through Freedom of Information Act, Nuclear Weapons Databook Project, Natural Resources Defense Council, September 22 1987.

41. Shaun Gregory and Alistair Edwards, ibid, pg 106.

42. 'Observations on Navy Nuclear Weapons Safeguards and Nuclear Weapon Accident Emergency Planning', US General Accounting Office (GAO), Report to US House of Representatives, GAO Report, NSAID 123, 29th July 1985.

43. Patricia Axelrod and Dean Babst, 'Accidental Explosions and Nuclear Bombs', Technical report No. 5, Nuclear Age Peace Foundation, May 1987, pg 4. citing documents released to Mr I Lind in the case of Catholic Association versus C.Weinberger.

44. A Parliamentary question asked on 'how many incidents involving nuclear warheads, in which the accidental discharge of radioactive material was narrowly averted, have occurred in the last ten years", received the reply 'that no such incident had occurred in the UK in the last ten years'. Yet this is a narrow definition of an incident. in Official Report, Written Answers, Question by Mr Ashley, Vol 123 No 55, pg 439.

45. Shaun Gregory and Alistair Edwards, ibid, pg 168.

46. Joshua Handler and William M. Arkin, ibid, pg 2.

47. 'Royal Navy Fires', News in brief, Janes Defense Weekly, 17th October 1987, pg 861.

48. Shaun Gregory and Alistair Edwards, ibid pg 71.

49. Shaun Gregory and Alistair Edwards, ibid pg 166, citing Norman Solomon,'Pentagon denies LX09 Safety Hazard', Pacific News Service, San Francisco, 1981, pg 1.

50. Duncan Campbell, 'Accidents Will Happen', New Statesman, 27th November 1981, pg 11.

51. Malcolm Spave, ibid,

52. A recent study by the UK National Audit Office contradicts this position by stating 'Most of the expenditure on development and production (of the UK Trident warhead) is incurred in the US.' 'UK National Audit Office',

Ministry of Defence and Property Service Agency: Control and Management of the Trident Programme, HMSO, London, 14th July, p 18.

53. William M. Arkin, 'Nuclear Notebook', in Bulletin of the Atomic Scientists, May 1988, Vol 44 No 4, pg 55.
54. 'Replacing the Hidden Bomb', Panorama, BBC Television, 16th May 1988.
55. Shaun Gregory and Alistair Edwards, ibid, pg 160.
56. Shaun Gregory and Alistair Edwards, ibid, pg 160.
57. 'Nuclear Accident Aboard a Naval Vessel Berthed in Copenhagen, Denmark: Quantitative Analysis of a Hypothetical Accident Scenario', W. Jackson Davis, Ph.D, Commissioned by Greenpeace Denmark, Issued by the Environmental Studies Institute, May 1988, pgs 10-17.
58, CLYDEPUBSAFE, pg 2-3 paras 2.9 and 2.10.
59. ROSPUBSAFE, ibid, 1.7. para 1.10.2.
60. CLUDEPUBSAFE, ibid, pg 1-5. para 1.16.
61. ROSPUBSAFE, ibid, pg 1-4, paras 1.12 a,b,c.
62. CLYDEPUBSAFE, ibid, pg 1-6 para 1.18
63. ROSPUBSAFE, ibid, pg 1.4, para 1.7.2.
64. CLYDEPUBSAFE, ibid, pg 1-4, para 1.13.
65. ROSPUBSAFE, ibid, pg 1.5.
66. CLYDPUBSAFE, ibid, pg 1-4 para 1.10
67. CLYEPUBSAFE, ibid, pg 1-5 to 1-6, para 1.7
68. ROSPUBSAFE, ibid, pg 1.6.
69. CLYDEPUBSAF pg 4-4-4.
70. ROSPUBSAFE, ibid, pg 2.10, para 2.18.1.
71. Dr. Jackson Davies, 'Meltdown of a Naval Propulsion Nuclear Reactor: A Site Specific Analysis For The San Francisco Bay Region', ibid, pg 64.
72. ROSPUBSAFE, ibid, pg 2.2, para 2.2.2 no. c.
73. CLYDEPUBSAFE, pg VI, letter of promulagation.
74. Joshua Handler and William M. Arkin, ibid, pg 26.
75. ROSPUBSAFE, ibid, pg .3, para. 1.6.3.b.
76. CLYDEPUBSAFE ibid, pg 1-5 para 1.17 a. and pg 1-4, para. 1.10. In the Rosyth Safety Scheme it is explicit, 'for the purposes of emergency planning it is Ministry of Defence policy to assume that all accidents have consequences as severe as the Maximum Design Accident. This will almost always be pessimistic...' [source]
77. CLYDEPUBSAFE, ibid, pg 1-4 para 1.11
78. CLYDEPUBSAFE, ibid, pg 1-5 para1.16
79. CLYDEPUBSAFE, ibid, pg 1-6 para 5.

The Rosyth Safety Scheme states that 'Even in the worst possible case it is unlikely that these countermeasures will be required at distances greater than 2km for issue of stable iodine and 1km for evacuation' ROSPUBSAFE, pg 2.1, para 2.1.3 note 1.

80. CLYDEPUBSAFE pg 3-4 para3.4 c.
81. Letter from the Ministry of Defence to Greenpeace UK in response to questions concerning emergency plans, Ref, D/ACDS (Pol/Nuc)200/7/2, 8th June 1988, para a.
83. CLYDEPUBSAFE, ibid, pg 2-3, para 2.10
84. CLYDEPUBSAFE pg 3-3 para3.1 b.
85. CLYDEPUBSAFE pg 2-4 para 2.11.
86. ROSPUBSAFE, pg 2.5, para 2.11.2 part c.
87. CLYDEPUBSAFE, ibid, pg 2-4 para 2.13 and page 2-5 para 2.16 and 2.20.
88. ROSPUBSAFE, ibid, page 2. Under the Rosyth Public Safety Scheme no action is required until a category two is declared by the commanding officer, ie a 'radiological hazard external to the reactor plant' is detected.
89. CLYDEPUBSAFE, ibid, pg 3-7 para 3.13.
90. CLYDEPUBSAFE, pg 3A-1.
91. 'Combined Barry and Cardiff Special Safety Scheme for visits of nuclear powered warships', Chief Executive South Glamorgan County Council, Newport Rd, Cardiff, and Flag Officer Plymouth, June 1985 pg 2-9, para 27.
92. 'Areas Around Nuclear Facilities Should Be Better Prepared For Radiological Emergencies', US Government Accounting Office, ibid, pg 27.

93. 'Minutes of the Local Liaison Committee Meeting Held at Clyde Submarine Base on Wednesday 27th June 1984', Clyde Submarine Base, Faslane, Helensburgh, Dunbartonshire.
94. Parliamentary Question submitted by Mr Brian Wilson MP (Labour, Cunninghame North) answered by Mr Ian Stewart, Minister for Armed Forces, Wednesday, 20th January 1988.
95. CLYDEPUBAFE pg 3-6 para 3.7
96. Peter Taylor, 'A Critical Review of Emergency Planning for Reactor Accidents and Spent Fuel Transport in the United Kingdom', PERG Research Report RR-12, December 1984.
97. Peter Taylor, Emergency Planning For Major Nuclear Accidents, ibid, pg 35.
98. Letter from the Ministry of Defence to Greenpeace, ibid.
99. 'Too Hot To Handle: An Interim Report On The Under Insurance of British Nuclear Reactors', Greenpeace Report, 18th December 1986.
100. Official Report, Answer to a question from Harry Cohen by Armed Forces Minister Ian Stewart, 2nd November 1987, Col 607. and Col 539, 2nd December 1987.
101. 'Environmental Monitoring and Dispersal of Radioactive Wastes from US Naval Nuclear Powered Ships and Their Support Facilities, 1987' Report NT 88-1. Naval Nuclear Propulsion Programmed, Dept of the Navy, Washington DC, February 1988, pg 2.
102. G.J. Hunt, 'Radioactivity in surface and coastal waters of the British Isles 1986', Aquatic Environment Monitoring Report, No 18, Ministry of Agriculture, Fisheries and Food Directorate of Fisheries Research, Lowestoft, 1987, pg 45.
103. First Report of Environmental Radioactivity and Radiological Measurement from May 1987 to March 1988', presented to the Standing Conference of Local Authorities in the Forth Estuary, 9th May 1988.
104. Dr R. F. Wheaton, 'Report to Greenpeace UK of initial surveys for radioactivity around UK naval bases which accommodate nuclear submarines', Edinburgh Radiation Consultants, June 1988.
105. Dr R.F. Wheaton, ibid, p 13.
106. National Radiological Protection Bureau Report GS8, 1987.
107. 'Environmental Monitoring and Dispersal of Radioactive Wastes from US Naval Nuclear Powered Ships and Their Support Facilities, 1987', pg 2.
108. 'Environmental Monitoring and Dispersal of Radioactive Wastes.. ibid, pg 1.
109. Correspondence Between Ministry of Defence and Greenpeace, 8th June 1988, ibid.
110. 'Occupational Radiation Exposure From US Naval Nuclear Propulsion Plants And Their Support Facilities Naval Nuclear Propulsion Program', Report NT-88-2, Department of the Navy, February 1988, Washington DC, pg 33.
111. 'Occupational Radiation Exposure from US Navy Nuclear Propulsion Plants', ibid, p 43 and 44.
112. The Sunday Times, 12th June 1988.
113. 'Interim Guidance on the Implications of Recent Revisions of Risk Estimates and the ICRP 1987 Como Statement', National Radiological Protection Board (NRPB-GS9), November 1987.
114. 'Cancer Incidence and Mortality in the vicinity of Nuclear Installations in England and Wales 1959-80', Cook-Mozaffari et al, Studies on Medical and Population Studies, HMSO 1987.
115. The Guardian, 9th June 1988.
116. E. Roman et al, 'Childhood leukaemia in the West Berkshire and Basingstoke and North Hampshire District Health Authorities in Relation to Nuclear Establishments in the Vicinity', British Medical Journal, Vol (294) 7th March 1987.
117. Transcript, 'Inside Britain's Bomb', Yorkshire TV, October 1985.
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119. Leukeamia in Young Persons In Scotland, Scottish Health Service Evidence to the Dounreay Enquiry, in J. Urquhart, 'Leukeamia and Nuclear Power In Britain: the evidence so far', Friends of the Earth, London, 1987.
120. John Urquehart, 'Leukeamia rates around nuclear submarine facilities' - interim report, May 1988, unpublished, available from Greenpeace
121. James Cutler and Rob Edwards, Britains Nuclear Nightmare, Sphere books Ltd, 1988, pg 160.
122. Inside Britain's Bomb, Yorkshire TV, 1985, ibid.
123. 'Areas around Nuclear Facilities Should Be Better Prepared for Radiological Emergencies', GAO Report to US Congress, pg 46.
124. 'Environmental Monitoring and Dispersal of Radioactive Wastes from US Naval Nuclear Powered Ships and Their Support Facilities', 1987, ibid, passim.

NOTES FOR PART TWO

1. William M. Arkin and Richard W. Fieldhouse, 'Nuclear Battlefields: Global Links in the Arms Race', Institute for Policy Studies, Ballinger Publishing Company 1985, Appendix A.
   And Duncan Campbell, 'The Unsinkable Aircraft Carrier', Paladin Press, London 1986, pg 207-9.
2. The power of the Hiroshima bomb has been estimated between 12-15kt of TNT. Thomas B. Cochran, William M. W.M.Arkin and Milton M. Hoenig, 'US Nuclear Forces and Capabilities', Nuclear Weapons Databook, Volume 1, Natural Resources Defense Council, Ballinger Publishing Company, New York, 1983, pg 32.
3. 'Nuclear Battlefields', ibid, Using the figure of 12kt for Hiroshima.
4. Thomas B. Cochran, William M. W.M.Arkin and Milton M. Hoenig,'US Nuclear Forces and Capabilities', ibid.
5. Joshua J.Handler and William M. W.M.Arkin, 'Nuclear Warships an Naval Nuclear Weapons: A Complete Inventory', Neptune Papers No. 2, Institute for Policy Studies/ Greenpeace, Washington DC, May 1988. All figures and weapons data cited and subsequently cited is drawn is from this source unless otherwise stated.
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7. Malcolm Spaven, 'Fortress Scotland: A Guide To The Military Presence' ibid, pg 135.
8. Thomas B. Cochran, William M. W.M.Arkin and Milton M. Hoenig, 'US Nuclear Forces and Capabilities', ibid, pg 134-7.
9. Cochran, W.M.Arkin and Hoenig, ibid, pg 139.
10. House Armed Services Committee, (HASC) FY 1982 and EWDA part 7, p 312 in W. M. W.M.Arkin, R. Cochran and M.M. Hoenig, ibid, pg 141.
10. Duncan Campbell, 'The Unsinkeable Aircraft Carrier: American Military Power In Britain', Paladin, London, 1986 pg 230.
11. W.M.Arkin, Hoenig, Cochran, ibid, pg 145-6.
12. Ibid, pg 145-7
13. Personal Communication with William M.Arkin, Director National Security Program, Institute For Policy Studies, Washington DC, May 16th 1986.
14. Malcolm Spaven, Fortress Scotland, ibid, pg 138.
15. Senate Armed Services Committee (SASC), Strategic Force Modernization Programs Hearings, October and November 1981, pp 172 and 179-80, and House Armed Services Committee FY 1986 EWDA, Part 7, pg 414.
16. W.M.Arkin and J.Handler, ibid, pg 11-12.
17. Senate Armed Services Committee (SASC), Strategic Force Modernization Programmes Hearings, October and November 1981, PP.172 and 179-80; House Armed Services Committee, FY 1986 EWDA, Part 7, pg 414, in W.M. W.M.Arkin and J. J.Handler, ibid.
18. William M.Arkin, Robert S. Norris, Thomas B. Cochran, 'The Implications of the START Agreement', Natural Resources Defense Council, Washington DC, December 1987, pg 17.
19. W.M.Arkin and J.Handler, ibid, pg 40. These estimates are derived from simple calculations using data from this source and the one above.
20. The US Navy has six more Trident II submarine under construction. House Armed Services Committee FY 1988/1989 Department of Defense Seapower and Strategic and Critical Materials Subcommittee, pg 745. cited in W.M.Arkin and J.Handler, ibid, pg 40.
21. House Armed Services Committee (HASC) FY 1984, Department of Defense, Part 4, pg 208. in W.M.Arkin and J.Handler, ibid, pg 54.
22. W.M.Arkin and J.Handler, ibid, pg 11.
23. Personnel Communication from Mr Malcolm Spaven, Arms Control and Disarmament Infromation Unit, concerning the arrival of Simon Lake. The Simon Lake has been confirmed Trident I servicing capable, in W. M. Arkin and J. Handler, pg 54 citing House Armed Services Committee, FY 1984 Department of Defense, Part 4, pg 208.
24. Written Answer, Official Report, House of Commons, 19th November 1986 (225), 'In Parliament', ADIU Report, Vol 9 No 1 pg 10.
25. W. M. Arkin and R. W. Fieldhouse, 'Nuclear Battlefields', ibid, pg 125.
26. Testimony of Admiral William Studeman, Director of Naval Intelligence, to Seapower and Strategic and Critical Materials Sub-committee of the US House Armed Services Committees (HASC), cited in 'Economics force cut back in naval power', Janes Defence Weekly, 26 March 1988, pg 600.
27. William M.Arkin, Thomas B. Cochran and Richard R. Fieldhouse, 'The Implications of the INF Treaty', Natural Resources Defense Council, December 1987. Up to 100 other US GLCM;s as yet undeployed may be destroyed. W. M. Arkin and R. W. Fieldhouse, ibid, cites 758 nuclear variants for the early 1990's.

Also Arkin and Handler, ibid, pg 12. As of December 1987 31 attack submarines in the Atlantic and Pacific were 'certified"(see not 68 below) to carry Tomahawk, although not necesarily all conventional and nuclear variants. This number will rapidly increase to 51 in the mid 1990s as furhter submarines with the appropriate control system achieve certification.

28. Testimony of Admiral William Studeman, Director of Naval Intelligence, to Seapower and Strategic and Critical Materials Sub-committee of the US House Armed Services Committees (HASC), ibid.

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36. 'First Strike Weapons At Sea: The Trident II and Sea Launched Cruise Missile' The Defense Monitor, Vol XVI No 6, 1987, Center for Defense Information, Washington DC, pg 5.

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38. The Arms Control Reporter, Section 611 1987-8, passim.

39. New York Times 14th February 1988, cited in The Arms Control Reporter, ibid, Section 611.B.442.

40. 'Strategic weapons' are those generally allocated for attacking the homeland of the enemy, such as Poseidon or Trident Submarine Launched Ballistic Missiles (SLBM's). 'Theatre' nuclear weapons are those for use in regional plans and confrontations, such as cruise missiles, where the intent is tactical surprise and the destruction of targets such as bases and support facilities that provide reinforcement for the battle. W.M.Arkin R. Cochran and M.M. Hoenig, ibid, pg 2.

41. William M.Arkin, 'The Tomahawk Sea Launched Cruise Missile', IPS/Greenpeace, Fact Sheet, July 1987, Washington DC.

42. Statement of Commodore Roger F. Bacon, Director, Strategic and Theatre Nuclear Warfare, Division in the Office of Chief of Naval Operations before the Strategic and Theatre Nuclear Forces Subcommittee of SASC on Sea Based Deterrent, 13th March 1984. in W.M.Arkin Fieldouse, ibid, pg 126.

43. 'First Strike Weapons At Sea: The Trident II and Sea Launched Cruise Missile', The Defense Monitor, ibid, pg 5-6.

44. Senate Armed Services Committee (SASC), FY 1983 Department of Defense, pt 5, p 3083, in William M.Arkin and Richard W. Fieldhouse, Nuclear Battlefields, pg 126-7.

45. For the seminal statement of the Maritime Strategy see: Admiral J.D. Watkins, 'The Maritime Strategy', US Naval Institute Proceedings, Annapolis Maryland, January 1986 (Special Supplement) pg 6.

46. See for example William M.Arkin, 'The Nuclear Arms Race At Sea', Neptune Papers No 1, Jul 1987, Institute for Policy Studies/Greenpeace, Washington DC. or Barry R. Posen, 'Escalation of NATO's Northern Flank',International Security, Fall, 1985. Former US Navy Admirals who are critical of the Maritime Strategy include Admirals Jean La Rocque (Ret), Eugene Carroll (Ret) and Stansfield Turner (Ret).

47. Admiral J.D. Watkins, 'The Maritime Strategy', ibid.

48. Testimony of Admiral Nils Thunman, Deputy Chief of Naval Operations for Submarine Warfare before the House Armed Services Committee of the US Congress 1985 and Testimony before Senate Armed Services Committee, FY 1986 Department of Defense, part 6 p 4493, in William M.Arkin, 'The Nuclear Arms Race At Sea'. ibid pg 44.

49. 'Naval Operations in 1984' The Naval Institute Proceedings', May 1985 Review Issue, Annapolis Marylandl

50. J. Handler and W. M. Arkin, ibid, Tomahawk SLCM's will eventually arm 107 US Navy attack submarines by the end of the cerntury. Citing House Armed Services Committee (HASC), FY 1987 Department of Defense, Procurement of Aircraft Missiles, pg 979.

51. William M.Arkin, Thomas B. Cochran and Richard R. Fieldhouse, 'The Implications of the INF Treaty', Natural Resources Defense Council, December 1987. Up to 100 other US GLCM;s as yet undeployed may be destroyed.

52. W. M. Arkin and R. W. Fieldhouse, ibid, cites 758 nuclear variants for the early 1990's. Arkin and Handler, ibid, pg 12. As of December 1987 31 attack submarines in the Atlantic and Pacific were 'certified"(see not 68 below) to carry Tomahawk, although not necesarily all conventional and nuclear variants. This number will rapidly increase to 51 in the mid 1990s as furhter submarines with the appropriate control system achieve certification.

53. 'First Strike Weapons At Sea: The Trident II and Sea Launched Cruise Missile', The Defense Monitor, Vol XVI No 6, Center For Defense Information, Washington DC, 1987 pg 5.

54. The New York Times, 23st April 1987, in the Arms Control Reporter, Institute for Defense and Disarmament Studies, Section 403.B.469 1987.

55. 'Chronology of NATO Nuclear Modernization', Arms Control Reporter, Institute For Defence and Disarmament Studies, ibid, Section 403.E.2, 1988.
56. 'West Germany May Renege On Battlefield Missile Plan', The Washington Post, 12 July 1987 pg 1.
57. The Washington Post, 6th March 1988, cited in Arms Control Reporter, IDDS, ibid, Section, 403.B.658.
58. William M.Arkin and Richard W. Fieldhouse, 'Nuclear Battlefields: Global Links in the Arms Race', ibid, pg 221.
59. William M. W.M.Arkin and Richard W. Fieldhouse, 'Nuclear Battlefields: Global Links in the Arms Race' ibid, pg 223.
60. This account is drawn from William M. W.M.Arkin and Joshua J.Handler, 'Briefing paper on La Maddalena: Key Site For Sixth Fleet Tomahawk Cruise Missiles', Prepared for the Greenpeace Nuclear Free Seas Campaign, 22 June 1988.

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61. Chief of Naval Operations, 'Fiscal year (FY 1985) Fleet Modernization Program (FMP)' for Execution, OPNAV Instruction 4720.94, 17th August 1984, p 65, and 'Fiscal Year (FY 1983) Fleet Modernization Program (FMP) for Execution', OPNAV Instruction 4720.91, 16th June 1982, pg 40, and House Armed Services Committee FY 1987, DoD, Part 4. pg 156. in W.M.Arkin and J.Handler, Nuclear Warships.ibid. pg 53. Released through Freedom of Information Act.
62. Written Answer, John Stanley 7th November 1986 (641-2) and 19th November (225), in ADIU Report, In Parliament, 9:1, pg 10.
63. This picture was taken by Mr Harry Bickerstaff, is available from Greenpeace UK.
64. Official Report, Written Answers, Mr Ian Stewart, 14th December 1987, House of Commons, Vol (124), No 64, Col 2.
65. Official Report, House of Commons, Written Answer, Mr I Stewart, Vol (120), No 25, 23rd July 1987 pg 226.
66. Port visit date for 1984 and 1985 from Institute for Policy Studies, Washington DC. This also confirms for the first time names and dates for US Navy ships to US port in this period.
67. Personal Communication with Mr Joshua J.Handler, Naval FOIA researcher for the National Security Program, at the Institute For Policy Studies, Washington DC, USA, June 24th 1988.
68. Confirmed by Mr Joshua Handler, Institute For Policy Studies, May 25th 1988. The term 'Certified' denotes the holding of a US Navy 'Naval Technical Proficiency Inspection Certificate'. This confirms that a naval unit is prepared to conduct its nuclear mission. The Navy requires that such an inspection occurs every 12 months for each unit. NTPIs are a 'Technical inspection of a nuclear capable unit conducted by Navy and/or Marine Corps inspectors to determine their ability to accomplish their technical mission. The scope...include examination of technical assembly, maintenance, logistic movement, storage functions, handling and safety..,drills will be conducted to determine the units ability to respond to a nuclear weapons accident or incident,..." in Chief of Naval Operations, 'Nuclear Weapons Technical Inspections', (OPNAVINST 5040.6E) 17th June 1975 (FOUQ), pg.1
69. Written Answers, Official Report, Question from Mr Cohen asnwered by Mr Sainsbury, Col 225 10th December 1987.
70. Arms Control and Disarmament Information Unit Report (ADIU), 'In Parliament', Vol 9, No 1, January-February 1987, University of Sussex.
71. Transcript of an interview with UK Secretary for Defense, George Younger on 'Left Right and Center', BBC-1 Scotland, 2225, 24th October 1986.
72. Written Answers, Official Report, House of Commons Vol. (103) No. 169, from Armed Forces Minister J.Stanley to question from Mr Boyes MP.
73. Answer to a question by Congressman Lowery to Rear Admiral John P. Jones, Jr, CEC, USN, Commander, Naval Facilities Engineering Command, Department of the Navy, before House Subcommittee on Military Construction Appropriations FY 1987, House of Representatives, March 11th 1986, Part 5, pg 202.
74. Written Answer, Official Report Stanley, 19th November (224) and 9th December (147) 1987.
74. Official Report, George Younger, Oral Answer, Col 178, May 24th 1988.
75. Michael Gordon in, 'US Aide Offers Plan To Cut Arms At Sea', The Washington Post, April 5th 1988.