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OCCASIONAL PAPER NO.1

The Safety of Nuclear Powered Ships

Critiques and Analyses

of the 1992 Report

Proceedings of the CPS Seminar held

at the University of Auckland

3 July 1993

July 1993

Centre for Peace Studies
University of Auckland
Private Bag 92019
Auckland
New Zealand

Tel. +64-9-3737599
ext. 8808/8889/8805
Fax. +64-9-3737445

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Centre for Peace Studies
University of Auckland
Private Bag 92019
Auckland
New Zealand

INTRODUCTION

On 3 July 1993 the Centre for Peace Studies held a public seminar at which a number of speakers presented comments, analyses and critiques relating to the report entitled *The Safety of Nuclear Powered Ships* released in December 1992 by the Government.

This report presented the work of The Special Committee on Nuclear Propulsion which was established early in 1992 and was comprised of three senior scientists, Professors P Berquist, D Elms and A R Poletti, and the Chairperson the Right Honourable Sir Edward Somers. At about the same time The Alternative Comrnittee on Nuclear Ship Visits involving scientists and other qualified people was set up at the instigation of Peace Movement Aotearoa , with Dr Robert Leonard serving as Convener. One purpose of the Alternative Committee was to see that all aspects of this issue were examined as fully as possible, since the Terms of Reference established by the Government for the Special Committee did not appear to guarantee this. These Terms of Reference, given in the official report, concentrated on technical aspects of nuclear powered ship visits.

A number of other people in the scientific community and outside it became concerned by aspects of the Special Committee's report as they examined it during the early part of 1993. The Centre for Peace Studies decided that a public seminar should be held at which these concerns and the views of the Alternative Committee and others could be aired and responded to by the Special Committee to achieve a balanced discussion of the report. The Centre invited all members of the Special Committee to attend and participate, and offered to meet major expenses involved. The Public Advisory Committee on Disarmament and Arms Control (PACDAC) had very kindly given the Centre a grant to cover these and other costs of the seminar, an expression of support greatly appreciated by the Centre. Unfortunately only Professor Poletti agreed to take part. Professor' Berquist and the Sir Edward Somers were unable to attend, and Professor Elms declined our invitation. The seminar was held on 3 July in the University of Auckland Conference Centre.

The names of the speakers who contributed, and an indication of their areas of comment or concern, are given in the seminar programme that follows. Not all the papers presented here are exactly as given on 3 July, some speakers preferring to include an edited manuscript. Some material is also included that was not given at the seminar, but relates very closely to topics covered during the seminar. A complete tape recording of the proceedings is held by the Centre, and is available for loan.

The seminar was attended by about forty people, and was opened by Professor Poletti who presented some personal thoughts on the question of the safety of nuclear powered ships and the problem of misinformation and disinformation in the public domain concerning this and related issues. Concerns of the Alternative Committee were then presented, followed by six other speakers. Professor Poletti was provided with the opportunity to respond to some of these presentations during the afternoon session.

The papers are presented as supplied. No attempt has been made to standardise the formats.

CENTRE FOR PEACE STUDIES

UNIVERSITY OF AUCKLAND

THE SAFETY OF NUCLEAR POWERED SHIPS

CONFERENCE CENTRE, 22 SYMONDS STREET, 3 JULY 1993

Programme

9.00 - 9.30	Registration, $5.00
9.30 - 9.40	Welcome and Introduction, Dr Robert White
Morning session	Chairperson: Professor Jack Woodward
9.40 - 10.40	Professor Alan Poletti, 'The Special Committee's Work, Misconceptions and Disinformation Encountered.' Professor Poletti will consider the need to discard nuclear phobia and adapt to the new world situation.
10.40 - 11.00	Morning tea
11.00 - 12.00	The Alternative Coirllnittee's comments on the Report, presented by Drs Peter Wills and Bill Wilson
12.00 - 12.30	Professor Peter L.orimer, 'The Eirst Finding', the concept of risk, accident probability estimation, and other comments
12.30 – 1.00	Ms Stephanie Mills, Greenpeace, risk assessment and safety, accident records, and other aspects of the report
1.00 – 1.45	Lunch - can be bought at the Wynyard Cafe, 29 Symonds Street, across the road. Tea and coffee also available at the Conference Centre.
Afternoon session	Chairperson: The Right Honourable David Lange
1.45 - 2.15	Dr Robert White, comments on the Report's 'model' reactor, and radioactive release estimates.
2.15 - 2.45	Dr Robert Mann, 'A New Zealand Historical Perspective on Nuclear Powered Shipping.'
2.45 - 3.10	Responses from Professor Alan Poletti
3.10 - 3.30	Afternoon tea
3.30 - 4.00	Dr Charles Crothers, social aspects of the nuclear powered ship visit question
4.00 - 4.30	Mr Owen Wilkes, 'Who Won? The Special Cominittee or the Anti-Nuclear Movement?'
4.30 - 5.00	General discussion and concluding remarks

There will be time to question speakers after their individual presentations. Most speakers will also be available in the concluding half hour. Copies of some presentations are available for purchase at cost price. Copies of the full proceedings will be available at cost from the Centre for Peace Studies during July.

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THE CONTRIBUTORS

Prof. Alan Poletti, Physics Department, University of Auckland
Dr. Peter Wills, Physics Department, University of Auckland Dr. Bill Wilson, Medical School, University of Auckland
Prof. Peter Lorimer, Mathematics and Statistics Department, University of Auckland Ms. Stephanie Mills, Greenpeace
Dr. Bob White, Physics Department, University of Auckland, (retired)
Dr. Bob Mann, University of Auckland (retired), writer and inventor
Dr. Charles Crothers, Sociology Department, University of Auckland
Mr. Owen Wilkes, independent Peace Researcher, Wellington/Hamilton
Dr. Simon Hales, Physician, Christchurch
Mr.John Gardenier, Engineer, risk analysis consultant

The Safety of Nuclear Powered Ships

- some personal thoughts

A R Poletti, Department of Physics, University of Auckland

1 Introduction

The following talk and the views which I will express have resulted from my involvement with the question of the safety of nuclear propelled ships. This came about when I agreed to serve on the **Special Committee on Nuclear Propulsion** which was asked to report to the Prime Minister of New Zealand on this matter. Our report took the form of a 269 page book which was published in December 1992 (SCN92). Following that date, the committee ceased to exist. Any views which I now express are therefore mine alone and can in no sense be construed to represent the views of the corrunittee.

I think that the other Committee members would agree with me that we saw our job as one in which we tried to establish the facts concerning the safety of nuclear propelled vessels as accurately as we could. Without this, an important element in the political discussion concerning the visits of these vessels was lacking. It was in the course of this work that we were confronted with the wide and diverse literature on the subject. As a result of this, I had to reluctantly conclude that a great deal of this material contained many statements by well intentioned people which, when checked, turned out to be incorrect or misleading. I began to reflect on the motives of the people who made these statements and to realise that in many cases desired ends were allowed to distort the presentation of facts or influence inferences in an unfortunate manner. I am taking part in this seminar because I think that the perspective which I have obtained as a result of my involvement should be of value to all who are interested in fostering peace and because I feel strongly that, in a democracy, sound policy can only be based on a full understanding of the facts which are involved. To set the scene, I will first discuss the Terms of Reference given to the committee, briefly summarise **The New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987** and also refer to the **South Pacific Nuclear Free Zone Treaty.**

2 Terms of Reference for the Special Committee on Nuclear Propulsion

These are given fully in the report. To summarise briefly, the committee was asked to consider:

a the safety & environmental record of nuclear powered vessels.
b the regulations, codes and liability regimes adopted by New Zealand and other countries.

c the contingency plans and emergency procedures which have been adopted.
d any other technical, safety and environmental considerations.

The committee were given the power to conduct public hearings and were asked to report to the Prime Minister within four months. Our work took rather longer than anticipated snd we were finally able to report in early December 1992. There would be widespread agreement that the request for a report was driven by the desire of the National Party to find a way to resume a less strained relationship with the United States of America, following the rift occassioned by the passage of the **The New Zealand Nuclear Free Zone, Disarmament and Arms Control Act 1987.** It is therefore useful to look at this Act, though not in detail. Its passage into law, by the previous Labour Government under Mr David Lange, was fiercely contested by the National Party who were then in opposition.

3 The Act and the South Pacific Nuclear Free Zone Treaty

I give the headings of the sections of the Act of most relevance to our present discussion:

4 New Zealand Nuclear Free Zone
-defines NZ as the region covered by the Act
5 Prohibition on acquisition of nuclear explosive devices
6 Prohibition on stationing of nuclear explosive devices
7 Prohibition on testing of nuclear explosive devices
8 Prohibition of biological weapons
9 Entry into internal waters of New Zealand
-defines the conditions under which the Prime Minister will permit visits by foreign warships
10 Landing in New Zealand
-defines the conditions under which the Pi-ime Minister will permit landings by foreign military aircraft
11 Visits by nuclear powered ships - Entry into the international waters of New Zealand by any ship whose propulsion is wholly or partly dependent on nuclear power is prohibited. [I give this section in its entirety. Internal waters are defined elsewhere. For our purposes, they can be considered to be harbours or anchorages.]

The Act is generally and incorrectly assumed to forbid nuclear reactors in New Zealand. In terms of the Act, "Nuclear Free" means a prohibition on nuclear explosives in New Zealand and the entry of nuclear powered ships. The Act does not cover any other use of nuclear technology. All of the discussion and the work of the Committee has thus been occassioned by the one sentence in section 11. We note too that the **South Pacific Nuclear Free Zone Treaty** which came into force in New Zealand on 11 December 1986, apart from a prohibition on radioactive waste dumping at sea, in a similar manner, does not prohibit any peaceful use of nuclear technology in the region. Signatories to the Treaty in August 1985 were Australia, Cook Islands, Fiji, Kiribati, New Zealand, Niue, Tuvalu and Western Samoa. Since then Nauru, Papua New Guinea and the Solomon Islands have also joined. Again, the focus was on keeping nuclear weapons out of the region but care was taken not to infringe on the sovereign rights of the signatories concerning visits by foreign ships and aircraft. It is to be noted that Australia as a signatory, has a research reactor which is also used for radio-isotope production and also allows visits by nuclear propelled vessels.

4 What the committee did

We began by reading the Australian Senate Report (COA89 - for me it was holiday reading over the Xmas 1991 period). But this was only a minor foray compared to the cascade of written material which began descending upon us as the work began in earnest. I personally felt that it was important to read as widely and as deeply in the subject as I could. This I did to the best of my ability. Material to read came in a great many ways. The secretariat obtained most of the references in the Australian Report. As a result of our own reading and of personal contacts we obtained a great deal more. Interloans were sought. I found the library of the Research School of Physical Sciences at ANU contained much useful information on nuclear engeneering matters. Again, in many cases, the secretariat found material for us which we requested. A great amount of material was collected on our visit to the UK, Austria, Canada and USA. (The technical data on the Sevmorput's reactor came to us in this way from Greenpeace in London.) We received material from those making submissions, all of which I read. These often contained references to further works which we also followed up. We did receive a small amount of classified information. Interestingly, it served only to confirm conclusions we reached on the basis of material in the open literature. None of our conclusions depend on this classified material.

As we digested this material we quite soon concluded that we needed to check up on all statements, no matter who made them. We did this by asking the following questions.

- Were they self consistent?
- Did they agree with the known physics?
- Were they based on sound engineering, especially in the areas of risk analysis and safety assurance?
- Were they consistent with other statements? If not, who was more likely to be correct? How could we cross-check them?

This process gives the report its underlying strength. It is not like an anchor chain - break one link and you are at the mercy of wind and tide - rather it is like a rope - every strand must fail before you are adrift.

Furthermore in the area of risk assessment and safety analysis, there are many possible techniques which can be used to assess the risks posed by complex systems. We explored essentially all of them, and were able to use several approaches. By doing this we further enhanced the resilience and strength of the report. One of these well established approaches to questions concerning safety is the technique of Quantitative Risk Analysis. We did not pursue this path in any detail because we did not have the resources and certainly would not have had access to the detailed quantitative engineering data which would be required to carry out the programme. Nevertheless we were able to find answers to many of the questions which are posed in the course of the overall safety analysis of any system. I stress that these questions cover much more than just an assessment of the design of the reactor. Among the important elements which must be considered are certainly the design. But this is the design of the whole ship and its propulsion system and the ways in which all components interact. In addition the construction process must be carried out in a way which ensures that the design specifications are faithfully and correctly produced. Furthermore the way in which the entire system is operated is crucial to its safety. This, of course, depends on the training of the naval personnel involved in its operation. If safety was to be assured, all parts of this prograrnme must be in place. But of more importance is the fact that this overall quality assurance process must give rise to a well defined safety audit system. The approach can be expected to vary from navy to navy, but it must be there, it must be obvious and the auditing methods must conform to those which all reliable Quality Assurance Programmes display. An important part of our analysis was therefore a process of auditing the auditors.

In this enterprise, David Elms, an engineer with a special interest in safety assessment and risk analysis, played a vital role. With this background, he introduced us to that field and the area of quality assurance and quality management, and of the methods and literature of that discipline. It is no secret that David had prime responsibility for chapters 2 (Risk and Safety), 6 (Safety Recards) and 7 (Quality Assurance and Safety Management). Anyone who wishes to understand why the committee reached the conclusions it did, must not only read those chapters with great care, they must be prepared to put in the mental effort needed to understand them. Anyone who does this must recognise their importance. What is more, their significance far transcends the immediate subject of the report. The lessons to be learned from those chapters have a very wide applicability indeed.

In parallel with this analysis of the quality assurance and total quality management programmes of the US and Royal Navies, we also looked at the physics and materials engineering aspects of the problem. We established bounds and limits and investigated the practical consequences for propulsion reactors and their safety of the statements we encountered. It was as a result of this cross checking procedure that we came across much of the material in chapter 13 of the report ("Myths and Catch-cries") and became disquieted by the way in which that material appeared to be propagated.

5 Why we considered many statements to be untrustworthy

As we worked through the material which was before us we encountered many statements which just did not accord with physical laws, sound engineering practice, established experimental facts, or the documented approach to Quality Management in the US or Royal Navies. In trying to understand this feature which was revealed to us from our reading of the submissions and meeting and talking with people both in New Zealand and overseas, I saw that there were several characteristics which could be teased out of the evidence which we encountered. I will describe some of these in this section. I do so in some detail. This is not because I feel a need to justify the report, but in order to demonstrate to anyone interested in world peace, the disservice they do to their cause through the use of specious arguments or attempts to propagate statements which are not true.

5.1 The Fringe Scientists

A feature of discussions of all aspects of nuelear technology for many years has been the existence of a fringe group, whose views often find their way into the popular media. At the edges of every scientific discipline there are always a few people who do not agree with the consensus of the majority. There is nothing wrong with that. Questioning of aceepted dogma should be a continuing feature of all scientific pursuits. Important advances in our understanding of the world have, in the past, occurred because someone did not acceptthe consensus view. An experiment conducted to test new theories sometimes vindicates them and scientific understanding is advanced. Most theories proposed by those on the fringe of a discipline do not share this happy fate. They either contradict experimental facts which are already known or are, within a short time, shown to be in contradiction to newly established experimental findings. This is the case for the work of people like Bertell, Goffman, Tamplin, Jay Gould (not the famous palaeontologist), Goldman and Stemglass. In the 1970s Ralph Nader unashamedly used their writings in his attack on the nuclear energy industry. After reading much material, we considered the writings of this fringe group to be unreliable, either because their theories have been shown to contradict established facts or because some of their work has demonstrated the selective use of data.

S.2 Continuing propagation of material which is just wrong.

My second point concerns the way in which material which was factually incorrect was presented to us by many well intentioned people who made submissions and who obviously accepted it. It surprised us to find that many of the submissions referred to material which had originated from this fringe group. Obviously, these views were being very efficiently propagated. I must be quite blunt here. The evidence is that Greenpeace is a prime culprit. I was greatly saddened when I was forced to this conclusion.

In their submission, Greenpeace:

- Referred to the "dangers of low level ionising radiation" (myth 14 of the report).
- Continue to maintain that the several propulsion reactors on the sea floor pose a severe environmental threat. It is known that they are not.
- Stated that between 1945 and 1988 the world's navies suffered 1,276 documented major accidents, ...' (I have added the tunderlining.) The figure comes from a Greenpeace publication, (Ark89) which will be referred to later. It is actually a catalogue of 1,276 accidents involving many types of ships from many navies. Many of the accidents were quite trivial.
- Sought to exaggerate by thousands of times the radiation doses to the general public from the Shippingport reactor and use the questionable data of Sternglass to support this untrue claim. (Commissioned in 1957, this power reactor, the first to be operated commercially in USA, was designed by the US Naval Reactors Branch.)
- Showed that they confuse long lived isotopes with those which have a high level of radioactivity because they are short lived.
- Attempt to use a Soviet civil defence document to imply that there is a very high likelihood of a reactor accident in which nearly 8000 people would die in the short to medium term.
- Bring up the speculation of Jay Gould that releases of radioactivity from nuclear facilities may be "100 - 1000 times too high", when already, allowable dose to a member of the public who insisted on sitting on the perimeter fence of a nuclear facility all the time is not allowed to exceed about one half of the dose we all receive from the natural activity of the environment .
- By using the phrase,"The BEIR V Report cites ... the study of Stewart and her associates demonstrating that extremely srnall radiation doses in the environment are capable of affecting the future health of individuals exposed as fetuses", attempts to imply that this highly respected BEIR report supports Stewart's conclusions: It does not.
- Maintain that there were 40,000 excess deaths in the United States in the months immediately succeeding the Chenobyl accident . This is incorrect. It is a figure produced by Sternglass.

I was further saddened when the co-ordinator of the Nuclear Free Seas Campaign, who appeared before us to elucidate the case made by Greenpeace was incensed that we should dare to ask her to explain and support these many statements. I think she felt that we should suspend our scepticism and our scientific and engineering understanding and judgement and accept her statements although they just do not agree with the known facts or the best judgement of those in the world who, after assessing all the evidence, have the responsibility to make recommendations concerning radiation safety at the national and international level.

Further propagation of this material occurs when it is taken up and uncritically accepted by members of the general public through their reading of such publications as 'Peacelink', 'NZ Environment', 'Greenpeace Magazine', 'Greenpeace Campaign News', 'Nuclear-Free', 'Nuclear Issues Fact Sheet', 'Newsletter of International Physicians for the Prevention of Nuclear War' and 'Boom Times'. Now I am not saying that everything in these publications is rubbish - far from it. Unfortunately, the good is mixed in with the bad and the reliable with the tendentious. It was clear from submissions received that many readers of the above publications accepted the veracity of this material. It is little wonder that there is such widespread misunderstanding of nuclear matters in the minds of the general public.

A distressing feature of submissions from several organisations that drew their members from various professions was the way in which they often uncritically repeated untrue or ill founded statements - similar to those listed above. I had looked for more thoughtful submissions from:

- International Physicians for the Prevention of Nuclear War
- Engineers for Social Responsibility
- Architects Against Nuclear Anns

I was to be disappointed, the Engineers, for instance, unthinkingly accepted the exaggerated claims concerning the alleged problems concerning the transportation and disposal of nuclear waste, embraced conspiracy theories, accepted the figures given by Kaplan when even The Neptune Papers expressed reservations about some of them (See ARK89, KAP83a, KAP83b and KAP87), displayed a regrettable lack of understanding of some simple engineering matters and repeated groundless alaims of physical health effects following the Three Mile Island accident. The Physicians also propagated the nuclear waste myth. It is not my place to comment on the several other matters which they raised. These are concerned mostly with the areas of economics, psychology and sociology. The submission from the Architects was brief but included a wide range of references of varying reliability. Nevertheless, they accepted myths 2, 4 and 6 and uncritically accepted exaggerated reports concerning the aftermath of Chernobyl (cf refs ICP91a, ICP91b which give the findings of an international group of experts). They appeared to accept all of the hyperbole of the anti-nuclear establishment when they stated:

> "The entire process from the initial mining of uranium through the whole nuclear cycle to the final waste disposal is a lethal one the likes of which humankind has never before experienced."

What especially puzzled and distressed me in these submissions, was the way in which well intentioned people were prepared to set aside their normal professional standards in an attempt to buttress an argument. I am afraid that their lack of judgement actually weakens their cause.

5.3 The use of qualitative reasoning, alarmist stories and worst case scenarios

A third category involves the popular press, television and to a lesser extent, radio who are the most important players in this game. Much of this material found its way into many of the submissions. The process continues and the New Zealand media are not alone in their efforts. Piers Paul Read (Rea93) recounts that on the fourth anniversary of the Chernobyl accident, "the [UK] *Sunday Times* published a story saying that as a result of Chenobyl whole wards in 'hospitals in the Ukraine, Byelorussia and adjacent provinces of Great Russia ... are lined with gaunt, dying and deformed children'." This statement is, without doubt, untrue. Exposure to the the low levels of radiation experienced by the general population as a result of the Chernobyl accident does not produce defomities or malnutrition. Read further continues: "A leading campaigner against official secrecy over Chernobyl, the botanist Professor Dmitri Grodzinski, told me that these stories were nonsense. He showed me magazines that had used photographs of thalidomide children to illustrate articles on the consequences of Chernobyl." The findings of the International Chernobyl Project (ICP91a, ICP91b) are largely ignored by the media. This report by a group of people expert in radiation protection and health physics found no health disorders that could be directly attributed to radiation exposure. It was not sensationalist enough. A more recent example from our own *Sunday Times* was headed "Chernobyl Worse Than Feared" and implies that the amount of radioactivity released has been severely underestimated because the molten debris reached the very high temperature of 2000°C. In actual-fact, we know from measurements, what the extent of the contamination was (this was treated by the International Chernobyl Project). Further from these measurements we know that the average ternperature which was attained was significantly below the boiling point of strontium of 1384°C. This is because the measured ^{90}Sr activity is around 1% of the ^{137}Cs activity. The boiling point of caesium is 670°C and the arnounts of ^{137}Cs and ^{90}Sr in the core at the time of the accident were comparable. The headline was extremely misleading. I expect that these false stories will continue to be featured.

5.4 The Authoritative Professional Witness

In a way, my next two points are merely different aspects of the same thing. However, by giving careful consideration to all statements and submissions, we were able to see why in both cases, the material could not be relied upon. Several submissions referred us to Mr John Large, a professional engineer who has a practice in London and who has acted as an expert witness in many cases involving nuclear matters. We met him in London. I liked his style. He very kindly agreed to visit the cornmittee at our hotel. While waiting in the lobby for him, a large figure fully clad in motor cycle gear strode through the doors. Upon his peeling off this garb, we discovered it was indeed Large - John Large. He began by trying to overawe us with nuclear physics and when he realised that we did know something of that field he continued and made many statements with absolute authority concerning nuclear reactors and nuclear propulsion. Subsequently in the manner which had now become second nature to us we checked them all out. They were all wrong.

5.5 The Sorcerer's Apprentice

I use this to describe a person who, because he lacks understanding in a particular area, can fail to appreciate that which he sees. We thoroughly studied the submission made by Mr John Harrhy, because he had worked in areas which were close to those in which we were interested. Furthermore, he has a high reputation in New Zealand as a naval architect. In his submission, he discussed a number of points concerning the containment structures of propulsion reactors. Because of his background, we examined these very carefully and, as with otlrer statements made to us, we subjected them to our cross checking process. We were forced to conclude, with respect to his statements concerning the provision of designed containments and biological shielding, that he was mistaken. We addressed these matters in Myths 5 and 6 of the Report. Although he was associated with the structural analysis of the containment of the shore based prototype reactor at Dounreay, I feel that he did not appreciate well enough what the functions were of the different elements of the reactor inside that containrnent. Although he has a high reputation as a naval architect, his expertise does not extend to nuclear engineeering. We were certainly not 'duped' as he maintained, we just did our home work thoroughly. Another success for the cross checking process.

5.6 Hysteria and the use of Hvperbole

I feel that this next point is important and one which the members of the peace community should examine carefully. (I still can't get over "the one stray electron will get you" submission). But more seriously, the cause of worid peace is not well served when greatly exaaggerated statements appear in the rnedia. For instance can anyone tell me who provided the opposition spokesman for the environment, Mr Peter Hodgson, with the statement which went something like this: "New Zealand would be uninhabitable for 250,000 years if the canisters containing plutonium on the the Akatsuki Maru were to leak into the Tasman Sea"? Last December, when he made this statement, this Japanese ship was carrying a plutonium cargo through the Tasman Sea. Can a person who makes a statement like this be expected to ever frame sound environmental policy? We felt we needed to comment on the toxicity of plutonium because of hyperbole like this and addressed the matter in myth 13. I am afraid that I must hold Greenpeace responsible for this one too.

5.7 Leaving a loaded gun lying around

Greenpeace are generally rather more circumspect in the way they present material. In a way all they do is to leave a loaded gun lying around. The Neptune Papers of Arkin and Handler give an example. Impeccably presented and documented, these articles list a very large number of 'accidents' involving naval vessels - both conventional and nuclear propelled. Many of those making submissions referred us to these papers and considered that they gave clear and alarming evidence of a terrible safety record of nuelear propelled vessels in particular. We comrnonly encountered statements like

> "Between 1945 and 1988 there were 1276 accidents involving nuclear ships ... collisions, fires groundings, explosions, equipment failures, sinkings, aircraft crashes and a raft of miscellaneous 'incidents'".

This material was provided in submission 43 from Friends of the Earth and refers directly to Neptune Paper No 3. (Ark89), (I have provided the underlining). The Centre for Peace Studies, University of Auckland was less sweeping:

> “There has been a large number of accidents involving nuclear-powered submarines - sinkings, groundings, collisions, fires explosions and radioactive leaks......"

Again, they refer to Neptune Paper No 3.

Because of the many statements like the two above and like the one in the Greenpeace submission which we referred to earlier, we carefully read and analysed Neptune Paper No 3. It is well researched and in its overview makes the statement, which I consider to be a reliable guide, that 'This report documents 1,276 accidents of the major navies of the world between 1945 and 1988.' When we looked more closely, we found that of the 220 accidents which did involve US or Royal Navy-nuclear propelled vessels, two involved the loss of ships at sea (Scorpion and Thresher) and three resulted in minor radiation exposure of workers during ship overhaul. No member of the public was involved in any of these. The report certainly did not demonstrate that nuclear powered vessels were unsafe.

Greenpeace can rightly claim that they can take no responsibility for statements rnade by others which might draw on material which they have produced, but maybe they should be rather more careful in the way they present it. In Washington, we met both William Arkin and Joshua Handler, the authors of 'Neptune Papers No.3'. When we pointed out to thern the hyperbole involved in a recent Greenpeace press release which was headlined "Soviet Naval Nuclear Accident Plan Admits to Thousands of Future Deaths", Joshua Handler replied, " Oh that's just Greenpeace hype". That is not good enough. The language of an extremely prudent contingency plan had been twisted into a statement which was meant to be taken as fact. If Greenpeace wishes to survive as a credible lobbyist for the environrnent and for peace, it is time it accepted a responsibity to present infonnation in an unbiased manner which does not mislead. It should not allow its worthy ends to distort the methods it is using to try and achieve them. The headline of the Reuters report based on the above news release illustrates graphically the 'loaded gun 'problem. Th.is headline was "Soviet Nucleal• Accident at Sea Could Kill 26,000 - Greenpeace Oslo".

5.8 The Hired Hack or the General Purpose Scientist

One of most amazing developments following the presentation of the report was that the Alliance Party brought Mr Norman Buske down to New Zealand as the "overseas expert". Perhaps they had not actually bothered to read the report, because in the measured language of such documents we had said he was a lousy scientist and we had explained why we had come to that conclusion. Greenpeace had subrnitted to us a paper by him which purported to show that the Puget Sound Naval Shipyard had emitted five times more radioactivity in the last year than was permitted for all naval shipyards. His experimental method just did not have the sensitivity to support such a conclusion. It wasn't the first time that he had produced such a tendentious study for Greenpeace. We can only hope it will be the last. Again, if Greenpeace are serious, they should at least ensure that commissioned monitoring work is reliable, for instance by having it independently reviewed.

5.9 Don't take any notice of him - he's an expert and therefore must be biased

One other characteristic which I came across is the handicap of expertise. There is no doubt that we must carefully assess the likelihood that a statement made by an expert is reliable. There are indeed situations where we need to be sceptical of an expert's judgement, for instance, a scientist employed by a tobacco company who tells us that there is no connection between smoking and cancer. However, in general, when we need the best advice we can get, we go to the person who is the expert. A legal problem - we go to a lawyer (with rather more circumspection now than a few years ago - but we go). We expect the pilot of the aircraft in which we are a passenger to have a very high standard of professional training indeed. On medical matters if we have any sense, we consult some one who is not about to be struck off as a Registered Medical Practitioner. Our car needs repairing we take pains to find a good mechanic. When it comes to nuclear issues, however, 'Peacelink in 1991', when discussing possible members of the Special Committee, did not want them to be either of the two most expert and knowledgeable government nuclear scientists who we have in this country. Anyone who has any expertise in nuclear matters is immediately labelled as biased if they question the veracity of the anti-nuclear myths. Expertise on nuclear matters is widely spread. There are many independent agencies and there are many nuclear experts whose advice can be relied on. Before looking at the implications of the observations in this section, I will commentbriefly on some of the criticisms of the report.

6 Criticisms of the Report

I have come across no criticisms of the report which would persuade me that we were mistaken in any of the findings. I do not propose to respond to them in any great detail and will mostly content myself with sorne general observations.

- Many were picayune in the extreme.
- Many others reveal their author's ignorance.
- Most objections to our findings sound like squeals of pain when we have not accepted a cherished prejudice.
- The importance of the cross-checking approach was not understood. For example, by cross-checking we found that we could consider statements made by Mr F R Faimer, who for over thirty years was the Director of the Safety and Reliability Directorate of the UKAEA, to be reliable. The same approach allowed us to conclude that statements made by Rosalie Bertell were not to be trusted.
- The importance of the approach to safety assessment and assurance which was outlined in Chapters 2, 6 and 7 was, in general, not understood.
- Often the anti-nuclear myths were accepted without question. We were then criticised because we did not accept them.
- Critics have sought to mis-represent what was in the report. Two examples will suffice:

It is maintained that we placed heavy reliance on land based reactor studies. We did not. Indeed we pointed out on several occasions the very substantial differences between the two types of reactor. It was this understanding of the difference which led us to construct the model reactor. Some of the criticisms have shown an almost wilfull misunderstanding of the approach taken in the construetion of the model reactor. The several approaches used in its construction are explained in the report. It is certainly not based largely on out of date information. It is not flawed, as has been frequently claimed. A similar reference design has been developed by Canadian nuclear engineers.

Some of those objecting have been academics who maintain that since we did not have all the information, we could not possibly make any recorrunendations. Now academics are wonderful people, but they are not good at making decisions in the face of inadequate or incomplete data. I have heard the cry so often: "let us postpone the decision until we have all the infornation." The Committee did not have that luxury. I took our job to be to give the soundest advice we could, based on the information available. This we did. In particular, we needed to come up with the best possible estimate concerning accident frequency and consequences. We did this because we felt that it was important to be able to compare the possible hazards with others with which people are perhaps more familiar and as a guide to any organisations who could be given the responsibility for contingency planning.

Academic criticism of the indicative frequency consequences curve (fig 5.2) attempts to focus on this lack of information. The information we lack has no significant consequence. In particular the position of the left hand end of the curve is considered to be completely indeterminate. Not at all. For the curve to be useful, the Iodine-131 release associated with this left hand point only needs to be known to within one order of magnitude. This is because of the demonstrated low probability of any accident. Here is what we know. Any accident involving the release of less than 1 Curie of Iodine-131 will pose no hazard to any member of the public. (Even the 17 Curies released from Three Mile Island was shown to have no discernable effect). Any release involving 10 Curies of Iodine-131, would have been detected by many monitoring agencies. No release of even a minute quantity of Iodine-131 has ever been observed from a US or Royal Navy propulsion reactor. The point is thus confined to region between 1 and 10 Curies. We took a conservative approach and placed it at the right hand end of this region. We lacked some the information, but we had sufficient understanding to make a sensible and robust estimate. No one has yet proposed a better estimate, than that which we gave, of the frequency which should be associated with this point. Several academics have complained and produced nothing.

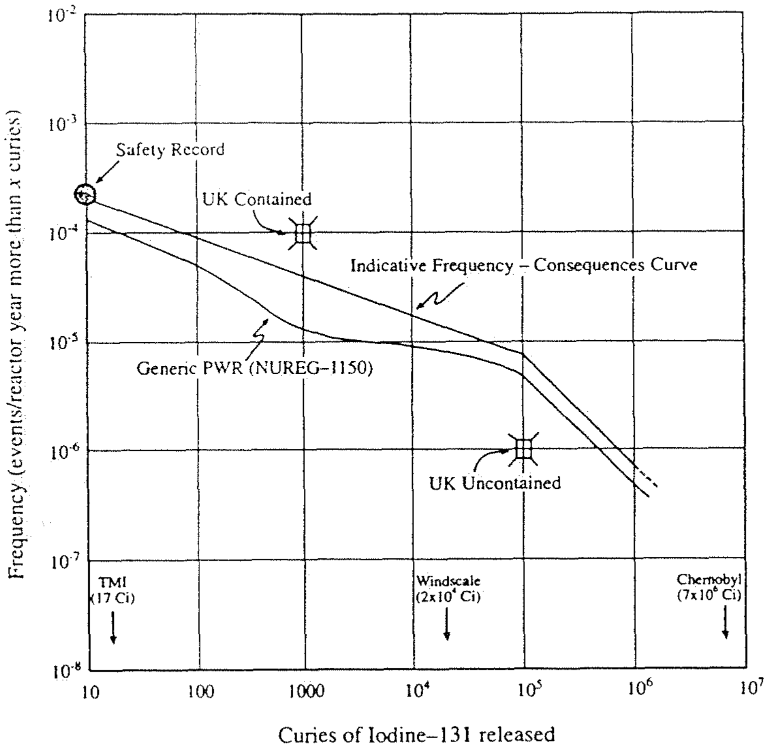

Figure 5.2
INDICATIVE FREQUENCY-CONSEQUENCES CURVE

Indicative frequency-consequences curve for naval nuclear propulsion reactors (refer to the text for a full discussion). A feature of all data shown in this graph is the very low frequencies associated with all estimates of release. A frequency of 10^{-4} per year corresponds roughly to one event in the period of time from the last ice age, whereas a frequency of 10^{-6} per year represents one event in the time since the beginning of the Pleistocene Epoch in geology and mankind's first beginnings.

Because of the impressive safety record of nuclear propulsion reactors we needed to invoke theoretical considerations in order to obtain the indicative frequency consequences curve of fig 5.2. The logic of those who told us that they were terribly unsafe and then complained at our need to appeal to theory in constructing this curve, escapes me.

The resilience of the report and its robust nature are not unexpected - they are a direct consequence of the cross checking approach which we adopted. They are also very firmly underpinned by the methods explained in chapters 2, 6 and 7. These have been largely ignored because the importance of the approach taken in these chapters has not been appreciated.

7 Implications

There are those who would argue that the extremely desirable aim of world peace justifies the use of hyperbole and meretricious and specious arguments. It does not. Worse, that use can hamper the search. It has done so in New Zealand. It was because the argument that nuclear propelled vessels were unsafe had been put to David Lange and because he accepted them, that section 11 was placed in the Act. [Entry into the internal waters of New Zealand by any ship whose propulsion is wholly or partly dependent on nuclear power is prohibited] . He did not need section 11 to achieve his policy aims. Its inclusion weakened the Act because it was based on the false premise that nuclear propulsion was unsafe. The Act is an important one and signalled an increasing independence of New Zealand's foreign policy from the influence of the United States. The inclusion of section 11 unnecessarily exacerbated our country's relations with a very powerful countiy which also happens to be an important trading partner. The hysterical reaction to the plutonium shipment has, I believe, similarly affected our relations with Japan, another important trading partner with the strongest economy of any Pacific rim country. In both cases, our ability to influence the policies of these countries has been decreased because their policy advisers look at New Zealand and see a counny which is unable to assess questions concerning advanced technologies in a dispassionate manner.

8 The search for international peace in the Pax Americana era.

Rather than defining the present era in terms of the one we have now left, ie the Cold Wax era, I prefer to define it by naming it for the country whose very strength means, of necessity, that its influence on the search for world peace in the near future will be pervasive. This situation can be expected to persist for perhaps two decades until the growth of the Asian economies brings them to a par sometime in the first decade of next century and the CIS countries get through their painful present restructuring problems.

It is my perception that the peace movement generally has not adapted its thinking to this new Pax Americana era. Much of your thinking is still in cold war tenns. Strange isn't it? Like the British Army of anecdotal fame, you are still preparing to fight the last war.

9 Areas where attitudes and policies need to be re-examined

I should really begin by saying something like "As a result of my involvement with the question of the safety of nuclear propelled ships I have been led towards certain conclusions. I know that they are not likely to find ready acceptance from the audience here today, but I offer them for the very reason that I think that I have been given the chance to see the problems from a different perspective and sometimes it just helps to hear a different point of view." Although the style is in the imperative, the aim of this section is to invite you to re-examine some of the tenets and assumptions which have been your guides. Changed circumstances sometimes lead to the need to change policies and approaches. Some of the points which I invite you to look at are listed rather briefly below.

- Seek to gain a better understanding of the many important aspects of nuclear technology. In this way you will be better able to frarne policies which are robust because their foundations are sound. It is a technology which has much to offer. Ill founded fear is inhibiting our ability to make the most use of it.

- Get rid of your fixation on the dangers of nuclear reactors. Nuclear power is now an important source of electrical energy for many countries. Its importance will continue. In particular, it will be increasingly important in several of our Asian neighbours.

- You act as if the Cold War were still with us. A11 of your attitudes, nurtured by the 40 years of this era need to be re-examined and adapted to the new reality of the Pax Americana era.

- Stop looking for conspiracies. This search was a feature of many submissions. Scepticism is vital, but the sort of elaborate conspiracies which we were assured were in existence, are difficult to enact and even more difficult to hide for any length of time.

- Re-examine your attitudes to the United States of America. It is a powerful country and we do not have to love it. The way we act can nevertheless affect our ability to influence its policies.

Accept that at least for the next decade and probably for the next two, there will be only one super power. I fear that much effort in the past has been driven by anti-Americanism. It is time now to look carefully at the bases of policies. Many need to be changed. While maintaining foreign policy independence, this country of ours needs to be asking how it can steer the actions and policies of this one remaining super power towards the achievement of world peace. To that end it is important for all of us to gain a better assesment of the strengths and weaknesses of the country. In particular, remember that it is the world's most stable constitutional democracy. For 217 years, its citizens have been voting every two years, under that same constitution, to choose all the members of the House of Representatives and one third of its Senators. Despite a relative lack of power, a small country like New Zealand, can hope to influence United States policy because of the existence of this stable democratic base and the existence of shared democratic ideals. But New Zealand will only be in a position to do this if our own policies are soundly based and coherent.

- The complete destruction of all nuclear weapons held by the present nuclear powers will not produce a stable and safe international system.

An important development, and one which the peace movemenr must view with relief and a measure of satisfaction, has been the steady reduction in the number of nuclear weapons deployed by USA and the USSR over the last decade. This reduction can continue safely for sometime yet. However, the harsh fact of life is that complete destruerion of all nuclear weapons by USA, UK, France and Russia and their renunciation by Ukraine, Belarus and Kazakhstan, would produce a situation of much danger. Wars involving conventional weapons can at least be contained, although as the sad tale of Yugoslavia unfolds, it is a reminder that the international coirununity finds it very difficult to stop them. The scenario which most concerns me is one in which a relatively small country ruthlessly pursues the development of its own nuclear weapons capability. Moral suasion is of little utility in the circumstances. I am afraid that the only thing which could ultimately prevent such a countiy using its newly developed nuclear weapons when it suited it to do so, is the threat posed by a country or grouping of countries who possess more powerful weapons. It must not be forgotten, too, that the effectiveness of such weapons depends on many other things besides their actual explosive capability. Delivery vehicles, command and control capability, navigation and communication technology and an extensive and sophisticated industrial base are only some of these additional factors. For this reason, I find the obsessive attemptto shut down all civilian nuclear power appiications to be strangely myopic. Interestingly, a number of countries with an infrastructure which could support a nuclear weapons programme have chosen not to develop them. Countries like Argentina, Brazil, Taiwan and Indonesia after investigating such developrnents, concluded that a conventionally armed military force was to be preferred. Countries lilce Canada and Japan have reached a similar conclusion.

- Re-examine attitudes to the United Nations. The new era which we have just entered will make it easier for New Zealand to hew to an independent foreign policy, but it will also bring with it an increased responsibility as a member of the United Nations.

New Zealand's move towards a more independent foreign and defence policy has coincided with the move away from communism in all of Eastern Europe and the CIS states. This latter development has presented the United Nations with both its greatest opportunity and a major challenge in its seareh for world peace. It can now mount peace keeping operations which are widely supported. These operations all involve the co-operation of the armed forces of many countries. Our independence is constrained by our need to co-operate through the UN with the other countries with which we will become involved in present and future peace keeping operations. The ability to co-operate effectively is now compromised by the difficulties which our defence forces face in taking part in joint exercises, principally those involving Australian or US forces. A reassessment of New Zealand's policies in this area is clearly needed if we are to assume the responsibilities which our membership of the United Nations places upon us.

10 Conctusion

- Nuclear propelled ships are indeed safe.
- It is time the Peace Corrununity got past its collective hang-up on almost all nuclear matters.
- It is time to reassess attitudes and policies.
- Because of the momentous changes which have recently occured on the world scene, there are many questions which are a great deal more pressing than the safety of nuelear propelled warships. It is these which you should be addressing.

I thank the Centre for Peace Studies for the invitation to attend this Seminarand hope that the different perspective which I have given, assists your search for ways in which New Zealand can contribute to the cause of world peace.

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The Safety of Nuclear Powered Ships
Criticisms of the Report of the Special Committee
3 July 1993

Peter R Wills
Alternative Committee on Nuclear Ship Visits

The Alternative Committee was set up in opposition to the Government's plan to legitimise renewed military contacts with the US by sanitising visits by nuclear powered ships. The Government set up the Special Committee to fulfil this political function, but the first condition of success obviously had to be that the Committee itself not acknowledge any such funetion. This was facilitated by focusing the Terms of Reference of the Special Committee on technical questions, like safety and the integrity of the environment, dissociated from the main political task.

The Committee quickly saw that any analysis in terms of costs and benefits could be avoided by concentrating on purely quantitative aspects of "risk", like estimates of probabilities and measures of consequences. In evaluating a risk, it is normal to balanee gains in taking the risk against potential losses and to comment on how such a judgment has been made. The Committee studiously avoided considerations of this sort (althaugh that was what the public indicated was important in many of its submissions). Instead, they found they were able to circumvent the need for any such analysis and *still* arrive at a positive conclusion, because the risks in question turn out, in their assessment, to be, for all practical intents and purposes, zero.

Thus, the main finding of the Committee can be put in absolute, objective terms. There is, quite simply, nothing to worry about. "The presence in NZ ports of nuclear powered vessels of the navies of the US and UK would be *safe.*" Not safe relative to a particular definition of that term, given that different people may have different standards, but *actually* safe. Safe in a sense that a scientist may regard as verifiable.

As far as any potentially serious accident in a New Zealand port is concerned, the likelihood is "so remote that it cannot give rise to any rational apprehension." So say the impartial judge and the objectively-minded scientists. Any apprehension which New Zealanders have about radioactive contamination from accidents during naval visits by allied nuclear powered ships is irrational. It *cannot* be rational.

However the apprehension that the public has about visits by nuclear powered ships does not arise from consideration of the likelihood of an accident alone. According to many peoples' reckoning, risking the consequences is not balanced by commensurate benefits no matter how remote the likelihood of an accident. That was the point of view adopted by the Alternative Committee. We endeavoured to look at the putative benefits of renewed American ship visits, nuclear powered in particular, and compare them with the possible consequences of having an accident here. In our view, the risk is simply not worth taking.

In the first place we opposed the expenditure of $480,000 to write a report saying what had been said many times before, at least as far as generally agreed conclusions can be reached. The public has not gained much benefit from the Report, nor I might add, has it shown much interest. Before the budget and membership of the Special Committee were made public, an effort was made to ensure that the Committee had as a member at least one person who was a known critic of the nuclear technology, especially its military applications. However, the government did not see the need for any such "balance" at that stage.

I believe in the fair and honest expression of differing viewpoints. For a discussion to be fair, those who oppose one another must demonstrate respect for one another, and that means giving credence to the integrity of the other's viewpoint. It also means acknowledging and making explicit one's fundamental ideological assumptions and the fallibility of one's assessments.

That is where, in my view, the government's Special Committee failed in its work. The Report presents the Committee's findings as the received truth. What are essentially value judgments become portrayed as matters of fact. The Report claims *authority* for the Committee`s findings and leaves the public either to believe what it is told, or to be stupid. (The words used are "irrational" and "nonsensical".) The attempts of critics to question the Report are useless and the Committee feels no further need to justify or discuss its assessments. The Committee is generally unwilling to engage in public debate about its main findings, especially those with political significance.

How and where are value judgments portrayed as matters of fact in the Report of the Special Committee? Take the fourth finding as an exarnple. Nuclear ship visits would "occasion no significant risk or threat to the natural environment." But what is significant for whom? Just because some-one has guessed that the rate of occurrence of some more serious accidents is less than 1 per 1,000,000 years per reactor does not mean the risk is insignificant. By saying that it is insignificant, the Special Committee has made a value judgment. It has said that the risk can be taken with impunity and strongly advises us to understand this. Even if there is nothing to be gained (and the Committee refrains from any discussion of what this could possibly be), there need be no fear of anything lost (by way of accidents) from nuclear ship visits. The worst conceivable accident is acknowledged as a possibility, in principle, but in practice a person would be inconceivably unlucky to experience such a thing. He/she is more likely to be struck by lightning.

Evaluating risks from a purely quantitative point of view misses the point. Some people have a legitimate fear of electrical storms. Furthermore, it is possible to take steps to minimise the risk of being struck by lightning if, for example, a storm descends when one is playing golf. Likewise, it is possible to take steps to minimise the effects of background radiation and *no* deliberate extra exposure is worth acecpting without commensurate benefit. And how do we decide what commensurate benefit is? We all have our own ideas and make our own individual choices, but when the extra exposure or risk to be taken is shared between us in the community we use our democratic processes to decide whether we will accept it. The Report of the Special Committee tells us that no such process is necessary in this instance. The risk is essentially zero; it is not a matter for consideration in deciding whether nuclear powered ships should be allowed in our ports and any residual public apprehension about accidents is irrational.

I disagree thoroughly with this analysis and I do not accept that the Special Committee has the authority to decide whether or not people's apprehensions have a rational basis. Their claim to the high ground of rationality is invalid. Members of the public are not stupid and irrational. They express carefully ordered hierarchies of values, and on this issue many peaple feel, quite legitimately, that *absolutely no extra risk,* and especially any possibility of radioactive contamination, is worth taking in order to give solace to the aspirations of the world's most powerful military machine and the closely guarded advantage it gains from its dependence on nuclear technology.

Thus, the real opposition to the Report of the Special Committee is ideological. Whereas the Special Committee says that the risk is so close to zero as to be no issue, opponents feel that any arbitrarily small risk will remain an issue because of the character of the activity which is being pursued in taking the risk. The testing of nuclear technology for military purposes, in the case of weapons, has wreaked havoc on, and has often shown complete disregard for, innocent civilians, particularly indigenous peoples around the Pacific. The highly enriched radioactive material used in reactors aboard nuclear powered warships is produced together with the material which goes into nuclear bombs, and indeed could be adapted for such purposes. Under United States law, information about how these reactors work is protected by provisions more general and more stringent than those applying to information about nuclear weapons. The rationale for this is that the United States fears that it would lose some of its military advantage if other countries were to find out how to build similar reactors.

Opposition to warship visits which has become focused on the issue of nuclear propulsion is based on a rejection of the legitimacy of the activities and processes used to gain and maintain military power. Military nuclear technology, so closely guarded and protected, is, in the public perception, a symbol of the naked power which is routinely exercised to intimidate the less powerful and maintain control over global resources. And the possibility of further radioactive contamination therefrom is a symbol of ordinary peoples' susceptibility to the suffering which accompanies military solutions to human problems. It is on that basis, quite rational in my view, that apprehension of even the tiniest risk can serve as reason for rejecting visits by nuclear powered ships.

The Special Committee gave no credence to this sort of reasoning and it made no apparent effort to find the coherence and integrity in many of the submissions which expressed this point of view. Rather, groups like Greenpeace, whose submissions reflected thinking of the sort I have outlined, were criticised for the quality of their input and the Committee looked for ways of explaining away the widespread negative public reactian to nuclear technology. I am going to look at some examples of how this is done in the Report, but first I want to make a few more general points.

The first is that the Special Committee has not escaped from adopting an ideological viewpoint and its Report is not primarily a scientific report. This in itself is not a problem and the Committee could not be criticised for writing such a Report if it had laid out clearly its ideological assumptions and differentiated carefully between facts and value judgments. The validation of judgments depends ultimately on an appeal to standards which are generally held. The Committee claims rationality for its own judgments, but it does so without laying out its position on the underlying matters of concern for many members of the public. In judging the significance of the risk associated with nuclear ship visits, many people feel that the main criterion for consideration should be the fact that the ships are warships. The Committee was told this, but then they restricted their considerations to this category of ship without giving any consideration either to what distinguished it as a categary in the first place and or to how it is that the world has so organised itself that the only nuclear powered ships likely to want to visit New Zealand are allied warships. To say that such general considerations are of no concern is honest enough, if that is what is felt, but when there is no caveat attached to the findings saying that they are limited to this narrow, unsatisfactory context, the Committee loses both its claim to general validity and its credibility. At that stage it becomes an instrument in the ideological battle between those who support the New World Order and those who don't.

Had the Special Committee restricted itself to saying that the risk of an accident is very, very small, and *in their view* not worth taking much notice of, I could have accepted it and continued to disagree. If I had been on the Committee I would have asked that it be noted that many people think the risk is worth taking notice of (for the reasons I have outlined above). But the Committee's report tells us *as a fact* that the risk is not worth taking any notice of. The presentation of views as facts reduces the Report to the level of political propaganda. (Two can play the game of making that accusation.)

The Special Committee portrays people who still have apprehensions about nuclear ship visits as irrational, but they are offered a way out of their unfortunate mental state. They need only realise that what they believe based is on the myths and catchcries of anti-nuclear pseudo-experts and disinformation mongers. After all, one member of the Committee started out sympathetic to the anti-nuclear position but was converted from a state of scepticism about safety to become an admirer of the US Navy's "culture of safety". This "culture" is the public's ultimate guarantee. There is no sign of Navy standards slipping meaning that accidents are going to remain very, very unlikely into the foreseeable future. We can beheve this because we are told it by four New Zealander`s who have talked to the people in the United States who really know about such things. All that the Committee has left to do is persuade the public to set their fears aside.

Because so much has been made of the public's serious lack of understanding and knowledge of the safety and technical issues related to nuclear powered vessels, let me look at some of the myths and catchcries which the Report tries to put to rest.

Myth One: A nuclear reactor can become a bomb.

The Committee attempts to refute this supposed myth by discussing the differences between the processes which sustain fission, in a normally, operating reactor and in an atomic bomb. Reading quotations like "...it is absolutely and unequivocally scientifically impossible for a reactor to blow up like an atomic bomb" one might be forgiven for thinking that a reactor' cannot suddenly release too much nuclear energy and blow itself apart. However, it is possible for a reactor to blow up. It has been done deliberately on one occasion and has happened accidentally more than once. Under the most unfavourable conditions, the reactor fuel could be spread as debris over a wide area in the event of a reactor explosion. Although the mechanism whereby such an explosion could occur different from that which facilitates the much larger release of energy from a typical *nuclear* bomb, the sort of explosion which a reactor could undergo would be comparable with a large chemical explosion. Furthermore, the source of energy would be nuclear, and the result would be a radiological nightmare. The Murmansk disaster contingency plan, is based on considerations of this sort. It is not wrong to think that a reactor can become a bomb. It is correct to think so. It would only wrong to claim that the amount of nuclear energy released in a reactor explosion could be comparable with that from a typical nuclear weapon.

Myth Eight: Emergency core cooling systems (ECCs) are not designed and built into naval propulsion reactor systems.

In fact US submarines have no provision to force a reserve volume of water into a leaking reactor to prevent it from melting down. The "Emergency Cooler" shown in Figure 4.2 on p39 of the Report is designed to cool down a reactor when it is still full of water. It operates only by passive convection and heat exchange with the ocean water outside the hull. It supplies no extra water and cannot combat leaks. The distinction between this provision and what informed people understand by the term "Emergency Core Cooling System" when it is applied to land-based reactors is very clear. The Report acknowledges the difference and then obfuscates the discussion by pretending that there is no functional difference. In the event of an accident, the difference could be decisive. The Committee says "We are able to state without reservation that ECCs are an integral part of the design and construction of all naval nuclear propulsion systems". The supposed myth is fact, not fantasy, if by ECC you understand the sort of provision which is required to be made for all commercial land-based reactors. Naval reactors have some provision for emergency cooling, but the systems are mueh less effective and would be likely to fail in the event of a serious leak and loss of coolant pressure, which is exactly what real ECCs are meant to cope with. (I thank John Mi11er for pointing this out.)

Myth Nine: The increasing age of nuclear propelled ships makes them less dangerous

The Committee judges that the normal "bath tub curve" (more frequent failures near the beginning and end of reactor lifetime) is flattened out through expexience gained with land-based prototypes, that quality assurance programmes militate against the expected effect and that nuclear engineering is a mature discipline, meaning that the problems that can arise have been dealt with. It is the age of the hull (in terms of number of dive cycles), not the age of the reactors aboard, which is the limiting factor. None of this convinces me that a vessel nearing the end of its life is likely to be less reactor-problem prone than one which is more or less new. The Committee seems to be saying that in the special case of nuclear propulsion our allies have managed to defy normal engineering tendencies. That to me is the mythology of the Report. Nuclear technology is portrayed as something fundamentally different from and superior to other kinds of technology.

Myth Sixteen: If the Wahine had been nuclear powered, thousands would have died.

I don't know of this ever having been said. There were at some stage posters put about which said thousands *could* have died and several people, including me, have written about "worst conceivable accident" scenarios of this sort, but I don't know of anyone who has suggested that a sinking *would* result in a simultaneous reactor accident involving massive breach of containment and environmental contamination. The Report says "It is not apparent how, and nonsensical to say that, thousands would have died". This seems to me to be a crude attempt to misrepresent peoples' concerns by exaggerating them, and then to portray them as stupid. Once again, peoples' real concerns are not dealt with. A lot of things went wrong and bad decisions were made before the Wahine sank. It is facile to suggest that a similarly disastrous scenario involving a nuclear propelled vessel, and an associated serious reactor accident, is essentially impossible. The posters were designed to make that point in a few words. The Murmansk contingency plan offers justification for suggesting thousands of eventual deaths in the "worst conceivable accident" close to a city like Wellington. The "myth" discussed in the Report is not what people said. What they did say was justifiable as far as it went.

US Navy Accident Contingency Plan

As a final example, I want to discuss, very briefly, the Report's treatment of the US Navy's secret accident contingency plan, OPNAVINST 3040.SB, which I supplied to the Committee. The Report says "We indicate plainly that in our view the US Navy instructions require that the host nation be informed of any accident and show that it is highly concerned for safety and dissemination of information relating to safety". In two paragraphs on page 143 they state that my analysis of the document is categorically wrong. For the record, I stand by my analysis of this document, in particular my claim that the Captain of a vessel is given discretiona.ry powers in determining whether or not the public needs always to be informed when there is an accident. In respect of the formal definitions of the terms "nuclear reactor accident" and "radiological accident" advice is given that application of these definitions "necessarily involves judgment as to the nature and extent of the accident or emergency and the need to contact all [relevant authorities]". No discretionary power is consistent with the diplomatic assurance that "the appropriate authorities of the host government will be notified immediately in the event of an accident involving the reactor of the warship during a port visit". It is not a question of unnecessarily constraining the actions of a person responsible for our safety. It is question of guaranteeing his accountability to us, the affected population, for his actions. I challenge the Special Committee to demonstrate in what way my analysis misrepresents or misquotes the document, as stated on p 143 of the Report.

To sum up, I want to emphasise the basis of my reasoning and my criticism of the Report. Visits by nuclear powered ships do pose a finite risk and it is precisely the purposes which they serve which makes the taking of that risk unacceptable for many people. The Special Commiitee gave no credence to that consideration. Instead it set itself up as an authority and dictated to people how they should put their values in order of priority. It then sought to depreciate legitimate concerns by making them look like groundless prejudices. The hidden agenda of the Report, to paint a rosier picture of nuclear technology and make its application to naval propulsion seem like a worthy human endeavour, can be found by reading carefully between the lines.

For my part, the US Navy's high level of concern about safety and preparedness for an accident, their public affairs protocols to deal with the media and authorities in the event of an accident, and their strong motivation to avoid damage to life and property ashore do not satisfy me. In the final analysis, I do not ever want my safety to depend on the actions of an institution whose priorities and values are as warped as those of the United States military. I need go no further than this week's newspapers. The killing of a celebrated Iraqi artist was described as "collateral damage" in a cruise missile attack on Baghdad which the President said "sent the message we wanted to send". "I feel quite good about what transpired," he said. Carelessly annihilating a creative mind in the course of political grandstanding using technology of sophistication and expense not available for alleviating widespread human suffering demonstrates a fundamental lack of proper moral values.

I'm not about to give up my "nuclear phobia" as a way of adjusting to the new world situation. The new world situation is in too many important respects just like the old world situation. The people with the money and inclination to operate nuclear powered ships don't seem to me to be worthy of any invitation to come and visit us.

"LOW DOSE" IONIZING RADIATION AND THE SPECIAL COMMITTEE REPORT.

William R. Wilson

Alternative Committee on Nuclear Ship Visits

In this brief paper I would like to address two aspects of the report of the Special Committee on Nuclear Propulsion which present particular difficulties for me. The first is the terms-of reference of the report, which are too narrow to be useful. (I will limit my comments on this problem since it has been discussed by others today). My second major concern, and the main focus of this paper, is that the Special Committee's interpretation of the health consequences of low doses[1] of ionizing radiation is at variance with current scientific opinion.

I'd like to commence by quoting the second sentence in the report, which says:

Nobody has contended, or could contend, that nuclear powered ships are absolutely safe - that nothing could go wrong with them.

Now that, in essence, is the whole matter and it is the concession which invalidates the Committee's case. The possibility of a serious accident is very low but the consequences are very substantial. It is not appropriate to expose New Zealanders to any additional risk unless some tangible benefit can be demonstrated, and yet the terms of reference of this report are sufficiently narrow that the larger issue (whether there *are* any tangible benefits) cannot be addressed. A balanced assessment of this issue is obviously impossible within such a narrow frame of reference. The Committee concedes that it is impassible to give an assurance that there is no risk; it follows that it is also impossible to conclude that there is a case for altering the current legislation without addressing the issue of benefits.

It is useful in this context to point to what is widely accepted as the cornerstone of modern radiation protection philosophy, the so-called ALARA Principle, which stands for As Low As Reasonably Achievable. The key assumption behind this principle is the now widely-accepted view that any dose of ionizing radiation carries with it some risk of a deleterious health effect and for this reason exposure is not acceptable unless there is demonstrable benefit (and that the benefit is understood and accepted by those at risk). It is therefore necessary to ensure that radiation doses at all times be kept as low as possible, and exposure can only be justified at all if there is some potential benefit to be derived. The application of this principle in the present conteart would require that nuclear-powered ships stay out of New Zealand waters unless there is some overriding reason why they need to be here. New Zealand has already established a zero risk of radiation exposure from this source and has shown that this is, indeed, "reasonably achievable". From the radiation protection perspective, it would not be responsible to alter the status quo unless the New Zealand public accepted that there was an overriding benefit that justified the risk. Clearly, that is not the consensus view.

There are other problems which arise from the very narrow frame of reference of the

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[1] In discussing "low doses" of radiation I am referring to doses which will not cause prompt death due to radiation sickness, but which may (in a small proportion of cases) lead to death from cancer at a much later date.

Committee. Not only is the issue of safety examined in isolation, but the health consequences which are addressed relate to a very narrow view of health and one which ignores the psychosocial dimensions of radiation contamination and exposure. For example, the reactor accident at Chernobyl has resulted in only a small number of acute radiation fatalities (although radiation epidemiologists acknowledge that there will be a very large number of cancer deaths in Europe as a result of that event). But, beyond that, the spirit of a whole society has been irreparably damaged through the alienation of the people from their land. It is now painfully clear that the people of Chernobyl experience themselves as unwell. Professor Poletti touched on this point in his paper, and presented the view that this is a demonstration of an irrational response to radiation effects. However, when health is viewed from an appropriately broad perspective, the spiritual and psychological (as well as physical) implications of radiation contamination rnust be acknowledged and addressed. The ability of New Zealand to absorb the effects of an accident of even a small fraction of this magnitude without profound and irreparable damage must be called into question. The report itself briefly acknowledges, on page 132, the economic and social impact is likely to be of much greater importance than radiological fatalities resulting from a major accident. It fails to then address this issue in any form. So the very narrow frame of reference which it adopts precludes any serious discussion of health issues.

In a sense, this criticism of the authors of the report is more appropriately levelled at the political masters who commissioned it. But I want to acknowledge it quite explicitly since I do not want the following remarks about health consequences of low dose ionizing radiation to be interpreted as representing the major issue. I disagree strongly with the way in which the Committee has represented the situation in relation to low radiation doses, but even if they were to be judged as correct in their interpretation this would not amount to a case for reintroducing nuclear powered vessels to New Zealand waters.

Given that caveat, I want to show why I consider the treatment of' low dose effects of radiation by the Committee to misrepresent the prevailing view in the scientific community. The Committee identifies as a myth the view that radiation is dangerous in low doses, and provides the following examples of the statements made in submissions which it considers demonstrate this myth (Special Committee Report, pg 168):

a. Indeed even "low" level e.xposure nray he having significant health effects on nuclear workers.

b. The effect of long-term exoasure to low grade radiation is now well-recorded. The effect is cumulative and is an increasing cause of cancer and also genetic changes.

c. Since genetic damage can occur from a one electron injury... If your grandchild happens to develop leukaemia from an unnecessary stray electron....

d. There is no such thing as a safe level of radiation.

The Committee offers these statements as examples of the type of nuclear hysteria which it wishes to expunge. As a scientist with a professional interest in radiation biology, I have no difficulty with any one of these four statements. Nor would most other radiobiologists. It's quite true that the terminology is a little loose and non-technical in one or two places, but it is now widely accepted that there is no threshold dose below which radiation is innocuous, and that the passage of a single ionizing particle through a cell nucleus can induce a cancer (although with very low probability). T'he evidence for this is now very strong and derives from many sources. The clearest evidence comes not from studies of humans (or animals) exposed to low doses of radiation but from recent investigations at the molecular and cellular level which have elucidated the basic genetic lesions which gives rise to cancer (namely oncogene activation resulting from DNA breakage and misrepair), and have demonstrated that these events can indeed be triggered by the passage of a single ionizing particle[2].

The Committee goes on, and I'm continuing to quote directly from the report (pg 168):

The thesis that "low level radiation is dangerous" can be traced back to writings by JM Gould, J Goffman, E Stemglass and R Bertell. Their work finds no support from the leading international agencies expert in this subject.

Which is quite an extraordinary statement. The three major multi-authored internatiorial reports in this field, cited by the Special Committee, are known as BEIR V, UNSCEAR 88 and ICRP 60. What is remarkable is that all three of these reports accept the massive international body of evidence (which does not derive particularly from the work of Gould, Goffman, Sternglass or Bertell) that low level radiation is dangerous, and that there is *no threshold below which radiation is without* effect. This position is implicit in the approach taken in all three reports, and it is explicitly stated in their acceptance of the so-called zero-threshold linear model for the relationship between radiation dose and cancer induction. The Special Committee states that these publications represent the considered consensus of the international radiological community, which is correct, and then totally ignores their conclusions in stating that "it is not difficult to see why 'low-level radiation is dangerous' is a myth". Let me outline the argument that is then offered in support of this statement and ask Professor Poletti to correct me if I have got this wrong.

First of all, the Committee says that the average background radiation is about 2.4 mSv (millisieverts) per annum, which is more-or-less correct in New Zealand. They say that just what is meant by low-level radiation is not clear, but they decide that they are going to assume that it means a tenth of this figure. Why, we don't know exactly. Most people, when they are talking about low-level radiation, mean radiation in the vicinity of background and they are concerned with elevation above that figure, The Report then points out that an intercontinental airline crew receives up to an extra 9 mSv per annum and they say that if 0.24 mSv is dangerous, intercontinental airline crews must be in grave danger: And I quote:

If low-level radiation is dangerous, no one should travel by air at all and life expectancy of an intemational airline stewardess would be extremely short.

I point to this argument because I think it demonstrates a pseudo-scientific sleight-of-hand which is common throughout the Special Committee's report, the introduction of some sort of quantitation to give the impression that a calculation of risk has been made, allowing a rational conclusion to be drawn. There *is* actually no linkage whatsoever between the numbers presented here and the extraordinary conclusion. It is actually now widely accepted in the radiological protection world that travelling by air is dangerous: If you fly across the Pacific, you will increase your risk of getting a fatal cancer. That increase in risk is very low, and it is one that most people would probably be prepared to take. (Sadly, the information is never presented in a form that the travelling public can access. Regulatory authorities in

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2 It is not my intention to review the extensive literature on this subject here. A useful introduction is provided by GE Adams ("Radiation Carcinogenesis", In: Introduction to the Cellular and Molecular Biology of Cancer, Eds LM Franks and N Teich, Oxford University Press, 1986, pp 154-175). The molecular nature of radiation-induced DNA lesions and their role in carcinogenesis and cell killing is reviewed by Bedford *(Int J. Radiation Oncology Biodogy and Physics, 21:* 1457-1469, 1991), Obe et al. *(Mutagenesis,* 7: 3-12, 1992), Ward *(Radiation Research,* 104: 103-111, 1985) and Steel *(Radiotherapy and Oncology,* 29: 71-83, 1991).

this country and elsewhere are more concerned about avoiding public concern that facilitating informed debate). The Committee appears to be arguing that, since airline stewardesses do not die quickly from radiation effects, low doses of radiation must be safe. This argument betrays a fundamental misunderstanding of the stochastic nature of radiation-induced cancer. As radiation dose increases, it's not the *severity* of the effect that gets worse, it is the *frequency.* There is an increased chance that aircrew will develop fatal cancer because of radiation exposure, but they won't do so quickly. The latent times for appearance of tumours are very long, whether the radiation dose is low or high. The Committee's analysis is thus a misrepresentation of our current understanding of the effects of low-dose ionizing radiation. This analysis goes on to say that:

The average annual dose to the public from all nuclear power activities in the UK is 0.0024 millisieverts per year. It is hardly a threat.

Again, this is an extraordinary statement. We've now averaged the radiation exposure from the nuclear power industry across the entire population of the UK. We've ignored the fact that some people working in the nuclear-industry are exposed to very much larger doses of radiation. But the conclusian is made that this is not a threat.

I have laboured the point in relation to this section of the Special Committee's report (Section 13.14 Myth Fourteen: Low doses of radiation are inherently dangerous). But is it noteworthy that the above are the only arguments the Special Committee offers to refute the view that low doses of radiation are inherently dangerous. The Committee's interpretation of the conclusions of the major international agencies on radiation effects is nonsensical, and directly contradicts prevailing scientific opinion. The only other two arguments presented (radiation doses to airline crews and to the public from the nuclear industry) do not actually address the question as to whether low doses of radiation are hazardous.

Let me illustrate further the logical-problems the Special Committee gets into by examining one other section of the report which discusses the effects of low-dose radiation. Individual risks from a variety of sources are compared with risks due to radiation in Section 5.3 (pages 49-50). The report estimates that the risk of dying of cancer due to radiation is about 5% per sievert, which I accept as being in line with current thinking. It is further stated, however, that:

the relationship is reasonably well-established, the actual risk could be greater but it is more likely to be less

We don't know why it's more likely to be less, but the Committee decides to take that position. In reality, there is considerable evidence to suggest that this risk estimate is not conservative, as noted below.

The report then points out that the average dose per person due to medical x-rays in New Zealand is about 0.3 mSv per annum and does some simple arithmetic to show that this represents about 50 deaths a year in NZ due to the medical use of x-rays. The Committee points out that this is not high, compared to other causes of death in New Zealand. The report then proceeds to state that the historical record of both the US Navy and the Royal Navy yields no nuclear accidents. Because exposure of the general public due to nuclear powered ships is so small, predicted deaths due to this cause must be almost vanishingly small. Of course it doesn't actually matter about the calculation that has just been presented; this conclusion stands without doing it. This is pseudo-science again; numbers are generated in support of a contention which actually bears no relationship to the calculations.

Well, let's look at the numbers used by the Special Committee. The calculation is based on medical x-rays, which contribute about only one eighth of the average ionizing radiation exposure in New Zealand. So the actual dose of radiation that we're all exposed to in a typical year is about 8 times higher than that. This leads to an estimate, using the Committee's own figures, that *deaths due to fatal cancers caused by ionizing radiation in New Zealand are currently about 400 a year.* Let's rank that against the other numbers that the Committee offers for causes of death:

Lung cancer	1300
Motor vehicles	600
Murder	60

Interestingly, deaths due to melanoma caused by ultraviolet radiation (about 200 p.a.) were not mentioned. None of these causes of death are considered insignificant in our society, and the problem of ultraviolet radiation exposure is widely considered to require public education and prevention. But, with a curious logic, the Committee somehow twists this comparison to imply that low doses of radiation are not hazardous. The available evidence does not show that low doses of radiation are harmless; it indicates exactly the opposite, and the figures used in the Special Committee's report argue that ionizing radiation at the levels we are already experiencing is a major health issue in New Zealand.

The induction of cancer by radiation at background levels is difficult to detect simply because the disease is very common and because radiation-induced cancers cannot be distinguished from cancers due to other causes. In addition the latent period before the cancer becomes detectable is very long. So it is essentially impossible to relate exposure of any one individual to subsequent outcome. These difficulties do not make radiation-induced cancers a less serious problem. There is a fundamental flaw in the logic used by the Committee at this point. Ionizing radiation is an *invisible* carcinogen, but this does not make it an unimportant one.

I'd like to conclude just with a very brief comment about the view of the Special Committee that the current risk coefficients for radiation-induced cancer are conservative: I think the first thing to look at is the historical record. After the discovery of x-rays just under 100 years ago, it soon became apparent that large doses of radiation produced serious biological effects (radiation necrosis in bone, cancers, etc) but these were considered to be restricted to sites receiving a large radiation dose above some presumed threshold. It wasn't until about 1934 that the newly-formed International Commission on Radiological Protection started to develop guidelines for the dose limits to which workers in the early nuclear industry should be exposed. They proposed a limit which, in modern units, corresponds to 460 mSv per annum. Using the risk coefficients that we currently accept, this would actually mean that working for 20 years in this industry would result in about a 5O% chance of developing a fatal cancer! The "acceptable" dose for radiation workers and for the general public has fallen progressively since that time, with the ICRP now recommending a dose limit of only 20 mSv for workers in the nuclear industry and 1 mSv per annum for the general public. This demonstrates how dramatically our appreciation of radiological hazards has changed in the course of this century. There has been a continuous monotonic decrease in the dose of radiation which is consldered to be acceptable, and there are strong reasons to believe that this trend is continuing. The most widely-accepted reports currently place this risk at about 5% per Sv which already makes ionizing radiation, at the levels we all receive in our daily life, an important contributor to cancer as noted above. The CNR report by Prof John Goffman, which is based primarily on epidemiological data at low radiation dose but was ignored completely by the Special Cornmittee, suggests a risk coefficient considerably higher. And there is now substantial experimental data (e.g. failure of repair induction at low doses, supralinearity due to cell killing at high doses) to suggest that further downward revision of internationally accepted risk coefficients may well occur over the next decade.

In conclusion, the report of the Special Committee on Nuclear Propulsion misrepresents prevailing scientihc opinion as to the health implications of low doses of ionizing radiation. It is not my objective to argue that radiological hazard issues are of paramount importance in the debate about nuclear powered shipping. Militarism, political independence and broader aspects of public health and the environment are all central issues. However, it must never be forgotten that radiation is dangerous, and the facile reassurances of the Special Committee cannot be allowed to distort the fact that there is no radiation dose which is without health implications. Despite Mr Bolger's recent contention that the Nuclear Powered Ships debate is now an environmental issue, not a safety issue, we need to remember that the threat to the environment ultimately stems from the pernicious and long-lasting health effects of ionizing radiation to all living things.

A critique of some parts of

The Safety of Nuclear Powered Ships

Peter Lorimer
Department of Mathematics and Statistics
Centre for Peace Studies
University of Auckland

THE FIRST FINDING

The first finding of the Special Committee on Nuclear Propulsion is:

"The presence in New Zealand ports of nuclear powered vessels of the navies of the United States and The United Kingdom would be safe. The likelihood of any damaging emission or discharge of radioactive material from nuclear powered vessels if in New Zealand ports is so remote that it cannot give rise to any rational apprehension."

This is the first of the seven findings *of the* Committee as published in their 269 page report *The Safety of Nuclear Powered Ships.* In that the report is long and cost so much it is not too much to ask that it set out the evidence clearly and convincingly and, in that it uses the word *"rational",* we should expect it to include a clear argument from its evidence to its conclusions.

The purpose of this critique is to examine the evidence offered, to investigate the argument which leads from the evidence to the First Finding and to compare it with similar findings of others. The conclusion reached is that:

(1) apart from the present safety record of nuclear powered vessels, the evidence consists only of statements by agencies of the Governments of the two interested countries, the US and the UK.

(2) the argument from the evidence to the First Finding is crude and mostly invalid

(3) contrary to the first finding, the US Navy does have an apprehension about damaging emission or discharge of radioactive material from nuclear powered vessels to the extent that it does not allow them to visit New York or Boston after *"such factors as tide and current characteristics, harbour traffic, population density near the proposed berth, etc. were taken into consideration and weighed against a possible nuclear accident for the power plant, not necessarily a worst case analysis."* The Australian Nuclear Safety Bureau has the same apprehension about visits to Sydney and does not allow these vessels to visit that city.

The critique is in three parts, one devoted to each of these points.

The evidence

The firmest piece of evidence in the report which is relevant to the First Finding is this:

(1) "The US navy has amassed aver 4100 reactor-years of operating experience and there has never been a nuclear accident." "The 18 nuclear powered submarines in the Royal Navy have czn operating experience of over 300 reactor years and there has been no inacdvertent release of fission products from the uel."

Although these figures are not uncontroversial, for instance they corne from government agencies with an interest in keeping them looking good, the US Departments of Energy and Defence and the Royal Navy, it is not my purpose to discuss them further here. But, notice the emphasis in the UK figures on the fuel (the underlining comes from the report). Are we supposed to think that there have been leaks from other sources? It is an unfortunate thing about the report that many things are not spelt out fully enough for them to be fully accepted by the sceptic.

This can be thought of as the $10 piece of evidence, because that is about how much it would cost to collect it.

The other relevant evidence in the report be summarized as follows:

(2) The Committee received information from a number of government agencies in the US and the UK, namely;
(1) the Navy, the Department of Defence, the General Accounting Office, the United States Nuclear Regulatory Commission and the Advisory Committee on Reactor Safeguards in the US.
(2) the Navy, the Nuclear Powered Warships Safety Committee, the Nuclear Installation Inspectorate and the Safety and Reliability Directorate in the UK.

The committee concluded that *"in the Naval Reactors division of the U.S. Navy a sound quality assurance and safety management regime is in place. The strong and uncompromising emphasis on safety has impressed us with its rigour* and that *as with the American nuclear powered fleet, but for different reasons, we believe that quality assurance and safety management are thoroughly in place on the Royal navy nuclear powered submarine programme."* However, no hard evidence of these things is provided to us: we are just asked to accept the assurances of the Committee, based on the assurances of their sources. So, these conclusions can be accepted only to the extent that these Government sources can be trusted.

(3) "The maximum design accident, the probability of which is assessed to be no greater than 1 in 10,000 years may result in a slow release from the primary to the secondczry contaanment of up to 40TBq (1,000 curies) of Iodine-131 together with up to 4PBq (100,000 curies) of other volatile and gaseous fission products. Secondary containment procedures ensure that only a small proportion of this

release will reach the atmosphere. A more serious accident, the probability of which is estimated to be no greater than 1 in 1,000,000 years, is one in which the primary containment is breached. It may result in a more rapid release of up to "4BPq (10,000) of lodine-131, together with 400FBq (10,000,000 curies) of other Volatile and gaseous fission products." This is part of the response by Mr. Stanley, the UK Secretary of State for Defence, to a Parliamentary Question in 1987 and is significant for us because the Committee regards at as being *"the most authoratative quantitative estimate made available to them."* Like the other statements, it is to be trusted to the extent that its authors, Mr. Stanley and his advisers, are to be trusted.

(4) Mr F R Farmer, who the Committee assures us is a member of the secret UK Safety and Reliability Directorate, said in a TV interview, that the probability of a *"maximum design accident is so low as to be near absolute zero, lower than any number I could put my confidence on."* Again we are offered this on authority of the person quoted.

The deductions

The First Finding is written in terms of the word *rational* and it seems appropriate to consider the path from the evidence to the finding in terms of its rationality. If the Mathematics in the report is soundly based and leads us logically from the evidence to the finding, then we will be forced to accept the finding. If, on the other hand, the arguments in the text show a lack of understanding of what they are about and apply mathematics inappropriately, then we will be forced to reject the assurances of the Committee about the safety of the ships. A close scrutiny of the report forces us into the second position.

Types of risk

The report continually confuses three different types of risk.

In Chapter 2 we are told: *"In home or office we usually feel safe, so much so that we never think about it. This is not to say that the risk is zero,, though it might be small. There may be a fire or an earthquake, an attack by an intruder or a meteor strike."* (You might ask why workshop, forest and farm is not included along with office.) While it is true that we are continually in peril frorn many dangers, one of the main purposes of a house or office is to reduce the risk that we are subject to: for example, by keeping our houses warm *we* reduce the risk that we will die of exposure.

The second type of risk is that taken by riders of bicycles and those of us who undergo medical applications of radiation. The report tells us that 30 cyclists are killed each year in New Zealand by being struck by motor vehicles. However, it would be wrong to divide 30 by the population of New Zealand, (say 3 million), and conclude that the risk of death for each of us is 1 in 100,000 because all the risk is concentrated on those among us who are cyclists: the risk of most of us being killed last year in this way was zero because we didn't get on a bike even once. The report tells us that “the average annual dose to New Zealanders from medical applications and dental X-rays” is 0.4 mSv: Again, the risk is concentrated in a particular-section of the population, those who submit to dental X-rays and those ill enough to need radiataon treatment. According to the report itself, the amount of radiation given in radiotherapy for specific organs is well above the amount that gives a 50% chance of death and is even off the scale they use: it is simply not useful to average these huge doses over the whole population.

The third type of risk is that with which the report is principally concerned, that from visits of nuclear powered vessels This type of risk is different again in that its present value is known to be zero for all inhabitants of New Zealand and it can only increase if ship visits are allowed.

As part of their appeal to *“rationality”* the committee wants us to compare the risk of a ship visit with the risks that all of us take everyday and the risks that some of us take some of the time: those comparisons are not plausible.

Independent events

According to the chapter of the report on "Risk in Perspective", *"Uncontained accidents could theoretically occur but are far less likely even than the scenarios depicted above. This is because a number of events, each in itself highly improbable, would have to occur together and independently."*

It is a common fault of writings on risk analysis to confuse independent events and conditional ones. Thus, by way of illustration, here is a simple example: two things that could go wrong on a ship are that there could be a fire and that the fire-fighting equipment could become inaccessible As a fire could cause the eqiupment to become inaccessible, these two events cannot be regarded as being independent. The same is generally true of any set of things that might go wrong in the confined spaces of a ship: if one goes wrong it will usually increase the probability of others going wrong as well. Unless there is good reason for it, events should not be treated as independent. At the other extreme from the independent case is the possibility that if any one of a number of things goes wrong then they all will. The truth will usually be somewhere between the two and there seems to be no good reason for the committee to adopt the extreme position of complete independence. The attraction of independent events is that the probability of them all going wrong together is easy to calculate.

The Anti-nuclear game

The report contains 3 remarkable tables taken from a book, *The Anti-nuclear Game* by Gordon Sims and published in 1990. Although these tables are not refered to in the text it must be supposed that they are there to support the Committee's findings and one of them certainly gave the New Zealand Herald its headline *Nuclear ships 'safer than bicycles'.*

TYPICAL RADIOACTIVITY CONCENTRATION PER LITRE FOR A NUMBER OF LIQUIDS

Type of Liquid	Radioactivity Level (Picocuries per Litre)
Typical Nuclear Plant Waste-Water Discharge	Less than 10
Domestic Tap Water	20
River Water	10 - 100
Beer (4 percent)	130
Ocean Water	350
Whisky	1,200
Milk	1,400
Salad Oil	4,900

From The Anti-Nuclear Game, G Sims (SIM90)

Box 8.2

According to the first of the tables, typical nuclear plant waste water discharge has a radioactivity level of less than 10 picocuries per litre. As it also tells us that domestic tap water has a level of 20 and river water has 10 to 100 we might ask ourselves where the typical nuclear plant gets the water that it discharges at a level of 10? To have any sort of credibility, a statistic like this needs some explanation, but none is offered. By comparison the report also tells us that sea water close to the nuclear processing plant at Windscale (Sellafield), has a radioactivity level of more than 200 picocuries per litre due to Caesium-137 alone! Are these figures consistent?

The second table from this book, Table A10.1, *is* headed *"Loss of life expectancy due to various causes"*. Being unmarried and male, for example, leads to a loss of life expectancy (LLE) of 3,500 days. However, like many things in the report, it is not at all clear what this means. Does it mean, for example that the average age at death of an unmarried male (including children) is 3,500 days less than the average age at death for the whole population? or does it refer to males of an age at which marriage is relevant or what? The figure that appealed to the sub-editor of the Herald was that accidents to bicyclists leads to an LLE of 5 days and again it is hard to imagine what the figure means: does it refer to cyclist only or to cyclists who have accidents or what? Presumably the relevance of the table to the report is that the LLE due to reactor accidents is in the range of 0.02 to 2 but, again, it doesn't tell us what this means: is it the LLE of a few spread over the whole population or what? the report gives no clue.

Table A10.1

LOSS OF LIFE EXPECTANCY DUE TO VARIOUS CAUSES

Cause	LLE (Days)
Being unmarried - male	3,500
Cigarette smoking - male	2,250
Heart disease	2,100
Being unmarried - female	1,600
Being 30% overweight	1,300
Being a coal miner	1,100
Cancer	980
Being 20% overweight	900
Cigarette smoking - female	800
Stroke	500
Dangerous job - accidents	300
Motor vehicle accidents	207
Accidents in the home	95
Suicide	95
Being murdered - homicide	90
Average job - accidents	74
Drowning	41
Falls	39
Accidents to pedestrians	37
Safest job accidents	30
Fire - burns	27
Poison (solid, liquid)	17
Firearms accidents	11
Natural radiation	8
Coffee	6
Oral contraceptives	5
Accidents to bicyclists	5
Reactor accidents	0.02-2*
Radiation from nuclear industry	0.02*

Data are from US sources. Estimates have been compiled by the Union of Concerned Scientists, the most prominent anti-nuclear critics in the USA. The items marked with an asterisk are deliberately worst-case figures. They assume that all US electrical power is nuclear. The lower number is the estimate of government-sponsored scientists, and the higher number is the estimate of nuclear critics.

From: The Anti-Nuclear Game, 1990 (SIM90)

Table A10.2

ACTIVITIES WHICH INCREASE RISK OF DEATH BY ONE IN A MILLION

Activity	Cause of Death
Smoking 1.4 cigarettes	Cancer, heart disease
Spending 3 hours in a coal mine	Accident
Travelling 480 km by car	Accident
Flying 1,600 km by jet	Accident
Flying 9,600 km by jet	Cancer caused by cosmic radiation
Living 2 months in a stone or brick building	Cancer caused by natural radioactivity
Living 2 days in a large city	Air pollution
Eating 500 grams of peanut butter	Liver cancer caused by aflatoxin B
Eating 100 charcoal-broiled steaks	Cancer from benzopyrene
Living 5 years at the boundary of a nuclear power plant	Cancer caused by radiation
Risk of accident due to living within 8 km of a nuclear power plant for 50 years	Cancer caused by radiation

From: The Anti-Nuclear Game, 1990 (SIM90)

The third table tells us that smoking 1.4 cigarettes will increase the risk of death by one in a million. A nice statistic, but what exactly does it mean: is it the risk of death while they are being smoked or the risk of death over the next year or what? Does living 2 days in a large city increase the risk of death by one in a million during those 2 days or during the next year or what? It doesn't make sense to write about *the risk of death* as though that term had some meaning of its own. We know, for example, that we are all going to die during the next 200 years and there is no way we can increase our risk of death *over that time period.*

The Cornmittee has include three tables from *The Anti-Nuclear Game* in its report. While they have not formed a central part of their argument, in fact they have not been mentioned in the report at all, we must wonder why they have been included. And their spurious nature cannot help but throw doubt on the rest of what the Committee has written.

Accident frequencies

The graphs in Figure 5.1 illustrate six type of events which have or might cause fatalities. They appear to all refer to the whole of the USA except that for 100 nuclear reactors. The first thing you will notice is that only three of them are based on the historical record, the others being the results of calculations. Next you will notice that both axes for the graphs are on log scales, not the usual linear scale we are mostly used to. And, when you look at the curves for fire and aviation, you will see that they have a feature not shared by the other four: they have a point of inflection to the left of which they are convex downwards and to the right of which they are concave up.

According to the report, *five of these six curves share a feature which is comman for most man-caused events, namely that the frequency falls faster than the increase in consequence. For example in the case of air accidents, while accidents with more than 10 fatalities have an estimated frequency of about 8 per* *year, accidents with more than 100 fatalities haue a frequency of about 0.3 per year.* However, the point of inflection on the curve for aviation ought to have alerted the Committee that something else might be happening. In fact it can be read off the same curve, but to the right of the point of inflection that while the number of accidents with more than 206 deaths is 0.1 per year, the average number with more than 590 is about 0.05: accidents causing about three times as many deaths are only about twice as rare on this part of the curve.

The committee tells us that *"In attempting to assess the safety of any class of hazard it is vital to keep this general picture in mind."* In that they seem to have this picture twisted, we are entitled to question their ability to assess the safety of the hazards of Nuclear Ship Visits.

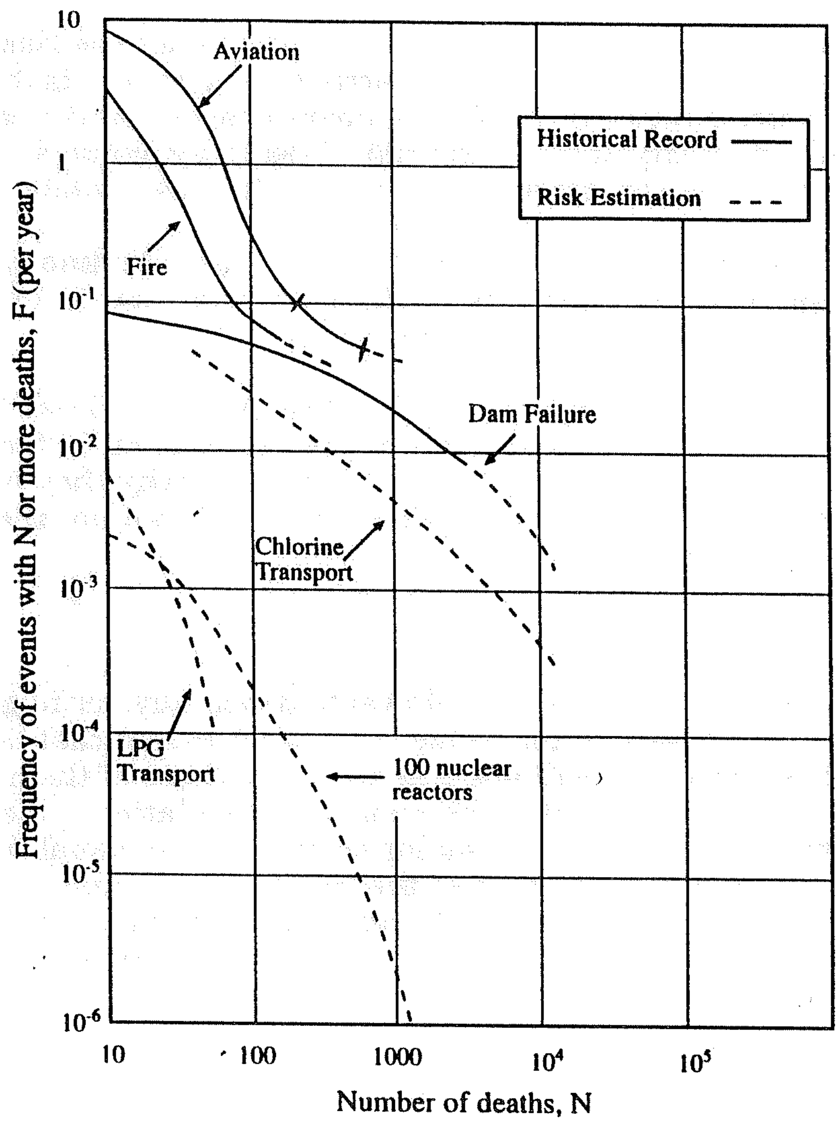

Figure 5.1
ACCIDENT FREQUENCIES

Frequency of man-caused events involving fatalities in USA (Coppola and Hall, 1981 as cited in ROY92). All of the curves show exceedances. That is they show the frequency of events which result in the number of deaths greater than a given figure. For the more common accidents or those for which a longer historical record is available, the curves are obtained from an analysis of historical occurrence. The frequency of less common events can only be estimated from theoretical considerations. This method can be applied both for extending curves based on the historical record into the low frequency region and for estimating frequencies of classes of accidents for which there is no historical record. The curve labelled 100 nuclear reactors is for 100 nuclear power reactors each with a thermal power of around 3000 MW(t).

The indicative frequency - consequences curve.

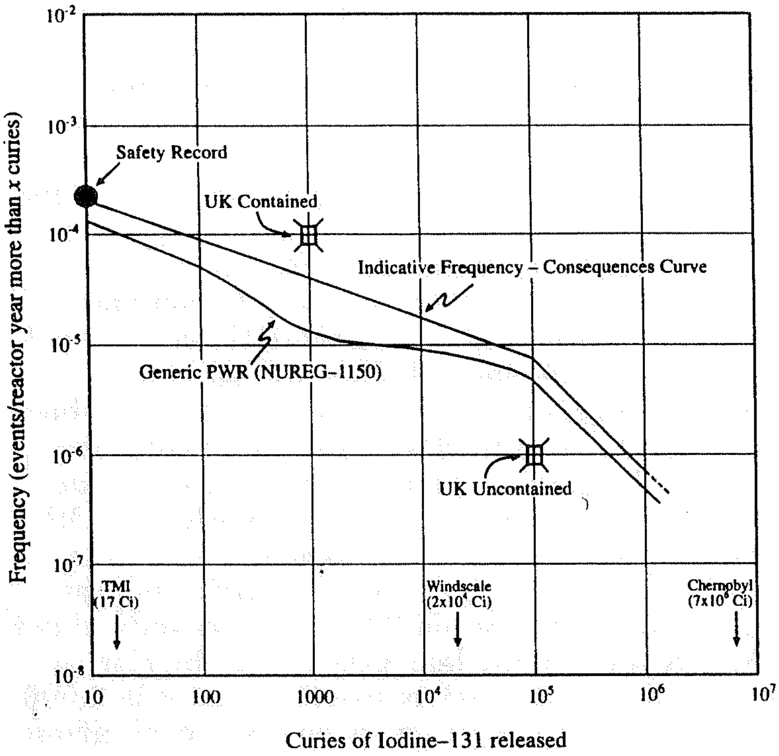

Figure 5.2
INDICATIVE FREQUENCY-CONSEQUENCES CURVE

Indicative frequency-consequences curve for naval nuclear propulsion reactors (refer to the text for a full discussion). A feature of all data shown in this graph is the very low frequencies associated with all estimates of release. A frequency of 10^{-4} per year corresponds roughly to one event in the period of time from the last ice age, whereas a frequency of 10^{-6} per year represents one event in the time since the beginning of the Pleistocene Epoch in geology and mankind's first beginnings.

Figure 5.2 purports to contain a curve giving the relation between the number of curies of Iodine-131 released in an accident and the frequency of there being an accident releasing more than that. The lower curve in the figure is the result of a theoretical study of three pressurized water reactors (PWR's). The indicative frequency - consequence curve is drawn to be of much the same shape of that for the PWR and parallel to it. Given that assumption, the only question remaining is: how far apart should the curves be? On the basis of the $10 "fact" that the US Navy has had zero accidents in 4000 reactor years, the report has a pseudo calculation that the actual frequency is as great as 1 in 5000 years. Although some calculations are given in terms of what is usually called a Poisson process, these are a great simplification and this figure has to be treated as the result of guesswork on the assumption, of course, that the US Navy is telling the truth about their accidents. An interesting thing now, is to find out what has been done with this figure of 1/5000 which can also be written as $2x10^{-4}$. The authors have used it to *"anchor the curve at its left hand end"*. They have used it to assert that the point labelled "Safety Record" in the figure lies on the graph and so find how far apart the two curves in the figure should be. The trouble with this procedure is that graphs drawn with a log scale on the horizontal axis don't have a natural left hand end! They will keep going as far as you like to the left without reaching zero! The committee has adapted the hidden assumption that the accident with a frequency of 1 in 5000 per reactor year, leads to a release of 10 curies of Iodine-131: why not assume a release of 1 curie or 1/10 of a Curie or, in the other direction a release of 100 curies and so on. The point is that "anchoring a curve at its left hand end", as they say they do, has no meaning.

Given the theoretical nature of the Generic PWR curve , the fact that the other is just drawn more or less parallel to it, the doubtful nature of the probabilistic calculation and that we don't know how far apart to draw the curves anyway, it has to be concluded that the information in the indicative frequency - consequences curve is not of any value at all.

And what does the report conclude from all this strange Mathematics? One thing is that *comparison with Figure 5.1 shows that all of the frequencies being discussed are around <u>one thousand times less</u> than those associated with accidents due to fire, aviation and dam failures.* We are now asked to compare two wildly incomparable things. In the first place, Figure 5.1 plots the number of deaths against a frequency and Figure 5.2 plots curies of Iodine-131 against a frequency. In the second case, Figure 5.1 appears to refer to fires etc for the whole of the USA and Figure 5.2 refers to a reactor in one nuclear powered vessel. If there was any sense at all in the graph in Figure 5.2, we might rightly conclude that if the danger of one nuclear powered vessel is comparable to one-thousandth of the risk of fire in the US, then they are dangerous indeed. Another spurious deduction that the committee could easily have taken from the two tables is that 100 nuclear reactors each with a thermal power of around 3000 MW are only about 10 times as dangerous as one 165 MW reactor in a nuclear vessel. Or the risk of one such reactor on a vessel is about the same as the risk of fire in a city of 200,000 people in the USA or much the same as the risk of 10 reactors on land, each about 18 times as powerful!! It is amazing what can be done with Mathematics.

The indicative frequency-fatalities curve.

According to the report, "*the issues involved in determining societal risks are becoming better understood through the work of groups such as the UK Health and Safety Executive (HSE) and the Royal Society. In particular, HSE has developed the concept of societal risk thresholds which include uarious levels af local and national intolerability for deaths from industrial and other accidents, ie risk levels, expressed as a combination of frequency and consequences, that society deems to be just tolerable. These are depicted in Figure 9:4."*

The first thing to notice here is that, after a little further calculation, th Indicative Frequency-Fatalities Curve has been added to the figure and is found to be in the region of negligible risk. Given the meaningless nature of that curve, its presence there is of little comfort,

Next, let us look at the table itself in detail. Although at is not really made clear in the report, the Negligibility Line is presumably the boundary between which some locality (which locality we are not told!) would distinguish between a negligible risk and one that is tolerable and as low as reasonably possible (ALARP), Thus <u>something</u> which causes an accident leading to <u>one or more deaths</u> might just be tolerated <u>by this locality</u> if it is likely to occur once every 10,000 years. There are immediately two things wrong with this statement: first, we are not enlightened as to what the <u>something</u> is (is it an industry or a machine in an industry or what?) and, second, we are not told what <u>locality</u> means -- as the whole thing is eventually applied to the locality of a port in New Zealand, this is of crucial importance.

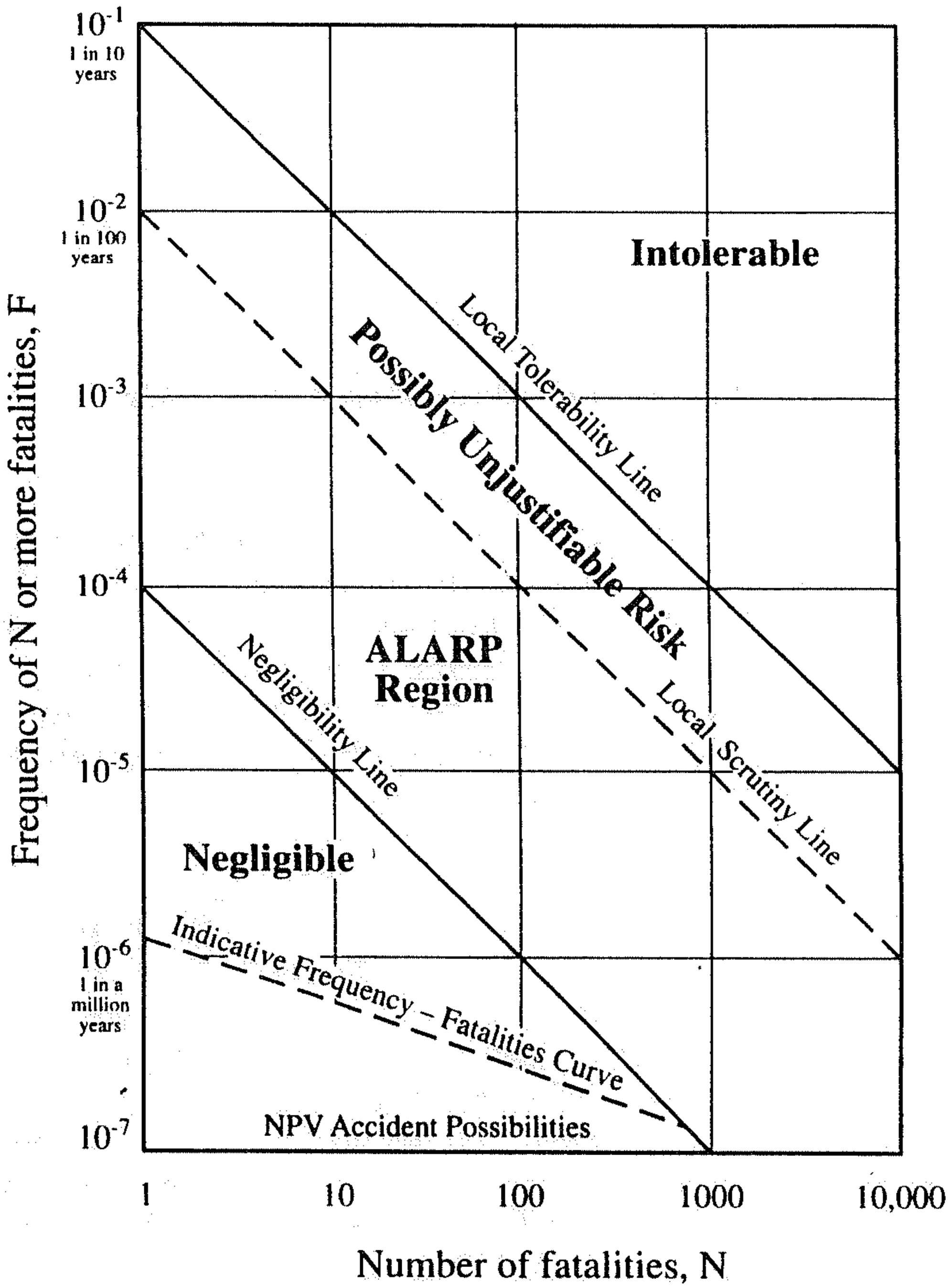

Figure 9.4 **INDICATIVE FREQUENCY-FATALITIES CURVE**
Adapted from Risk: Analysis, Perception and Management. Report of a Royal Society Study Group, London 1992 (ROY92)

Another important point worth mentioning here is the theoretical status of the figure. If something like this is going to be applied to our situation then it had better be based on a lot of reliable information which is relevant to our situation.

However, it is clear from its schematic form that it is based on the barest of information using the broadest of guesswork. Improvement of this sort of thing comes by collecting more relevant data. Thus it would be more sensible to use what is known about the way that nuclear technology is tolerated in New Zealand to improve the figure rather than to use the figure to tell us how nuclear technology should be tolerated.

These truly basic flaws in Figure 9.4 make nonsense of any possible application to the safety of nuclear powered ships.

Conclusions about other ports

On the basis of the evidence and what they have deduced from it, the Committee has come to its First Finding. *"The likelihood of any damaging emission or discharge of radioactive material from nuclear powered vessels if in New Zealand ports is so remote that it cannot give rise to any rational apprehension."* Given the criticism made here it is now reasonable to ask whether any responsible bodies elsewhere in the world have come to different conclusions. If this is the correct conclusion to come to for New Zealand ports then must it not also be the correct conclusion to come to for all ports?

At the end of the last Chapter, just before their findings, the Committee quotes from Captain James Bush, Associate Director of the US Centre for Defense Information: *"though the criteria used to answer each request (to visit a particular port) were different, in general, such factors as tide and current characteristics, harbour traffic, population density near the proposed berth, etc were taken inlo consideration and weighed against a possible nuclear accident for the reactor plant, not necessarily a worst case analysis."* On this basis *"several desirable US ports such as downtown piers in New York, Boston, etc would not be considered."* We note that the US navy appears to have an apprehension that something could go wrong! Further down the same paragraph the Committee writes: *"At present, and based on the Reference Accident, Sydney is not considered to be suitable for visiting by a nuclear propelled warship."* The Australian Nuclear Safety Bureau appears to share the same apprehensions as the US Navy and who could say that these are irrational`?

GREENPEACE
NEW ZEALAND

Seminar on the safety of nuclear powered ships
Centre for Peace Studies
July 3, 1993.

Stephanie Mills, Greenpeace.

I would like to begin by acknowledging the areas of commonality I hope we all share, whichever side of the debate we are on. They include a genuine desire for nuclear and conventional disarmament; a concern about the threat of nuclear proliferation, both vertical and horizontal; and a desire for a new world order based not on force or nuclear terror but equality between people and nations.

The world, as Professor Poletti points out, has changed.

In Sweden last month, the USS San Jacinto, a nuclear capable ship, confirmed that it had no nuclear weapons on board. Its tomahawk cruise missiles are on land, probably in bunkers in Virginia.

The "Neither Confirm Nor Deny" regime was not broken by the Swedish Government asking difficult questions, but by journalist from a daily newspaper. The Captain gave a relieved response: "..it is wonderful not to have your hands tied.... Now we no longer have to come up with dumb answers"

As the "Neither Confirm Nor Deny" response has been cracked open by the end of the Cold War, and the veil of secrecy lifted on this area of the nuclear state, so too must it on the issue of naval nuclear propulsion.

Parallel to this move in Cold War thought, I believe, is a shifting scientific, ethical and political thought from the paradigm of assimiliative capacity - the permissive approach - to the precautionary approach.

At the heart of the debate about risk and safety - relating to nuclear ship visits or other human activity - lies this paradigm shift.

The precautionary principle recognises the vulnerability of the environment and the scarcity of resources; it acknowledges the limitatians of science; and it reverses the burden of proof. The precautionary principle was adopted at the Earth Summit, and has been taken on board by many international fora, including the London Convention on the Prevention of Marine Pollution, formerly known as the London Dumping Convention.

The precautionary principle challenges the assumption that humans

GREENPEACE NEW ZEALAND INC. PRIVATE BAG 92507. WELLESLEY STREET, AUCKLAND
TELEPHONE 64 (09) 377 6128. FAX 64 (09) 303 2676.

can “manage” the environment by deciding how much damage the Earth, - or the oceans - can safely absorb without harm. It challenges our assumption, that once a system's assimilative capacity has been decided that we can then and will see to it that no greater damage is permitted by setting limits. It also challenges the assumption that we already know which practices and which substances are harmful and which are not...or that in the case of practices and substances that we never suspected are harmful, we will be warned in advance of their possible dangers by traumatic but sub-lethal shocks.

Recent history shows that these three assumptions are wrong. For example, “healthy” levels of exposure to radiation have consistently been revised downwards over the past decades. A re-evaluation of Hiroshima and Nagasaki survivors has estimated that the risks from radiation are three times higher than previously thought. In the UK, public dose limits are likely to be reduced from 5 millisieverts (mSv) to 1 mSv annually. In the US, the Atomic Energy Commission set.a limit for workers of 36.5 rems year in the 1950s; today the international standard is 2 rems annually. Standards have too often been arbitrary, and set at the edge of the nuclear industry's operating ability, rather than according to public health criteria.

Objective risk, a tool of the assimilative approach which has too often been used to narrowly assess risks without regard for the environment or the limits of current scientific knowledge, has also resulted in assessments, for example, of "reference accidents", based on what scale of accident is considered most "likely". However, it is clear that the unthinkable - the Erebus, the Chernobyl, the Exxon Valdez - does occasionally happen,, and that this is the risk people are most concerned about. Judged from our limited knowledge of nuclear naval history, nuclear accidents may be rare, but they are also quite serious.

It should also be mentioned that most serious industrial and transport accidents that happen have similar low probabilites of occurence.

A different approach to risk underlies the precaugionary approach. This approach goes beyond "objective risk”, which tends to focus on a specific activity at a specific point in time in isolation. The precautionary approach mandates an assessment not just of objective risk, but of alternatives. This approach has been adopted to some extent in New Zealand's Resource Management Act.

This means assessing the risk in absolute, rather than relative terms, and assessing the costs and benefits of the risk ie what hazards are tolerated to achieve what gains. Compared to other sets of risks and benefits, nuclear powered ships visits are an unacceptable risk, the New Zealand public have concluded, because they bring no particular benefits.

Based on the precautionary approach, Greenpeace is working worldwide for a global ban on nuclear propulsion. The precautionary principle is also the basis for Greenpeace's work on the elimination of all toxic, persistent and bio-accumulative substances and the promotion of the philosophy and practice of clean production; it also drives our campaign to protect our atmosphere from human-induced climate change by moving from dependence on fossil fuels towards greater energy efficiency and renewable forms of energy.

Greenpeace sees some encouraging signs pointing towards a ban on nuclear propulsion.

There is a trend to reduction in size and operations of the nuclear navies' nuclear-powered fleets, which may also lead to a reduction in the number of accidents. However this is not assured. Both the US and Russian nuclear submarine fleets experienced some of their worst disasters when the number of nuclear submarines was low. Also, the two recent collisions between US and Russian nuclear-powered submarines indicate that even lower operational tempos do not mean necessarily fewer serious accidents.

Although there are several lesser steps which could be taken to reduce the possibility of a serious accident - improved internal safety measures, better rules of the road governing nuclear submarine operatians, limits on nuclear submarine operations - and also steps which could be taken to improve accident response - better damage control, quick notification of problems,assembling international rescue and remediation teams - the optimal solution for eliminating the naval nuclear danger to the marine environment is a ban on nuclear propulsion at sea.

Several military, financial and political actors make this solution both desirable and feasible.

Nuclear-powered attack submarines were uniquely suited to the Cold War and a conflict between NATO and 'the Warsaw Pact. With the end of the Cold War and US-Soviet political confrontation, the US nuclear submarine force lacks any significant mission. Since the majority of Soviet nuclear-powered general-purpose submarines were for attaeking US submarines and carrier battle groups, their missions too are marginal. Already the number of general purpose submarines are declining precipitously and building programmes have been greatly reduced.

Nuclear powered ballistic missile submarines are also in decline. The US force will dwindle from a highpoint of some 40 submarines in the 197Os to 18 by the end of the decade. Conceivably these numbers may be further slightly reduced. In any event, the first eight Ohio class Trident submarines will begin to be retired around 2011 at the end of their 30 year lifespan. Currently, no new ballistic missile submarines are under design. The Russian force is also being reduced dramatically. Approximately 40-50 ballistic missile submarines will be retired as the Russian force shrinks to some 20 submarines by the end of the decade. Again, this force could decline further.

In tandem, new nuclear-powered vessels are becoming increasingly expensive even as the decommissioniong costs for older vessels are becoming apparent. The new US Seawolf nuclear submarines will cost more than a $1 billion each. Their anticipated follow-on, the Centurion class, will likely cost almost as much per unit. Decommissioning costs for 100 US submarines, including the scrapping of 85, are estimated to be $2.7 billion by the end of the decade. The crisis facing the Russian Navy in decommissioning its nuclear powered submarines is well described in the recent Yablokov Commission report on Russian radioactive waste dumping at sea.

The political costs of naval nuclear propulsion are also ever-increasing. Not only are naval reactors banned from New Zealand, Iceland and Denmark, but they are also controversial in Sweden and Japan. Iceland has brought up the subject of a safety regime for nuclear-powered vessels in the North Atlantic at the Unitecl Nations twice in the 198Os, as a result of the Mike submarine sinking. If another serious accident befell a nuclear vessel, more political opposition to their presence would result.

In short, the cost of nuclear power at sea is increasingly outweighing any supposed military benefits. The threat nuclear naval vessels pose to non-nuclear and nuclear countries alike in peacetime demands that steps are taken or an agreement is reached soon on a global ban on nuclear propulsion. A ban would not eliminate all sources of radioactive threat to the ocean environment, but it would abolish a radioactive threat that is particularly pernicious due to the secretiveness and widespread nature of nuclear submarine operations; the ability of naval nuclear accidents to affect innocent bystanders - the oceans and non-nuclear countries - and submarine operations frequent proximity to rich fishing grounds

So, what of the question in focus here, the safety or risks of nuclear powered ships?

On land, nuclear technology is subject to attempt's at rigorous and complex safety and monitoring proceedures. In the case of civil nuclear power, it is in the hand of institutians who are, in theory at least, answerable not only to the general public of their nation, but also to international regulatory bodies. Although the effectiveness of this apparatus is questioned, at least there is some semblance of control. At sea, even this is not the case.

The design of nuclear power reactors for military ships and submarines are not subject to the sort of safety evaluation, enforced upon civiliari design, and yet the conditions of operation and performance required by the military are often more demanding and so a11ow narrower safety margins. Once deployed there exists no body with responsibility for monitoring, let alone regulating, the operation of nuclear power at sea. No guidelines are set on safe proceedure, no sanctions exist against those who violate obvious codes of good practices, although recent collisions (in March 1993 off the Kola Peninsula and in February 1992) between US and Russian submarines are changing this.

The loss or accident of a US submarine thus remains an ever present concern to the US Navy. To quote from the US Navy Safety Centre's survey of selected ship collisions;

"In the past l0 years there have been five cases of submarines, at periscope depth, colliding with surface ships. The history of submarine disasters yields chapter after chapter of collision at periscope depth, or en route to periscope depth. ... Hit by a surface ship from the rear, a submarine will crack like eggshell. This was demonstrated by STICKLEBACK in the late 195Os. Numerous nuclear submarine collisions have caused severe damage to the sail. It is only a coincidental matter of relative depths that have saved us from further catastrophes."

We aiso have specific concerns about the several of the conclusions of the Nuclear Ships Safety Committee. The Committee makes errors in fact, raises red herrings, makes methodological mistakes, and exhibits a pro-nuclear bias.

This leads the Committee to not fully examine all the safety issues regarding nuclear-powered vessels, raises questions about the Committee's understanding of the presence or absence of reactor safety features on nuclear-powered submarines, and leads to misleading conclusions abaut the possibility of an accident occurring.

An independent review of the Committee's report would be useful. Also, another investigation into the safety of nuclear ships should incorporate more than a narrow examination of accidents involving the nuclear power plant. A broader view of the safety of nuclear-powered ships visiting New Zealand that looks at the possibility of non-reactor events -- e.g. fires and collisions -- which could affect the safety of the reactor is needed.

Finally, to make more clear the balance between risks and benefits, some investigation of the benefits or drawbacks of accepting nuclear-power at sea should be conducted.

Some examples of these concerns follow.

a. Factual problems

On pages 163-164, the Committee claims that Emergency Core Cooling Systems (ECCSs) are a part of all naval nuclear propulsion reactors. It quotes approvingly from U.S. and U.K. statements which claim sea water is available for emergency cooling or that mechanisms are available to cool the reactor in the event of loss of electrical power.

The U.S. and U.K. statements are true, but misleading in this case. In the Glossary, ECCSs are defined as "Nuclear reactor safety system designed to cope with loss of coolant accidents." ECCSs are commonly understood to provide injection of water INTO the primary coolant loop to cool the reactor core in the event of the loss of coolant.

Neither the U.S. or U.K. statement deal with providing emergency cooling to the reactor core in the event there is a loss of coolant. The Committee provides no evidence that what is usually understood to be an ECCS exists in nuclear-powered submarines or surface warships.

In fact, the diagram on page 37, shows what is the case: that there can be emergency cooling OF the secondary circuit and also there are mechanisms to provide emergency cooling OF the primary circuit. But there is no indication that there are mechanisms to provide emergency coolant to the reactor core of a nuclear-powered submarine if there is a loss of coolant.

b. Red Herrings

On pages 159-160, the Committee explains why a nuclear reactor cannot explode like a nuclear weapon. The Committee's desire to correct the public's misunderstanding of reactor physics serves to obscure and leave unexamined the more interesting and pertinent question for the Committee's inquiry: the circumstances when nuclear reactors can explode.

Although, it is physically impossible for reactors to explode like nuclear bombs, they can still explode, with fatal consequences. For example, in January 1963, the SL-1 reactor at the Atomic Energy Commission's Idaho Fa11s, Idaho, National Reactor Testing Station, exploded releasing large amounts of radiation and killing several workers. The explosion resulted when a control rod was withdrawn too far during maintenance, leading to a large increase in reactivity and a sudden increase in steam pressure. This blew the lid off the pressure vessel.

Another example is a reactor explosion which occurred on a Soviet submarine at a naval facility near Vladivostok in August 1985. At the end of a refueling the reactor vessel's lid was being reset when it tilted, raising some attached control rods. A reaction resulted which led to a steam build-up or even the vaporization of fuel and then an explosion. Ten crew members were killed instantly and some 7 million curies of short and long-lived radiation were released.

c. Problems in method:

The Committee's investigation is too narrowly focussed on reactor accidents. Accidents which could affect the reactor are not examined.

This is peculiar because the two most serious U.S. nuclear submarine accidents, which have now created the possibility for environmental contamination, were sinkings. Collisions are another type of “non-reactor” accident of concern. See the U.S. Navy Safety Center's survey of selected ship collisions conclusions above.

Another major non-reactor accident which could have an effect is fires or explosions. In January 1969, the eight naval nuclear reactors of the aircraft carrier USS Enterprise (CVA-65) were endangered when the ship was rocked by explosions and a fire during a two-and-a-half-day Operational Readiness Inspection 70 miles southwest of Pearl Harbor, Hawaii. Twenty-eight people were killed and 343 injured. The fire began when a tractor used to start aircraft was backed under the wing of a F-4 Phantom aircraft loaded with Zuni rockets. The hot exhaust from a small jet engine on the rear of the tractor cooked off a Zuni rocket's warhead. Shrapnel sprayed over the flight deck, puncturing tanks and starting fires. The fires caused other Zuni rockets and 500-lb. bombs loaded on planes and piled on deck to cook off, exploding planes, blowing holes in the solid steel deck, and spilling aviation fuel from punctured fuel storage tanks.

The captain of the ship recalled his concern over containing the fire to the aft part of the flight deck, since so little firefighting equipment was on the flight deck. He commented "If the fire had spread to the hangar deck, we could have very easily lost the ship."

Secondly, the Committee's attempt to deal with the problem of low-probability, but high-consequence events is unsatisfactory. The apparent historical safety record, although a yardstick of sorts, is not necessarily a predictor of future safety or risk in such circumstances. A better attempt to assess the possibilities of reactor accident needs greater access to naval nuclear reactor designs. The Committee admits this on page 59, but decides to proceed anyway, rather than pressing the issue with U.S. and U.K authorities to obtain better information.

d. Bias

On page 167, the Committeee in its haste to demonstrate why plutonium is not the most toxic substance known to man, states, "We uncovered no direct evidence that even one person has ever died of lung cancer as a result of inhaling dust which contains plutonium." While the Commission's overall point, that there are other substances that are more acutely toxic in small amounts than plutonium, is reasonable, the Committee leaves the reader with the impression that there is wide human experience with plutonium poisoning.

This is not the case. Most experience with the toxic effects of plutonium comes from multi-year beagle studies conducted in the United States. In the case of lung cancers, as one of the Committee's sources noted “Fortunately, there is no human experience in this area [deaths from cancers due to inhaled Plutonium-239] and conclusions can only be drawn by extrapolating from animal data or from effects observed in man caused by other elements.”[2] Also, damage to bones and lymph nodes from plutonium absorbed through the lungs is as much a matter of worry as the deleterious effects on the lungs themselves.[3]

There are many instances in the report where the Committee is overly reassuring about the available evidence concerning the dangers of radiation or the nature or causes of nuclear accidents.

The Committee has clearly made an interesting start af examining the question of safety of nuclear-powered vessels. However, their analysis suffers from:

- a lack of information about military nuclear reactors on nuclear submarines;

- a failure to examine all reasonable accident scenarios reactor and non-reactor re~ated which could affect the safety of the reactor;

- a pro-nuclear bias, which means their investigation does not evidence the requisite scientific skepticism and which raises questions about the overall validity of their analysis and conclusions.

Finally, the Committee by framing its analysis in the context of risk and consequences only leaves the more interesting question of gains unexamined.

People accept risks when there are perceived gains. Since the Committee cannot put any quantitative value on the gains from nuclear-powered ships, the whole report is missing an important and determinating factor in the equation. Even if, as the Committee concludes, the risk of a serious nuclear accident in New Zealand is very small, this risk must be balanced by some gain. It is very unclear what benefit is derived from nuclear power at sea or nuclear ship visits to New Zealand, even assuming the Committee's small risk.

Furthermore, nuclear vessels are free to roam at will on the continental shelves of the world, whose dependent ecologies are of vital importance to both the oceans and the economies and welfare of many regions.

Additionally, there are more nuclear power reactors at sea (450) than on land (420). Nuclear technology at sea is not a marginal aspect of the global industry. It is as great a problem at sea as it is on land.

The known saf'ety record supports this view. At least five nuclear power reactors now lie on the ocean bed as a result of accidents involving the vessels in which they were installed.

But the threat of accidents is not the only risk of marine nuclear operations. With several hundred decommissioned nuclear reactors requiring disposal over the next two decades, and with the Russian Navy at crisis point over its management and disposal of radioactive waste, international supervision and policy is required.

In March 1993, the Russian government provided estimates of the radioactive inventories of last submarines reactors and warheads and the dumped reactors off Novaya Zemlya at the time of loss or dumping. On average, lost reactors contained 130,000 Curies each, while dumped reactors had 330,000 curies each.

While the environmental impacts of this are not yet known, the Yablokov Commission notes that radioactive material thrown back onto shore may be a problem: a fragment of a high level fuel element was discovered on the Novaya Zemlya in 1984. Radioactive contamination has been nominated Russia's most severe environmental problem by President Yeltsin's environmental adviser.

Russia's continued dumping of liquid radioactive waste - largely military in origin - has been condemned by the London Convention on the Prevention of Marine Pollution, which is currently discussing amending the moratorium on radioactive waste dumping at sea into a permanent ban by the end of 1995.

In June, researchers warned the US National Research Council's Polar Research Board that they have some concern that a catastrophic amount of radionuclides could be released into the Arctic from the former Soviet Union.

"There is no evidence for massive or widespread (radionuclide) pollution at the present time" in the Arctic Ocean, said Lou Codispoti of the Office of Naval Research. But he also agreed that the potential for possible future contamination from waste in Russia or in Arctic waters needs evaluation.

Another researcher told the Council that before disposing decommissioned reactors in the Arctic, the Soviets encased the material in resin and cement--a procedure that effectively could keep the radioactivity contained. But they did not consider one important aspect of the Arctic environment in their disposal plan--the scouring of the sea floor by icebergs, he said.

Meanwhile, other wastes are packaged in steel containers that are thought to last about 30 years. Some wastes were disposed of in the 1960s and their containers are nearing the end of their estimated life.

Codispoti said the Arctic also is at possible risk from radioactive materials in sediments lining two rivers that flow into it--the Ob and the Yenisey--and from Lake Karachay, which has such a high concentration of wastes that people who approach it can die within weeks.

“There is some concern of possibly catastrophic releases” of contamination, Codispoti said.

He said if containers holding radioactive wastes begin to leak, contamination likely would threaten localized areas--especially communities of indigenous peoples near dump sites--rather than the entire Arctic region. However, the US is currently assisting Russia with funding of research aimed at monitoring the extent of radioactive contamination throughout the Arctic, including the uptake into the foad chain. Japan too, protesting at continued Russian radwaste dumping in the northern Pacific, has asked to participate in joint monitoring procedures.

Meanwhile, we know that from 1980-1989 US nuclear powered submarines experienced some 612 accidents. In the case of other nuclear navies, no official listing has yet been released, so historical data on accidents and accident trends is culled mainly from news reports and sporadic official information.

Greenpeace believes that the Special Committee on Nuclear Propulsion, hampered by self-imposed limitations and definitions of safety and risk, and hamstrung by military secrecy provisions, failed to assess the safety of nuclear ships according to the precautionary principle; that is, it did not consider the risks of other alternatives - that is, no ship visits.

We also raise the question: who benefits and who pays? Currently, those nations with the most extensive nuclear programmes - Britain, the US, France - refuse to accept responsibility for the risks of a technology they claim is safe and critical to the worid's future. They are obstructing attempts to revise the internationai nuclear liability system, and want any liability for nuclear catastrophe partial and limited. No commercial insurance company is willing to insure the nuclear industry, or nuclear submarines. As with global warming, the insurance industry is a clear barometer - and indeed the experts - in setting limits of acceptable risk. If nuclear safety at sea isn't safe enough to insure, how can it be safe enough to live with?

In the global village in which we live, New Zealanders have come to view their safety as tied to international political and environmental security. Nuclear powered ship visits and nuclear power have no place in that vision of security.

Thank you.

Sources

U.S. Navy Safety Center, Survey 2: Selected Ship Collissions, n.d., p. 30, released under the Freedom of Information Act.

J C. Nenot and H. Metivier, Biological Behavior and Toxicology of Plutonium and Transplutonics, Inorganica Chimica Acta, 94 (1984), p. 169. See also: W.J. Bair, Toxicology of Pluton Advances in Radiation Biology (Academic Press: New York an London, 1974) pp. 271-278; George L. Voelz and J. N. P. Lawrence, A 42-y Medical Follow-up of Manhattan Project Plutonium Workers," Health Physics; Vol 61., No. 2 (August) 1991, pp. 181-190.

With thanks also for additional information and discussion point's provided by Josh Handler, John Miller, Grant Hewison and Peter Montague.

THE SAFETX OF NUCLEAR POWERED SHIPS REPORT

A CRITIQUE

R E White Centre for Peace Studies, University of Auckland

May 1993

THE SAFETY OF NUCLEAR POWERED SHIPS REPORT - A CRITIQUE

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INTRODUCTION.

This report on the safety of nuclear powered ships was commissioned by the Government and released in December 1992. It was prepared by a Committee consisting of three senior university scientists and the Chairperson, Sir Edward Somers. The scientists were Professor Patricia Berquist a zoologist, Professor Alan Poletti a nuclear physicist, and Professor David Elms an engineer with expertise in risk assessment.

The Committee had the scientifie experience to assess the 'safety, environmental and other technical issues relating to nuclear powered ships which would arise if such vessels were to seek entry to certain New Zealand ports' as they were required to by their terms of reference. Their report (referred to below as the report) certainly has the appearance of a scientific document. It contains technical sections, tables, graphs and an extensive Bibliography. By comparison, a report published in 1989 by the Australian Senate Standing Committee on Foreign Affairs, Defence and Trade dealing with the same questions for Australia (referred to below as the Australian report) makes little use of these features. The report has been described as 'authoritative', and the Committee finds that visits by nuclear powered vessels (denoted below by NPV for nuclear powered vessels) would be safe. By contrast the Committee finds that there is 'a serious lack of understanding and much misinformation in the minds of the public concerning safety and technical issues related to nuclear powered vessels', and (p.12) believes 'the public has been misinformed to a considerable extent, particularly by single interest groups'.

This critique examines the evidence and analyses provided in the report to justify this, and other findings which support the claimed safety of such visits. The report is considered chapter by chapter. Page and paragraph numbers are given so the reader can easily find the portion of the report to which a particular comment applies. The aim of this examination was to assess the validity of the Committee's findings, the credibility of the report, and the claim that it is authoritative. The author of this critique is a nuclear physicist (recently retired) with over 30 years research experience and some 29 years experienee teaehing university physics. Other qualified people have seen the comments made here about the report.

It should be remembered that a budget of some $480,000 was provided to the Committee together with assistance from the Prime Minister's Department and other government departtnents, and that this is an official New Zealand Governtnent report.

Before presenting detailed comments, some major criticisms are given in outline, together with the overall conclusions reached about the report.

MAJOR CRITICISMS.

Naval Reactor Accident Probability and Consequence Assessment.

A prime goal of the Special Comrnittee was the assessment of the probability of a serious accident on a NPV resulting in the release of radioactive material, and of the nature and extent of that release and its consequences.

The assessment of the accident probability (Chapter 5) is based on what are here claimed to be invalid arguments, and the result found is challenged below. Further, the report states page 22 that 'a comprehensive quantitative risk assessment is not feasible as we have access neither to the vast quantity of technical data that would be required nor the resources required for carrying out such an assessment', but that some approximate risk estimates are given. Yet these estimates are presented in Chapter 5 in ways that make them appear relatively accurate rather than approximate. A statistical argument used there to support the probability assessment is incorrect. The whole question of how meaningful it is to make any estimate of accident probabilities in situations where there is no basis of experience is very debatable.

To assess the consequences of a serious NPV accident the Committee developed a model of the reactor used in a class of US Navy attack submarines that might visit here (Chapter 4 and Appendix 6), ie. an attempt was made to calculate technical characteristics of the reactor. Such information is highly classified by nuclear navies. Features of this model together with other data were used (Chapter 9) to estimate the characteristics of the radioaetive release in such an accident, and the consequences for the surrounding population.

This 1ooks like an impressive and useful body of work. It is argued below, that the model reactor is based largely on out of date information and consequently is very unrealistic, and that it contains a serious error of understanding. It is also argued that several significant factors relating to the radioactive release were not discussed in the report, and this invalidates to some extent the conclusions drawn about that release.

A close examination shows little original input to these sections of the report by the Committee apart from the flawed reactor model calculations, only trivial aspeets of which were used in Chapter 9. All other inputs used to assess the accident cnagnitude and consequences came from other sources with only some minor adjustments made by the Committee.

Finally, a US Department of State telegram of 25 March 1987 to the Australian report group states:

there are vast differences between US nuelear powered warships and commercial nuclear power plants with respect to the reactor size, plant. design, fuel integrity, manner of plant operation and operator supervision. Consequently, commercial concepts regarding accident potential or accident consequences do not apply,

These factors might be argued to make NPV reactors safer. The point is, where does this leave the present report and its heavy reliance on land based reactor studies for its NPV safety and aecident consequence assessments?

Risk Assessment and Safety Arguments.

Significant seetions of the report (Chapters 2, 5, 7) are devoted to discussions of risk assessment, arguments about how to put risks associated with NPV visits in perspective in relation to other risks we experience, and what safety is about. Comparisons are made with everyday risks and safety factors. But for NPV visits no cost-benefit analyses are given anywhere in the report whereas these play an important part in our decisions concerning the everyday risks we accept. Submission to the Committee did provide cost-benefit analyses, the report ignored these as outside its terms of reference. In my own submission, only costs could be found in allowing these visits again, but no benefits. What real point there is in comparing everyday situations with something as unnecessary and unusual as a NPV visit is also very debatable.

Further, the report nowhere makes reference to the present situation where the risk to us from NPV visits is zero because of our ban on such visits. Nor does it point out that for the other risks it cites that we face in normal life, eg. those in Table 5.1 p.50, we are working to reduce the risk in every case, not increase it as we would do by accepting NPV visits again, since the report itself page 1 says, 'nobody has contended, or could contend, that NPV are absolutely safe, that nothing could go wrong with them'. We can choose whether or not to expose ourselves to at least some of the risks discussed, eg. in

Appendix 10, but if NPV are allowed into our ports again, the associated risks are imposed on us, we have no choice about accepting these risks.

If we are to allow NPV visits again we will have to be given very good arguments for so doing. This report provides no such arguments.

Inadequacies of Information and Discussion.
There are a variety of what are seen as inadequacies of information and discussion in the report that tend to favour its arguments, arguments that manifest what can only be described as a pro-nuclear bias. In the accident study discussed above there are what are considered to be serious inadequacies in the discussion of the likely radioactive release in such accidents. The study is further incomplete in that reactors in US NPV vary significantly in maximum energy output. This affects the magnitude of the expected consequences of a serious NPV reactor accident, but the report does not discuss this.

Nor does the report discuss the interesting point that the model reactor it presents has a larger energy output than allowed by our present code, AEC 500, for NPV wishing to visit. Yet such a submarine has visited in the past, the Phoenix in 1983, and other NPV with even larger reactors have also visited. The legitimacy of these visits under AEC 500 is being investigated, but the report does not raise this issue even though it does recommend some modifications to AEC 500.

Again the report does not discuss the possible cost of setting up an adequate monitoring system should we accept NPV visits. The Canadian Government has granted about $NZ 11 million to upgrade equipment for its Nuclear Emergency Response Teams in ports visited by NPV, and this covers only three ports. This is an important consideration with the present cost oriented government we have.

Chapter 9 and Appendix 7 present curves of the doses at various distances following certain radioactive releases, fig. 9.2 and A7.1. These were calculated almost entirely by Dr McEwan of the National Radiatioil Laboratory. The serious inadequacy is that the report in fig.A7.l omits the dose curve calculated by Dr McEwan showing the most serious doses, to the thyroids of young children. These are several hundred times higher than the highest dose curve presented in fig.A7.l. The only reference to these thyroid doses is on p.132, but no real indication of their severity is given. The curve is ornitted in the body of the text because it is claimed that drinking contaminated milk would be prevented, but an unbiassed presentation would have seen it included in Appendix 7.

A further serious inadequacy occurs in the discussion of the consequenees of Chernobyl (p.54 and Appendix *). The report claims only 31 deaths due to the accident and tends to down play the overall consequences. The official death toll is now around 8000, and the long term health and pollution consequences are widely accepted as being extremely serious. The lack of any real discussion of cost-benefit considerations in relation to the safety of NPV visits, or for the other types of risk the report introduces, is a major inadequacy.

Finally, Chapter 13 on Myths and Catch-Cries, contains a significant number of inadequacies in its treatment of the questions raised. These are dealt with when Chapter 13 is examined. It is interesting here to comment on the report's suggestion on p. 12 that, 'the public has been misinformed to a considerable extent, particularly by single-interest groups', described in media comments by the Committee as a deliberate campaign of misinformation. Chapter 13 is said to address some of the resulting misunderstandings. However, an examination of the Australian report, which the Committee had, shows that almost all the supposed myths and points of misinformation the Committee claims to have uncovered here were met by the Australian Committee also. If there is a deliberate campaign it must be widespread it seems. These so-called myths for the most part reflect the sorts of concerns people would have regarding a complex technical systern, a naval reactor, about which little detailed information is available. Other consideration of this type will be met as the report is examined in detail.

The Committee reveals at times a degree of reliance on its findings as complete and unchallengeable that is considered disturbing. Possibly the worst example occurs on p.142 bottom when the report states 'It is clear from our investigations that the major justification for requiring that a comprehensive safety plan is in place is reassurance of the public.' This follows, the report says, from the Committee's assessment that a NPV accident far which planning would be prudent would not have serious consequences. But we have no experience of such accidents. The reason for a comprehensive safety plan is that the possibility of a NPV reactor accident cannot be ruled out, and the consequences are not known with certainty. See the discussion of this point in the comments relating to p.142. Chapter 13 also manifests this tendency.

The Report as a Scientific, Scholarly Document, and Overall Conclusions.
The report was written by three senior scientists, experienced in technical writing. Yet the language in it is often confusing, and the mode of expression difficult to follow. It contains a number of factual errors, and misprints. An example of the latter is found already in the Contents section where under Figures, 3.1 is listed as 'Schematic of a Typical (Large Dry) PWR'. But PWR stands 'for pressurised water reactor. The entry should have read, 'Schematic of a Typical Land Based PWR'. A dry PWR would, in the context of the report, be a disaster. **SEE ADDITIONAL COMMENTS P:39 0N.**

The Bibliography lists some 620 documents, and the text refers to some, but not all, of these. However, there are a further 19 references given in the text that are not in the Bibliography, two cases of 2 entries with the same designation, and 3 entries that do not appear to correspond to the discussion in the text. Where references are cited in the text page numbers are not, in most instances, given. Many of the references are quite lengthy, so this makes checking the text difficult. The Glossary contains some strange and confusing definitions. Some technical terms appear with different symbols in different places, and some terms are not really explained at all.

These may be considered relatively unirnportant points, but they would not be acceptable in a scientific document, which the report appears to be meant to look like, and they represent a poor standard of scholarship. Taken together with the comments that follow, if these are valid, the conclusion reached is that this report adds nothing of substance to our knowledge of NPV safety, which is very disappointing considering the resources made available for its production. It compares very badly with the Australian report, and certainly cannot be described as authoritative, and much of what it presents lacks credibility. There is little original work obvious in it, and what there is is considered to be seriously flawed in places, and highly debatable in other places. It is disturbing to see a document of this quality released as an official government report. It was released by the Department of the Prime Minister and Cabinet.

IMPORTANT POINTS TO REMEMBER.

For Many People Safety is Not the Main Issue.
These criticisms and those following do not invalidate the very good official safety record of US and UK NPV. But events might well have occurred on these vessels that represented situations in which one or two more incorrect steps or occurrences would have resulted in a major accident. We do not have access to such information. The real point to remember is that for many New Zealanders safety is not the main issue in relation to NPV visits. These warships, whether they are 100% safe or not, are major symbols of nuclear war-fighting strategies that we reject through our legislation, and of military nuclear systems with terrible environmental records that we do not wish to support in any way. A resumption of these visits could also affect adversely our good environmental image, and would have implications for our future security planning that many would find unacceptable. The report does not consider these factors.

Our Legislation is Not Unique in its Effects on Nuclear Ship Visits.
It should also be rernembered that we have been treated very differently by the US from Denmark, even though their situation regarding NPV and nuclear armed vessels is essentially the same as ours. Denmark bans nuclear weapons from its ports but trusts its allies to honour this policy, we try to enforce our ban. Denmark demands detailed information regarding the reactors and safety systems on visiting NPV that the US and UK will not supply. Consequently there has not been a visit to Denmark by a NPV since 1964. This is effectively a ban like we have, but unlike us Denmark has remained a NATO ally of the US and UK, and has continued to have visits by their conventionally powered nuclear weapons capable warships. The situation is similar for Sweden; conventionally powered US and UK warships visits but no NPV visits since 1964, even though it is a neutral country. We, by contrast, were effectively put aut of ANZUS by the US, and warship visits ceased in 1985. See also the detailed comments relating to Chapter 10 of the report and our present Code For Nuclear Powered Shipping, p.27-28 of this critique.

Basic Principles Relating to Radiation Hazards.
A body referred to a number of times in the report, the International Commission on Radiological Protection, derived three important principles that are well worth remembering. These are;
1. No practice involving radiation hazards should be adopted unless it produces a positive net benefit.
2. All exposures should be kept as low as reasonably achievable (ALARA), with economic and social factors being taken into account. This is referred to as the ALARA principle.
3. All necessary steps must be taken to ensure that individuals do not receive doses that exceed recommended limits:

The Risk From Nuclear Powered Ship Visits is Zero at Present.
We have complied with principle 2, achieved the lowest possible exposure from NPV visits - zero exposure. Allowing NPV visits again must be shown to comply with Principle l and produce a positive net benefit to be acceptable. Recommendations made in my subrnission to the Special Committee were:

1. No change be made in New Zealand's ban on NPV visits.
2. If any change is made in New Zealand's ban on NPV visits it should be that New Zealand adopt the regulations for such visits laid down in the Convention for the Safety of Life at Sea 1960 and Annex C to it, and their more modern equivalents (see below), the continuing Danish policy, and apply these to visits by ALL NPV as Denmark does.
3. If any change is made, the present liability arrangements relating to NPV visits should be reviewed (see for example 'Nuclear Energy in Perspeetive' Chapter 5, OECD 1989).

Recommendation 2 would require for each visiting NPV (see my submission pp.31-34):
l. A safety report providing a technical description of the vessel's reactor that would allow New Zealand authorities to evaluate the safety related standards of the vessel.
2. An emergency plan for reactor incidents and accidents.
3. A satisfactory liability agreement covering nuclear incidents and accidents.
The intent of Recommendation 3 is to remove any remaining ambiguities in the liability regimes now in place, and to clarify that any new regime accords with international requirements.

The Safety of Nuclear Powered Ships report could have technical and political significance, so it was considered necessary to assess it and comment on it in detail. Readers must decide for themselves about validity of the comments made. They are offered on this basis.

DETAILED COMMENTS.

The comments that follow represent only some of the comments that it is felt could, and really should, be made about the report. However, in the interests of greater objectivity, many of the more subjective and more minor comments recorded during the detailed examination of the report have been omitted. The comments that follow need to be read together with a copy of the report. References given in the Bibliography are referred to below, often just by their Bibliography designation.

OUTLINE.

pi. para 2. The limitation to US and UK NPV is questionable. We have never been visited by a UK NPV (they are all submarines). The CIS or Russia has NPV in the Pacific region, and a visit by one of these in the future seems much more likely than by a UK NPV.

pi. para 4. The understanding of the word safety given here as being when the likelihood of harm from an activity is so remote 'that it can occasion no rational apprehension', is unscientific as it involves a term -'rational apprehension' - not itself defined in the report, and not at all easy to define.

p.ii para 4. 'If there is a loss...... ' No evidence is presented in the report to show that the Committee has any detailed information concerning the emergency core cooling in NPV reactors (see comments relating to Chap.4 p.38 and Section 13.8).

p.ii para 5. The "model" reactor is examined in detail in comments on Chap.4, but is considered to be seriously flawed.

p.iii-v The various chapters referred to here are criticised fully below. Some of the major criticisms of these and other chapters have been outlined in the Introduction above.

p.vi The Findings will be considered later in the light of the criticisms presented.

1. THE REFERENCE AND THE INQUIRY.

p.2-4. Their interpretation of the terms of reference has been very restricted in relation to certain matters whieh it would appear possible to include under 'd' (p.2), but quite broad in other matters. For example the environmental record of the US military and its nuclear infrastructure is a matter of concern for many when considering whether effectively to support that system by accepting NPV visits, but is excluded from discussion in para 2: p.2 'The safety......' By contrast, Chapters 2,3,8 contain material of use, but much of it is scarcely within the terms of reference.

p.3 The question of which countries are likely to want to send NPV here has been commented on.

p.4 Table L2 This shows just how little access the US Navy would lose if they could only send conventionally powered vesseis here. Only 10 different US NPV visited between 1960 and 1984, and as Appendix 3 admits over 90% of all US Navy visits in this period were by conventionally powered vessels.

p.5 para l. "As we have mentioned....' It is considered that many of the issues listed here are admissible under Section 'd' of the terms of reference, and should have been discussed in the report.

p.5 para 2. The question of misconceptions is treated fully in the discussion of Chapter 13. Discussion of relative risk is given later in relation to Chapter 5 and Appendix 10.

p.5 para 3. 'those who campaign against nuclear power often do so by appeals to emotion rather than to reason'. This has definitely not been the experience of the author, a nuclear physicist, and co-founder of Scientists Against Nuclear Arms.

p.7 para 6. 'The vast literature......' This highlights the lack of publicly available material on NPV reactors. That the Committee chose to extrapolate from material on nuclear propelled merchant ships will be argued to have been a mistake that in part led them to produce a very unrealistic model of a US attack submarine reactor (Chapter 4).

2. RISK AND SAFETY.

This chapter provides interesting background material, although it is difficult to see how its inclusion is justified under the terms of reference. The discussion is considered incomplete, however, as it does not include any detailed treatment of the role of cost-benefit analysis in assessing the acceptability or otherwise of risk. This would have been particularly appropriate in relation to NPV visits since the government has, over a considerable period, presented just such arguments to justify a resumption of these visits claiming resulting economic and military security benefits, claims challenged strongly in submissions.

It would have also have been appropriate as the report uses comparisons between the risk frorn NPV visits and a number of every day risks we face, and often cannot easily avoid, to argue the safety of these visits. We make cost-benefit analyses of various sorts all the time for these other risks , and continually try to reduce the danger they represent to us. NPV visits represent no danger to us at present because we do not allow them. If we are going to accept an increase in the level of any risk, we need strong arguments showing that significant benefits will follow. No such arguments are to be found in the present report in relation to NPV visits.

The difficulty of assessing the probability of a serious accident on a NPV is discussed to some extent in this chapter, but some estimates are given in the report nevertheless. However, important criticisms of the sorts of probability figures that are to be found in the report and the method of deriving them, provided for the Australian report by Professor T Speed, now Professor of Statisties at the University of California-Berkeley, and echoed by others, are not debated, compare p.22 of the report. See also the comments below relating to pp.58-64 of the report and the frequency estimates given there.

3. WHAT IS A REACTOR?

Much of the material in this chapter is again hard to justify under the terms of reference, although in principle it provides useful background information. Unfortunately it is not well written, and would have been better replaced by equivalent material from one of the many books available that deal with this topic. It is difficult to decide who the chapter was intended for as it is a mixture of qualitative and quite technical material.

p. 23 Section 3.2, The first sentence is technically incorrect. Reactors do not and cannot affect how individual nuclear fission reactions occur, this depends on the nuclear properties of the nuclei involved. So reactors do not enable nuclear fission reactions to occur in a controlled manner. The reactor enables the rate at which fission reactions occur, the number that occur per second, to be controlled. This distinction may seem pedantic, but scientifically it is not, and this report was written by scientists. This, and other similar criticisms, reflect adversely on the credibility of the report.

p.23 Section 3.2 The second sentence tells us that 'the heat so released is used...', but no explanation of where heat comes from is given. This only comes on p.24, an example of the poor presentation common in this chapter.

p. 23 Seetion 3.2 The third sentence suggests that fission occurs only for certain types of uranium nuciei: This is not correct as even the report shows p.25 where it refers to the fission of plutoniurn-239. Also the term 'hit' is very poor technically. The sentence also includes the symbol U-235, but gives no explanation of what it means. Further in Box 3.1 the symbol ^{235}U appears: Are these the same? The reader has to recall that some explanation of these is included in Appendix 11, Section 11.3, but this section introduces the terms mass number and atomic number and the reader has to go to the Glossary for definitions of these. This is confusing for the general reader. The sentence says in the bracket, 'for instance U-235'. What other uranium isotopes are being referred to since the report only discusses U-235 and U-238, and U-238 does not undergo fission with thermal neutrons as U-235 does, only with higher energy neutrons, a distinction is not discussed, see p.25 para 3.

p. 23 Box 3.1 ' Other symbols appear, eg. n, that the reader has to find in Appendix 11.

p, 24 The first sentence states that neutrons form part of the nuclei of all atoms. This is incorreet. Hydrogen atoms, the most numerous in the universe by far, do not contain neutrons:

p.24 The second sentence does not explain how 'free' neutrons occur, outside atoms.

p.24 para 3. 'Much energy is released......' introduces the term 'radioactive decay`; Referring to the Glossary the reader finds that radioactive decay is 'The decrease in activity of a radioactive material, so the definition of 'activity' at least is needed. The Glossary gives this as 'The activity of a radioactive material refers to its rate of radioactive transformation or decay. The persistent reader thus ends up with the definition of radioactive decay as, 'the decrease in the 'rate of radioactive decay of a radioactive material'. This is confusing.

p.24 Box 3.2. This introduces symbols MeV and 10^{-13}, and the terms 'prompt gamma ray', 'gamma ray' and 'beta particle`. Reference to Appendix 11 and the Glossary is again necessary for these; but 'prompt gamma ray' is not included, and while the Glossary states that beta particles are electrons, Box 3:3 says they are 'very fast electrons'. This is again confusing, and the last statement is incorrect. Electrons are found with speeds down to zero in nuclear processes.

Also Box 3.2 omits one class of particles produced in fission, neutrinos, and any discussion of the energy they carry off.

p.24 Last para. How does a maderator reduce the speed of neutrons, and why are they then said to be'thermalised'? The Glossary does define Thermal neutron, but the reader has to remember to look there, and the definition is rather technical.

p.25 First sentence. Why is this so, and how important is this? Why include this infornnation if no clarification is to be offered?

p.25 para 1. 'Control is achieved......' so that on average slightly more than 1 of the fission neutrons is actually available....'. How does the reader conceive of slightly more than 1 neutron, and why is this necessary when on the bottom of the previous page we are told that control is arranged to ensure that on average just one neutron induces a further fission for every one (neutron presumably) which is consumed?

p.25 para l, third sentence. Hafnium is not used for control rods in commercial reactors, it is too expensive.

p.25 para 2 second sentence. The statement, 'this occurs when more than one neutron per fission causes a further fission' is confusing. It reads as if more than one neutron was now causing the same fission, but it means when more than one neutron liberated in fission causes further fissions. Also the statement in the last sentence that, 'a naval reactor contains about 0.3 tonnes' is an assumption, but this is not made clear.

p.25 para 3. The first sentence is incorrect. Natural uranium exists in nature in at least three isotopic forrns, U-234 0.0055%, U-235 0.72%, and U-238 99:274%, see the reference GLA81 p.5 Table l.1. The discussion here is very confusing. Why enrich in U-235 if it is so expensive and difficult? No explanation is given for the case of commercial reactors where cost is important.

p.25 para 4. 'Nuclear weapons...... as a pure metal not an alloy.' There has been no prior mention of alloys, why does the term appear here?

p.27 Box 3.4. Several confusing features appear in this box. The symbol 'R' is only explained in the last para, but appears in equation (1). What exp(-) means is not explained, and the half-life is denoted by $T_{1/2}$ here but by $t_{1/2}$ in the Glossary p.236. Which is correct, and are these symbols the same? How does the general reader know since half-life is only defined in the Glossary, not in Box 3.4.

p.27 para l. 'Ionizing radiation and radioactivity is a ubiquitious feature...' But these are two distinct phenomena, so the verb should be plural. Also if Radioactivity is looked up in the Glossary, we are told it is a property of 'some atoms', and that units used for measuring radiation are in a table 'following this Glossary'. Radioactivity is strictly a property of nuelei, not atoms, and there is no table following the Glossary. It is Table A11.4.1 on p.229 presumably.

p.27 para 1 The claim that at commonly encountered levels (or "doses") it is a negligible health hazard is debatable. Acceptable levels of radiation keep changing, always downwards.

p.29 3.3 para 1, Here a 1979 reference, NER79, is used for commercial PWR. Why use such an old souree? Many recent sources are available describing modern technology.

P.31 para 1. The claim, made with no qualifications, that tritium is not a cause of concern is very surprising to someone who has worked with this gas and complied with the very strict controls against an accidental release always imposed with tritium. Technical sources confirm that these controls are standard.

p.31 para 2. Gas containing radioactive isotopes....is 'held long enough for their radioactive decay to take place'. What this means is quite unclear. Is this for 3 half-lives, or 10 or 100, or to some set activity level? This is important if material is released to the atmosphere.

p,31 3.3.2. The reference AUS89 is not in the Bibliography. It should be COA89, but there are two COA89 listed, p.246.

Some of the comrnents relating to Chapter 3 may be thought rather trivial, but this was written by senior scientists, and many comments have been omitted for the sake of brevity. This chapter is considered to be very poorly presented, and the number of technical errors and confusions in it (not all presented here) do cast doubt on the credibility of the report.

4. NUCLEAR POWERED SHIPS.

p.33 para 1. The “model” reactor is discussed below.

p.33 para 2. The discussion here is somewhat misleading. It suggests some 91 US Navy NPV that might wish to visit us if visits are allowed again. But only vessels from the US Pacific Fleet are likely to want to visit , and from US Navy lists dated 3 April 1992 this fleet only includes 19 (688) class and 13 (637) class submarines and 5 guided missile cruisers, a total of 37 vessels. Only 5 nuclear powered submarines have visited in the 24 years from 1960 to 1954, see Table 1.2 p.4. There also 3 nuclear powered aircraft carriers in this fleet, each with two very large reactors that could, in principle, visit but would have to anchor outside the harbour in Auckland because of their deep draught..

p.34 para l. Refs. FOC78, REN78, DAA78 and YUT69 are not in the Bibliography. See the discussion of the model reactor concerning the relevance of these merchant ships. The claim in the last sentence that 'All were technically successful is a distortion in the case of the Mutsu, generally considered a technical disaster. It was launched in 1969 and achieved one experimental voyage in 1990-91 before being decommissioned.

p,35 para 1. 'A comprehensive study......' Surely to the list 1 to 3 should be added: 4. Specialised safety systems. They may include this in the reactor system.

p.35 paras 2,3. 'We can limit......' This ignore the fact that many naval vessels have been sunk in battles, storms etc., and there has not been a major naval engagement since NPV were developed.

p.35 para 3. The statements here are all claims, not supported by evidence offered in this report - or to any great extent elsewhere. In fact evidence contradicting some of the claims made was presented to the Committee, but disregarded, see eg. comments below relating to p.47 Section 5.2 of the report.

p.38 point 11. Details of the emergency core cooling systems (ECCS) on naval PWR are not available. The Australian report pp.97-102 could not conclude that NPV have effective ECCS equivalent to land based PWR. These latter have both active and passive elements in their generally quite complex ECCS. Naval PWR appear to have passive systems-only, relying on natural convection in the case of a serious accident, see point l3.

The emphasis on UK material is interesting, showing how little is available about US Navy NPV, the ones likely to visit us.

p.40 para 3. 'Information which gives some confirmation......' The reference CLA85 is the novel 'The Hunt for Red October', and not by a naval expert as far as is known.

p.41 para 2.' 'We have chosen......' This para and the following two are very difficult for the general reader to follow, but present the major features of the model reactor. In an attempt to understand how the various parameters of this model reactor were arrived at a very detailed and extensive study of this section of the report was made. For the sake of brevity, and to avoid lengthy technical-detail, only the major points of criticism of the report model will be presented in outline here. The full analysis af the model is available. It should be noted that the units kW/1 and Kw/1 which occur in consecutive sentences in para 2 are actually the same. They both mean kilowatt per litre, and should be kW/i to agree with Tab1e AlL2. Also the term 'thermal efficiency' which is very important later for calculating releases in a serious accident is never explained pp.40-41.

The Model Reactor - Criticisms.

Thermal Efficiency and Thermal Power.

The nuclear reactor basically produces heat energy which is converted by steam turbine into mechanical energy for propulsion, and electrical energy for the vessel's electrical system. This conversion process is not 100% efficient. The thermal efficiency is the ratio of the amount of useful mechanical and electrical energy obtained to the amount of heat energy generated expressed as a percentage. The report adopts a figure of 20% for this ratio based on data from the nuclear powered merchant ships discussed and an old (1971) reference HAR71. This would mean that only one-fifth of the thermal energy would appear as usable mechanical and electrical energy. But all these merchant ships except the Sevmorput were decommissioned long ago. Modern commercial PWR have efficiencies of about 33% (see eg. GLA81 p.29, 1.94), and reports by the United States Naval Nuclear Propulsion Prograrn say their reactors are very efficient. The Committee had these reports; see DOE90 and DOE91a in the Bibliography. The Australian report was given figures of around 30% for the thermal efficiency of US NPV. It must be remembered that the US Navy in particular has had very large budgets for its nuclear programmes compared to merchant ships that have to aim at commercial cost-efficiency targets. It is suggested that a figure of about 30% would be much more realistic than 20%, and this could be as high as 35%, This range 30%-35% is used in an alternative model that was developed by the author.

The term 'power' refers to the rate at which energy from a source, the reactor here, is used. The 688 class submarine's power unit develops 35,000 shaft horsepower maximum to drive it. This converts to 26.1 million watts by multiplying by 746 watts per horsepower, ie. to 26.1 MW. Adding 7MW of electrical power for other purposes the total power required at maximum speed is about 33MW. The thennal power required from the reaetor is then five times this using the model thermal efficiency, or 165 MW(thermal)= 165MW(t), but is 1 lOMW(t)' using 30%, and is 94 MW(t) using 35%. A figure given to the Australian report for these reactors is about 10OMW(t). This large differenee, 110MW(t) or 94 MW(t) versus 16S MW(t), show the importance of making a realistic estimate of the thermal efficiency. It is claimed here that the report figure is unrealistically low.

Core Life.
The rnodel reactor has a core, the region containing the U-235 where the heat energy is generated, which will operate for 12 years before needing a fresh supply of nuclear fuel, a core life of 12 years. No basis for this choice is given. But the US Navy documents DOE 90 and 91a contain statements clearly indicating that US Navy NPV have reactors that will operate for 20 years without needing fresh nuclear fuel, and have had these since the early 1970's, at least.

Discussing the nuclear powered aircraft carrier Enterprise, DOE90 says p.32, 'Second refuelling and overhaul was completed in January 1971 .... the Enterprise was completely overhauled and reactor cores of an entirely new design were installed in her eight reactor plants. These new cores provide her enough fuel to carry out all operations until her next refuelling, in 1991, thus making her truly independent of fuel logistics support for over 20 years.' The 1991 version of this document DOE9la p.33 discussing the US naval nuclear programme says that the first prototype reactor S1W operated for the last 22 years of its 36 year life using the same reactor core. It ceased operation in October 1989. So this 22 year life core was installed in 19b7. This document also says p.7 that Los Angeles class submarines, the class whose reactor the report model is supposed to model, 'represent the most advanced submarine technology at sea'. The Committee had these documents. A core life of 20 years is assumed for the altemative model.

Average Power.
For a reactor the power usage governs the rate at which the uranium fuel is consumed, and the total amount of this fuel needed to give a certain core life. The report assumes that on average only 20% of full power is required from the reactor. This is quite arbitrary, and could easily be 30% for example. Together with the design core life it governs how much uranium is needed in the reactor core to supply thermal energy for that core life. In the alternative model average power demands of 20% and 30% were considered.

The report model, using 20% of 165MW(t) and a core life of 12 years, finds that 180 kilograms (kg) of U-325 would be consumed to provide the necessary total power. This calculation involves using a figure of 170 MeV for the energy released in each U-235 fission (see Box 3.2). But several texts and other sources consulted all agreed that a more accurate figure to use is 200 MeV, the full energy release given in Box 3.2. This reduces the amount of U-235 required by some 17%, not insignificant.

Composition and Form of Fuel Flements.
The report assumes the fuel is metallie uranium in an alloy of 14% uranium by weight and zirconiutn (U-Zr), and is in the form of very thin plates. No evidence is cited to support these assumptions. But all modern commercial PWR use fuel elements made of uranium dioxide in the form of cylindrical pellets assembled into fuel rods. Also DOE91 a and other sources say that one of the contributions to the commercial reactor programme from the naval nuclear propulsion programme was developing this dioxide fuel, and one submission to the Australian report from Commander M K Gahan of the Royal Australian Navy names the fuel as uranium dioxide. This dioxide fuel has much better properties for use as a reactor fuel than metallic uranium.

The Committee seems to have chosen the alloy fuel since it was used in a very early reactor developed by the US naval reactor programme (the Shippingport reactor) and the ship Sevmorput uses it. But the other three merchant ships discussed use the dioxide fuel. The alternative reactor model assumes the fuel is uranium dioxide pellets, using 93% enriched U-235. This enrichment level is generally accepted as probably near the value used by the US Navy. Providing this enriched uranium for naval reactors has been a major activity for the US military nuclear programme. As the report says using this high enrichment allows the necessary quantity of U-235 to be assembled in a smaller volume, see p.25 of the report.

Total Core Loading of U-235 and Uranium Required.
This question is difficult to explain in a simple way, but it is here that the report is considered to contain a major error of understanding. Not all the U-235 in the core of a reactor is used during its life. A certain minirnum amount is needed to maintain the chain reaction as some neutrons produced in fission escape from the core and others are lost in capture processes. The report model assumes that only 60% of the U-235 is actually used dunng the life of the core, see p.203 point b. But this is a low figure compared to those for commercial PWR given in texts, where figures of around 70-75% of the core loading, of U-235 being used seem more normal. With a fresh core containing a large amount of U-235, control rods are used to limit the fission reactions and hence control the energy output. As the U-235 is used up the control rods are withdrawn to compensate for the reduction in available fissionable material.

The report again refers to a very old source for its estimates of 60%, WEI77, that discusses the U-Zr alloy fuel. The report states that WEI77 says the alloy 'performs satisfactorily up to a burnup of 3.3 atom % for uraniurn'. WEI77 actually says the alloy can withstand burnups 'in excess of 3.3 atom % uranium', so the report does not even quote WEI77 correctly. There is no evidence that WEI77 is referring to highly enriched U 235, it is much more likely to be discussing the levels of enrichment common in commercial reactors of 3.5-4% U-235, This 3.5-4% means that about 3.5 to 4 atoms in every 100 uranium atoms would, on average, be U-235 atoms, the rest being U-238. So, eg., in 1 million uraniutn atoms there would be 35,000 to 40,000 U-235 atoms. The U-234 can be neglected here, its abundance is so low. A burnup of 3.3 atom uranium then means that on average, 3.3 atoms out of the 3.5-4 U-235 atoms in every 100 uranium atoms in the reactor core are consumed in fission reactions in the fuel consumed during the life of the fuel in the core. If this interpretation of WEI77 is correct, it gives a usage or burnup of U-235 of around 82-94% in the fuel that is consumed.

The report p.41 says at the bottom that the U-Zr alloy with 93% enriched U-235 contains 5.5 atom % of U-235. The alloy, the report incorrectly says, only allows 3.3 atom % U-235 to be consumed, so only 3.3 of these 5.5 atoms in every 100 uranium atoms get used, ie. only 3.3/5.5 or 3/5 or 60% of the U-235 in the core is used to give energy.

This is assumed to be the origin of the 60% figure. Itis claimed here that this 5.5 atom % for the alloy has been interpreted incorrectly. As indicated, a statement that there are 3.3 U-235 atom % uranium means that on average (since we cannot have 0.3 of an atom) every 100 uranium atoms contains 3.3 U-235 atoms.

The error in the report is that the 14% by weight U-Zr alloy does contain on average 5.45, or about 5.5, U-235 atoms in every 100 atoms, but the remaining atoms are almost all zirconium atoms, 94.14, with 0.41 atoms of U-238 per 100 total. This is completely different from S.5 atom U-235 per 100 uranium atoms. So the 60% figure is erroneous, if these interpretations of burnup and the percentage U-235 composition are correct. This is important in determining the total loading of uranium in the core. The report apparently gets its figure of 320kg simply by multiplying 18Okg of U-235 by 5/3 to give a total of 300kg of U-235, corresponding to a 60% usage, 180kg out of 300kg available. Page 201 of the report, Appendix 6, gives about 295kg U-235 for their model. The uranium is 93% U-235, so the total amount of uranium is 300kg multiplied by 100/93 or 322.5 kg, about 320 kg as given p.41.

For a thermal efficiency of 35% and average power use of 20%, the alternative model reactor would require 210 kg of U-235 and 230 kg of uranium in the core. These become 370kg of U-235 and 400kg of uranium if the efficiency is 30% and the average power is 30%. These quantities includes an allowance of extra fuel to ensure that there is always at least the minimum needed to sustain the chain reaction and to compensate for loss of neutrons by capture processes in the core, a problem not discussed in the report. There is clearly considerable uncertainty in these quantities of U-235 and uranium. A report to the Austraiian study suggests a figure of about 200kg of highly enriched uranium as likely on average for US Navy NPV, but this is not very informative as there is a considerable range in the size of reactor used in different types and classes of these NPV.

Core Power Density.
This is just the thermal power divided by the core volume. This volume is unknown of course and again estimates are just that. The estimates given on p.41 for the model reactor give a power density of 96 kilowatts per litre of volume, 96kW/1. This figure tells us how much heat is generated per unit volume in the core and is important because the core has to be designed so that this heat energy can be extracted efficiently for use, and to stop the core from getting hotter than the materials in it can stand. This latter consideration is reflected in the model reactor design since the choice of U-Zr alloy fuel means the fuel must be kept below about 600 degrees centigrade (see p. 203 point b), so the power density cannot be too high.

However, 96kW/1 is low compared with the equivalent figure for modern eommercial PWR of about 102kW/1 (see eg. GLA81 p.74). Also the 600 degrees figure is very low compared with temperatures in these modern cores using uranium dioxide where the fuel pellets reach central temperatures up to 1800 degrees or rnore (see GLA81 p.503). The alternative model using dioxide fuel pellets would have central temperatures in the pellets of around 1800 degrees and a power density of 120kW/1. These values are considered more realistic in relation to US Navy reactors. DOE91a says p.40 that Los Angeles 688 class submarines have a 'high power propulsion plant', p.42 that the new Seawolf class submarines will have a 'high power density propulsion plant', and p.29 that the programme is working to 'design propulsion plants with increased power output without increasing their size'. These statements all suggest an emphasis on high power density reactors. The water coolant temperatures in the alternative model are rnuch as in the report model.

Neutron Flux.
This as an important quantity in a reactor since the rate of energy generation depends directly on how many neutrons there are traversing the core to produce fission reactions, ie. on the neutron flux. However, it is normally very difficult to calculate for a reactor

and requires computer programmes to cope with the complex geometry of the core which contains arrangements of fuel elements, moderator and coolant channels, and control rods. The model gives figures for the flux, but it is not known how these were obtained. A request was made to see the detailed calculations of the flux and other features of the model but these were not provided, so it has not been possible to check this point or the points raised above. Only rough estimates of the neutron flux have been made for the alternative model: The values found are of the same order as given in the report p.201 Appendix b.

Concluding Remarks.
There are other technical points that could be discussed, bur these will be left for now. These criticisms of the model reactor, if correct, are important for two reasons. They affect the estimates of the consequenees of a serious NPV reactor accident made in Chapter 9, this wiil be discussed when Chapter 9 is considered. They also reflect seriously on the credibility and authoritative nature of the whole report.

The Committee appears to have placed heavy reliance on rather old and out of date sources for its model, the merchant ship reactor designs, the old Shippingport reaetor and WEI77. Yet they had copies of the US Naval Nuclear Propulsion Programme publications DOE90 and DOE91a referred to above. DOE91a was the only document the Programme would release to the present author under a Freedom of Information Aet request for copies of all documents relating to US Navy reactors that could be released. Even though these are really public relations documents, they do contain a surprising amount of interesting detail, some of which has been quoted.

The author does not claim to be experienced in reactor design. However, the mere fact that it is possible for experienced nuclear physicists to develop two quite different models from essentially the same source rnaterial really shows that very little detailed knowledge of the construction and operation of US Navy reactors is available in the public domain. The Committee has not demonstrated any privileged knowledge of these reaetors, and this almost certainly applies to their knowledge of all features of the reactors including their safety systems, a point that will be significant elsewhere in this critique.

This lack of public knowledge of the details of US and other naval reactors is further discussed and highlighted by material in a recent book entitled 'Sunken Nuclear Reactors' by V O Eriksen, which includes the author's assessment of the structure of naval reactors. His model of a naval reactor differs from both the alternative model and the report model, eg. it specifies an enrichment af 97.3% in U-235, supports the consumption of about 76% of the U-235, and supports the use of uranium dioxide but in a different fuel form. The only reasonable conclusion is that given above, we do not really know what these reactors are like except in broad outline.

p. 42 para 1. 'An important......' The claim here is that a xenon poisoning problem will not exist for the model reactor. This form of poisoning could be a very severe problem in a naval reactor since, if serious enough, it could result in the reaetor being very difficult or even impossible to start after being shut down, in a port for example, until the xenon had decayed sufficiently not to inhibit the fission chain reaction, and this could take some hours. The NPV would be out of action during this time. The Australian report on the other hand says p.57 that for US nuclear powered subtnarines the hafnium control rods are used, among other things, to compensate for fission product poisoning, fuel burnup and power load changes. So perhaps xenon poisoning is not necessarily a negligible problem in actual US NPV reactors.

p.42 para 2. 'Important features......' All the features listed, 1 to 5, depend on the reality of the model reactor and this has now been extensively challenged. If this model is as flawed as has been claimed, little weight can be given to the claims in point 6 either. This comment applies equally to the para that follows 6, 'All of these considerations...'.

p.45 point 5. As described, and shown in fig.4.2, if the bursting discs between the primary and secondary containment in a submarine do burst, the crew is exposed to the consequences of the reactor accident. This does not seem very desirable.

p.45 point 6. What does the crew think about hull itself being the secondary containment with them inside it.

It is not obvious that the Committee has any really detailed knowledge of the containment features of naval NPV.

5. RISK IN PERSPECTIVE.

p.47 5:1. 'It is important to obtain a realistic picture of the risk likely to be posed by the visits of nuclear propelled warships to New Zealand ports. The first step in this evaluation is to compare such risks with those posed by comparable technologies.' The correctness of the first sentence depends on what is seen as realistic. What follows in this chapter is not considered to contribute to a 'realistic picture' of the risk from NPV visits because of the incompleteness of the treatment.

There are many things that could be said about this chapter; For the sake of brevity and objectivity the comments will be limited, and not necessarily be referred to particular pages or sections.

The report now proceeds to examine the risk from a number of technologies, transport, building presumably since fire is included in Fig 5.1 and is discussed but no associated technology is named, and so on. These are all technologies that we tolerate or accept because the majority have decided that significant benefits result. But nowhere are costs and benefits for these technologies and NPV technology discussed in any detail in this report, The Committee rejected such arguments as outside their terms of reference, yet it is not obvious how much of the material in this chapter is justified for inclusion under those terms.

p.47 para 1. 'Using the deseription of a typical submarine nuclear propulsion system...' The reliability of the description given in the repart is questionable.

P,47 5.2, '....routine operations have no significant personal or environmental effect' This depends on what is regarded as significant. Letters from crew members of the US aircraft carrier Nimitz, and submarine Finback, both nuclear powered presented in rny submission cast doubt on this claim. Also for many people the routine operation of NPV cannot be seen as separate from the associated nuclear infrastructure producing the enriched fuel and the nuclear weapons these NPV are designed to carry. The environmental record of this industry is terrible as my submission details. Further, the report appears to regard any radioactive releases that are below natural background levels as insignificant. For many people no unnecessary releases are acceptable.

The 1988 equivalent of the report MAN91b and 92b, 'Environmental Monitoring and Disposal of Radioactive Wastes from US NPV and their Support Facilities', states p.6 that 'the total volume af [radioactive] liquids released within 12 miles of'shore has been reduced from millions of gallons per year in the 1960's to less than 25 thousand gallons per year beginning in 1973. Thus the Navy has achieved its policy of reducing releases of radioactive liquids in harbours to the minimum practicable amount. Therefore, volumes have been deleted from this report.' It is claimed that the activity in these releases in the last 17 years has been less than 0.002 curies each year, excluding tritium which is short lived, into harbours and seas within 12 miles of shore, and 0.4 curies per year from 1975 to 1987 into the oceans beyond 12 miles (excluding tritium).

On p.7 this document says, 'The total amount of tritiurn released annually from all US Navy NPV and supporting tenders, bases and shipyards has been less than 200 curies.

Most of this has been into the ocean greater than 12 miles from shore...... Total tritium released into harbours within 12 miles from shore was less than 1 curie in 1987.' This is then shown to be very small relative to naturally occurring concentrations of tritium. But all these releases are added quantities of radioactive material, and the above figures imply the continued release of millions of gallons of very slightly radioactive liquids into the oceans.

p.49 5.3. Again this section presents common risks, Table 5.1, that we accept unwillingly, cancer and others, or try hard to avoid like drowning and accidents, and that in all cases we try to reduce. Any attempt to relate these categories of risk to those from NPV visits, which experience has shown we clearly do not need to live quite satisfactorily, is meaningless unless arguments showing the relative benefits of the activities generating the respective risks are presented and weighed.

pp.49-50 The calculation of possibly 51 deaths per year from x-rays is questionable. We are not told how the average of 0.3 millisievert/year dose was arrived at. Is this really the total x-ray dose/year divided by the-total population, regardless of how many people actually had x-rays, as would be required to make sense of the calculation given for the S1 deaths. Or is it the more useful figure showing the average x-ray dose for those who did have x-rays ie. the total dose divided by the number who had x-rays. The relevant input to any study of late cancer deaths associated with x-rays would surely only involve the histories of this latter group, Again this is a type of risk we generally accept because there are benefits in so doing. The relevance to non-useful risks like NPV visits is hard to see.

p.50-52 5.4. Many of the details given here are really assumption of what the sequence of events might be in a serious reactor aecident on a NPV. There is no evidence that the Committee has detailed information of this sort for NPV reactors, and no explanation is given of how they were derived. For example, p.51 last para says, 'The time sequence sketched out above depends on consideration which are directly calculable for the model reactor.....', but does not say they were actually calculated for the model reactor. The times and decay powers given in the preceding para follow closely those in fig IIIA.1 p.S22 of reference APS85 which deals with calculations for severe accidents in commercial reactors, and which is used extensively in Chapter 9.

p.52 para l. There are two COA89 in the Bibliography, they mean the first one. The correct page is Evidence 1300.25, not 1300.23, and does not mention 2Mpa pressure. Further on in this para the text refers to Section 5.4, but it means 5.5. This para is actually in Section 5.4.

In relation to the discussion in this section, a quote from the Australian report p.43 is very relevant. J C Consultancy Ltd prepared a report for the Commission of European Communities in 1986 called 'Risk Assessment for Hazardous Installations'. It says on p.68, 'a prerequisite of any worthwhile attempt to quantify the risks is that the analyst must have a detailed knowledge of the plant to be assessed. This knowledge must include details of the form of the plant, exactly how it is constructed, the temperature and pressure conditions it will operate under, the materials it contains, an understanding of any reactions that will be taking place within the plant, how the plant will be operated, the capability of the people who will operate the plant, the life of the plant, and the inspection and maintenance patterns.' The Australian report p.45 concluded that 'neither the [Australian report] Committee nor the Australian Government has the data necessary to quantify in a comprehensive way the risk of an accident to the reactor of a United States warship.'

The present report admits this in Chapter 2 p.22, but sections of the report, in the present Chapter 5 for example, tend to give an impression of a reasonable degree of quantification of risk for NPV reactors, or of knowledge of some of the factors listed in the quote from the risk assessment text cited above. There is no evidence that the New

Zealand Committee are any better informed than their Australian counterparts in these areas.

p.52 para 3. '...... Any radioactivity in the core material would remain within it.' This is after a meltdown of the core. How can this be known? No explanation is given.

p.53 5.5.1 para 2. There are three entries NRC91 in the Bibliography, they mean NRC91b presumably, and KEM8 is not in the Bibliography.

This section presents a rather positive view of the Three Mile Island accident, but according to Dr B Lambert in 'How Safe is Safe? Radiation Controversies Explained', 1990, p.92 'it shocked US public opinion and was one reason for the slowing down, if not demise, of the US nuclear industry ... no new reactors have been ordered in the USA since 1978'.

p.54 5.5.2 para l. Reference UKA91 is not in the Bibliography. Chernobyl is discussed when Appendix 8, Section A8.4 is dealt with. But contrary to the picture that section tends to give, most reports regard Chernobyl as a major disaster, and the official death toll is now around 8000.

p.54 5.5.3 para 1. Reference NUC57 is not in the Bibliography.

p.55 top, B Lambert p.91 points out that the 250 and 30 (he gives 30 not 13) were calculated using the then accepted ICRP risk factors. He says that a total collective dose of I-131 of 20,000 person-sieverts was delivered. Using the factor of 0.05 per sievert given in the report p.214 Table A8.2 this gives 1000 fatalities as a 1990 estimate if Lambert`s figures are correct.

p.55 5.6 Concerning the accident on the Mutsu when the reactor developed a leak, Nature 17 October 1991 p.594 reports that 'The crew desperately stuffed socks and [boiled] rice into the reactor to try to stem the flow of radiation while the government offered local fishermen in Mutsu City large sums in compensation to allow the ship back into port.' These fishermen had delayed the sailing of Mutsu for six years because of fear of radioactive pollution, and when it did sail the reactor started to leak almost as soon as it started operating. By 1991 when plans to operate Mutsu as a NPV were abandoned it had cost about $US930 million. Serious exposures to radiation may not have been involved;,but this is hardly a success story.

p,55 5.6 last sentence. The report omits mentioning that the maximum recommended dose is now 20 millisievert/year not 50mSv/year, see p.207 Table A7.1. Yet p.56 para 2 Of the quote gives 50 as the limit for the US Navy, in 1992.

p,S7 para L Radiation detectors all have limits below whieh they will not detect radiation. So a remote release of radiation might well not be detected if the amount of radiation reaching a detector site was below the detector's limit. It is difficult to think of detection sites that would be close to an accidental mid-ocean radiation release for example, so such a release could go undetected unless it was very large. This paragraph does not really say anything without further qualification.

p.57 para 3. This paragraph reflects a difference in attitude between the authors of the report and others. The report considers reactors on the seabed not to be a problem if they are not leaking radioactive material now. But what will be the situation in 100 years? Some of the core contents have long half lives eg. strontium-90 and caesium-137, 30 years. And for many people pollution of the seabed is unacceptable even if the pollutant is well contained.

p.58 5.7.3 Reference JAN91 is not in Bibliography, it probably should be JAN92.

pp.58-64 5.8. This section uses methods that have already been challenged or commented on to produce what it initially describes as an estimate for the frequency of serious NPV accidents. But it then presents these estimates in a manner that makes them appear relatively accurate. It even introduces the term, 'quantification of risk', despite the admission earlier on p.22 that this is not possible, and only approximate numerical estimates can be given. Even this will be challenged here.

The major points of dispute with this section are found in fig.5.2. First it uses arguments that are here considered incorrect or non mathematical to deduce the 'Safety Record' point. Second it does make the estimate of accident frequency presented look quite quantitative, ie. accurate. The 'Safety Record' point is smeared somewhat, but not by much. Third it uses analyses relating to commercial PWR to introduce curves on the graph. Finally the present situation is not indicated on fig 5.2.

The whole question of whether or not it is meaningful to even attempt to estimate an accident frequency when no accident record is available has been commented on briefly. The situation is that the US Navy has an official record of 4000 reactor years of operation with no serious accidents, although this only represents just under 40 calendar years of NPV operation. This 4000 reactor years is used to estimate an accident frequency of one in 5000 years with a 50% probability, p.60 point 2.

In the next 2000 reactor years of operation the US Navy could maintain its good record and again have no accidents. It could, by contrast, start to suffer from new problems associated with the ageing of its reactors, a possibility considered quite realistic by a number of commentators. The Australian report p.117 quotes the Director of the US Naval Nuclear Propulsion Programme speaking in 1986 to a Congressional Committee. He said,'.... these ships were originally designed for a 20 year lifetime. Now I arn asked to make them go for 30 years, but they were designed for 20 years. We have a large fleet approaching its original design limit', Dr P B Roberts af the DSIR Nuelear Sciences Group in reference ROB92a p.8 says, 'As reactor systems approach their design life it is reasonable to suppose that failures will become more likely.'

There could be 3 serious aecidents in this 2000 reactor years. A crude average frequency would then be 3 serious accidents per 6000 reactor years, or l per 2000 reactor years. Things could get very bad and there could be 6 such accidents in this 2000 reactor years giving a crude rate of 1 per 1000 reactor years, although to ignore the time dependence of the accident rate in these circumstance would be unaceeptable. So we have possible crude frequencies of 1 in 2000, or 1 in 1000 reactor years, or the information that there has been no serious aecidents in 6000 reactor years.

The claims that follow from this argument are that on the basis of the existing record we have no idea at all of the real or likely accident frequency, and that methods used to obtain the estimates given on p.60 are not mathematically justifiable in terms of what is normally meant by a 'frequency' for some type of event. The small blob on fig 5.2 called Safety Record is meaningless, and to introduce it onto a graph, a mathematical device, is poor mathematics. If anything was to be presented on such a graph to represent this frequeney it would have to be a very large blob covering a significant part of the left hand axis and, as will be argued, of the whole graph. This would be meaningless again as it would convey no useful information.

The frequency used of around 1 in 5000 reactor years is supported by a statistical argument given at the bottom of page 60. The argument is incorrect, and this was suggested to the Committee by an expert in statistics. It is incorrect because the approach used only applies to situations in which the probability or frequency of the events of interest, reactor accidents here, never varies with time. This cannot be claimed to hold for naval reactors, or any reactors. They do age, and this could make the accident probability change with time, as suggested above.

Next, calculations relating to commercial reactors are used to introduce curves into fig 5.2. Curves once on a graph tend to guide the eye and reduce the ease of judging the significance of data points on the graph. It has been argued that it is not acceptable to use results of calculation for commercial reactors to make anything but very general conclusions regarding naval reactors. See the quote in the introduction to this critique p.2 for example, and the quote on p.16 above relating to p.52 para 1 of the report. There are clearly very large differences between commercial and naval reactors, and this negates the introduction into fig 5.2 of the curves presented.

Further as a result of the particular graphical axes chosen, logarithmic axes, the present situation for New Zealand with an accident frequency of zero for all releases of I-131, would be represented by a line along the Curies released axis but at minus infinity on the frequency axis! This is artificial of course, but emphasises the lack of completeness in the information provided in fig 5.2 and in this section. No rnatter how this frequency information was shown graphically, the present situation would appear on the graph well below any estimated accident frequency, since zero is usually much srnaller than any finite quantity.

One important feature of fig 5.2 that is not made clear in this section is why the Safety Record point should have a release of about 10 curies of I-131 associated with it. It is assumed that this corresponds to the release of 11.7 curies in a serious accident estimated in Chapter 9, see p.119 Table 9.1, and rounded to about 10 curies on p.122. This will be discussed in detail when Chapter 9 is considered, as will the information given without explanation on p.59, 5.8.2 point 1 which comes from that chapter. There is some confusion here though since this 11.7 or 10 curie release is associated with a core inventory of 1.06MCi of I-131, see Table 9.1, but p.60 top talks of an I-131 inventory of 2MCi which would put the Safety Record point at 20 curie on fig. 5.2. This will be ignored. **SEE ADDITIONAL COMMENTS P.39 ON.**

However, in Chapter 9 three possible releases are considered, 10, 100 and 1000 curies of I-131, so it would be more complete to have three Safety Record points in fig 5.2 at 10, 100 and 1000 curies. The report to the Committee ROB92a by Dr P B Roberts also, gives frequency and release estimates, and for a frequency close that for the Safety Record point has a release of 5000 curies based on an accident scenario given in AEC 500, but not shown on fig 5.2, see p.64. These are all theoretical estimates for the same type of accident in which the radioactive material released is mostly contained by the reactor containment systems.

A more realistic discussion of this type of accident would, it is claimed here, have to say that there is a considerable uncertainty in the range of possible releases, from about 10 curies to about 5000 curies I-131 at least, and a similarly large uncertainty in the possible frequency of such accidents, if anything can be said at all about this frequency. If accepted, this means that there is no sound basis for the graphical presentation given in fig 5.2 at all. All that can reasonably be said is that the probability of a contained accident would be expected to be considerably larger than for an uncontained accident in which the whole content of the core escapes into the environment. The point UK Uncontained on fig 5.2 with a release of 100,000 curies I-131 conesponds to such an accident. These arguments also mean that no real association can be claimed between the distributian of the entries on fig 5.2 and the curve shown on it for land based PWR, the Generic PWR (NUREG-1150) curve, or the curve labelled Indicative Frequency-Consequence Curve.

Further comments relating to this section will be found in the critique 'The First Finding' by Professor P J Lorimer, Department of Mathematics and Statistics at Auckland University.

6. SAFETY RECORDS.

p.65 6.2. It is correct that many of the accidents listed by Arkin and Handler and in other sources are not very serious. What is worrying about these lists is the large number of accidents of various sorts that the US and other navies have. This rnakes claims like the US claim that there has 'never been a nuclear accident in 39 years' (see the report p. 56 top) more difficult to accept as completely reliable both for their nuclear reaetors and nuclear weapons.

p.66 para 1 The report states categorically that neither the Thresher nor the Scorpion losses resulted from reactor accidents. The Australian report agrees that this is the official position, but states p.138 Section 5.16, 'In neither accident were there any survivors, and relevant wreckage . . . has not been recovered . . . As a result no-one can say with certainty what caused either accident'.

pp.66-68 The US Navy is very careful about documentation of nuclear related activities and events as attempts made under FOIA to obtain such inforination from the logs of US Navy ships, which are publicly available to some extent, has shown. The US Navy record relating to the release of information concerning nuclear weapons accidents also shows this. For example a nuclear weapon was lost aff the aircraft carrier Ticonderoga in 1965. This was only admitted in 1981, sixteen years later, and it was then claimed that this happened 500 miles off the coast of Japan. It occurred in fact only about 80 miles off the Ryuku Island chain. Other instances of this sort are detailed in my submission to the Committee.

p.69 Box 6.1 What is this supposed to demonstrate? Treatment for hyperthyroidism and similar problems is, presumably, beneficial. Visits by NPV are unnecessary.

7. QUALITY ASSURANCE AND SAFETY MANAGEMENT.

p.74 para 1'The statement......' Regarding the quote given there it should be recalled that no NPV has yet been involved in a major naval engagement. Their battle suivival capabilities are unproven.

pp.75-76 The discussion given regarding problems on the Finback and the Nimitz presents a rather different picture from that given in material relating to these problems, and in actual letters from crew members on the Finback, pp.75-107 of my submission: These letters allege that lax procedures on NPV in the US Navy are widespread p.100 my submission.

p.87 para 2 'The SRD has...... ' says a safety study (case) for a UK nuclear powered submarine would involve about 90 person-years work: If correct, this emphasises how little time the Committee really had to make its own assessment, less than 3 person-years.

p.89-91 Section 7.3.7 The report prefers to cite a newspaper article concerning corrosion problems in UK nuclear powered submarines rather than discuss what looks like a well documented report by the Scottish CND, SCN92b, which they do not even mention but which relies extensively on official and naval sources, and which presents a much more serious picture of these problems. It includes (p.13) references to restrictions being placed on visits to foreign ports, citing a House of Commons Report No. 337 91/92 p.xiv, 'Progress of the Trident Programme', in contradiction to the statements pp.90-91 of the NZ report categorically denying any such restrictions. The discussion of these problems by Mr Farmer can also be seen as giving a more serious picture of these problems than given by the Committee.

p.93 para 2 Despite the categorical assurance given here about ECCS on NPV, there does seem to be conflict in statements from various sources concerning how extensive ECCS are for naval reactors, see comments relating to Chapter 4 p.38 and Section 13.8.

p.93 7.5 para 1 The Committee often seem to use rather old Sources, eg. PUG73 from 1973.

8. RADIONUCLIDES IN THE ENVIRONMENT.

Again we find another chapter which, while interesting, is hard to justify under the Terms of Reference, and is not paralleled in the Australian report. Also it is not a matter of putting possible radioactive releases from NPV in perspective relative to background radiation only, but also relative to the present situation where there is no possibility of such releases here. Refer to the three ICRP Principles stated in the Introduction to this cririque. The Australian report p.221 says that 'In effect, application of the first principle would require the Committee to conduct a risk-benefit assessment of the value of the [NPV] ship visits', but concluded that their Terms of Referenee precluded them from doing this. Considering the extensive sections given over to discussions of general aspects of risk and safety in the NZ report, it would seem that the Terms of Reference for our Committee would not have precluded such an assessment for visits to New Zealand.

p.95 para 3 'Background radiation levels....... ' This is confusingly written. It says natural radioactivity in the marine environment derives from the same sources as on land, but for land lists geology, building materials etc How do all these factors enter for the marine environment, and what does etc cover? To write 'etc' in such a discussion is unscholarly and dismissive.

p.95 para 4 This sounds fine, but the record does not always support the claims made. Consider for example the appalling environmental contamination record of the US military nuclear programme, see my submission p.48.

p.101 Table 8.5 The reference for this PRN88 is not in the Bibliography. They probably mean PEN88.

p,101 last para The reference UNS82 is not in the Bibliography. It probably should be UNS88.

p.104 para 2 'Because naval reactors.......' The assertion in this paragraph that the fuel cladding in these reactor cores is 'of high integrity in order to withstand battle stress' is rather alarming. The possibility of a reactor being likely to suffer battle damage to its core is most disturbing, and things would be very critical at this stage. High integrity cladding is a goal of power reactors generally. Also it is not clear why the fuel being highly enriched has any relevance in this particular discussion.

pp.105-107 Again, the general comment applies that no unnecessary release of radioactivity is justified no matter how small unless some definite benefit from this can be demonstrated.

p.110 para 1 'The degree.......' The discussion in the 1990 book 'How Safe is Safe? Radiation Controversies Explained' by Dr B Lambert from the Radiation Biology Department, Saint Bartholomew's Hospital Medical Cohege pp. 222-241 gives a rather discouraging picture of the discharges from Sellafield into the Irish Sea and their effects on people living nearby.

p.113 para 2 This refers to SWI88 and SWI92 with respect to polonium-210 accumulation. But these deal with plutonium according to the Bibliography.

p.113 bottom '....estimated dose .....always below ICRP recommended limits'. But in his book pp.238-9 Dr Lambert says that these doses have often breached the target dose (1/10 of the public dose limit) in the period 1976-1986. Also Box 9.1 p.135 says that the recommended dose for members of the public from regulated nuclear activities (as

Sellafield should be) is 1.O mSv/year. But the lower plot in fig.8.5 p.115 appears to show total doses in excess of this for all years from 1978 to 1983 (including the year 1180!). Note the text p.113 bottom refers to figures 8.Sa and b but there are no such labels in fig.8.5.

p.l 14 para 3 The reference LTNE82 is not in the Bibliography.

9. ACCIDENT CONSEQUENCES

This is an important chapter. It contains the material that the Committee used to estimate the likely radioactive releases from a NPV in the case of a contained accident, ie. when radioactive material is released frorn the reactor core in an accident of the type discussed in Chapter 5, Section 5.4, but is mostly contained within the NPV by the various containment barriers discussed in Chapter 4 Section 4.5. The radioactive material released to the environment is called the 'source term', it is the source of hazard to the environment and the 1oca1 population.

The Source Term.
The way in which this source term has been estimated in the report is considered to be based on some questionable assumptions, and to omit some important factors. These are considered below. The source term is very difficult to estimate in any situation, it depends on the quantities and types of radioactive nuclides present in the reactor core at the time of the accident. As the US Nuclear Regulatory Commission observed in 1987 (see the Austalian report pp.208-9 Note 103), 'The determination of the radioactive source term that would be released following severe accidents is perhaps the most difficult and uncertain area of risk analysis', and source term evaluation is an active field of study and the subject of large international conferences. This overall problem should be borne in mind when considering the reliability of the findings in Chapter 9.

p.117 9.2 para 1 This paragraph stresses that the radioactive material resulting from the fission of the U-235 fuel is normally retained by the fuel cladding, but there is no extensive discussion of how, and to what extent, this cladding might fail in an accident if core temperatures rise to high values except on p.120 by reference to some experience with land based reactors. But in his book, 'Sunken Nuclear Submarines' pp.118-121 V Eriksen argues that the detailed structure of the fuel elements and their cladding is very important in evaluating the source term, and this information is not available for naval NPV fuel. Again he is forced to rely on experienee with commercial PWR, and this raises the question outlined in the Introduction to this critique of how valid it is to apply commercial reactor experience directly to naval PWR as is done in Chapter 9. The quote given in the Introduction p.2 should be referred to.

There is another problem with the use of cornmercial PWR experience and calculations not treated in the report that is important here. As discussed, the fuel in a naval reactor stays in the reactor for a long period, up to 20 years possibly. The fuel in commercial reactors is cycled over a three year period, one-third being replaced each year, so its life in the reactor is much shorter. Consequently the inventory of fission products available for release (compare Section 9.3.1 p.118) from a naval reactor would be greater than from a commercial reactor of the same power output. The Australian report pp.84-5 agrees, but the NZ report does not mention this point. It takes about 6 to 7 half lives for a radioactive nuclide to build up to maximum concentration in the core. So eg. with isotopes like caesium-134 with half life of 2.1 years, or rubidium-106, half life 1 year, the time to reach maximum concentration is well over the three year life of fuel in a commercial PWR, but less than the life of fuel in a naval reactor core, and the build up of these would be quite different in a naval PWR.

p.118 9.3.1 To develop the source term for the report, the Committee did, nevertheless, just use calculations of the radioactive content for the core of a 3200MW(t) commercial PWR given in the reference APS85, a report on radionuclide releases in severe reactor accidents. They scaled the contents given there down by a factor of 80 to simulate the contents of the core of a 165MW(t) naval reactor that had been operating at 25% of full power for some tilne, at 40MW(t) that is. The results for a selection of radionuclides are presented in Table 9.1. This scaling is by a very large factor, and its reliability has to be open to question compared with calculating the core inventory from the nuclear physics involved.

However, as discussed under Chapter 4, this figure of 165 MW(t) is not accepted as correct. Further, the assumption of operation at 25% of full power is quite arbitrary and could be 30-35% just as well. Again, as explained in the report below Table 9.1 the reactor only has to operate for 4 days at full power to boost the I-131 level in the core by 100% to 2MCi (2 million curies). This arises because the half life of I-131 is about 8 days. If the reactor was operating steadily at full power, the I-131 content would reach a maximum value of 4MCi, 4 times that of 1.06MCi for 25% operation (see Table 9.1). It can easily be shown that a sudden increase of operating level from 25% to 100% over 4 days will increase the I-131 content by about 30% of this 4MCi maximum or 1.2MCi which, with the existing 1MCi, gives a new level of about 2MCi of I-131 in the core. But why 4 days rather than 8 days say giving a total of 3MCi of I-131, or some other number of days. This 2MCi is really quite arbitrary, as are all the radionuclide levels in MCi in column 3 of Table 9.1 to a not insignificant extent

The maximum of 4MCi that would be attained for steady full power operation explains the statement that appears on p.59 Section 5.8.2 para labelled 1 that the total amount of I-131 can never exceed 4MCi (not explained in the accompanying text) and the unnecessary detail about needing 50 days to reach 99% of 4MCi, also not explained. The half life of I-131 is about 8 days and 50 days is about 6 to 7 times this. The claim rnarked * at the bottom of that page that the amount of each fission product can be 'readily estimated' is not correct as should by now be clear. This would need much more detail of naval reactors and their operating patterns than is available.

That same statement says that the Committee did not ignore these other radioactive fission products even though they concentrated on I-131. This claim is disputed. As stated at the bottom of p.117, APS85 lists 54 significant radionuclides in the core of a PWR, the report Table 9.1 only lists 10 of these, the more volatile ones. But the report APS85 itself says p.S 19 that 'Relatively non-volatile radionuclide contributors to the source term have been neglected in many of the analyses by the US Nuelear Regulatory Commission and others. In view of the contributions from the dose conversion factors cited in Table IIB.3 [which measure the relative doses delivered in different ways to humans from the various radionuclides] and the equivalent release faetors computed above [Table IIB.4, which measure the estimated fractions of the core content of each class of radionuclides that will escape in an accident] the relatively non-volatile elements of the source term should be evaluated as carefully as the contributions of the more volatile radionuclides. This is particularly important when the release fraction of the volatile radionuclides is calculated to be small.' **SEE ADDITIONAL MATERIAL P.39 ON.**

The report p.120 and Table 9.1 gives the fractional release of I-131 to the primary containment as 2% of the 1.06MCi core content, the 2.13 x 10^4 Ci or 21,300 curies in Table 9.1. Then O.55% of this gets into the secondary containment p.120 giving 117Ci as in Table 9.1. Note the report p.120 para 2 says incorrectly 'we multiply by 0.55, it should read, by 0.55%. Finally 105 or 11.7Ci of this escapes to the outside environment. So of the 1.06 million curies in the core only this 11.7 curies appears outside the NPV. Or if the core content is boosted to 2MCi, about 23Ci escape (p.121 9.3.3). This seems definitely like a case of a small fraction of volatiles being released since the report treats I-131 as the most significant of these, and an instance where the problem of the non-volatile radionuclides should have been examined carefully. It was not examined at a1l. The source term analysis in the report is questionable for this reason alone.

This very large reduction by a factor of 100,000 between the core content and what might aetually escape is based only on assumptions about naval reactor design, and some experienee with commercial PWR of quite different design. So how reliable are the reduction factors assumed in the report for the various containment barriers? The report does cover this point, and some others, to some extent in that it finally considers releases of 10, 100 and 1000Ci of I-131 together with other volatiles (p.122 top). But it is not unreasonable to argue that, since there is no recorded experience of how naval reactors behave in serious accident situations, significantly larger releases could occur. A 10,000Ci release of I-131 would only represent 1% of the content of the core if this was 1MCi. It should be noted in this regard that the assumption that only 10% af the release reaching the secondary containment finally escapes was not made in the Australian report, see p.180 of that report and Evidence p.130Q25 to the Australian Committee. It was assumed there that some degradation of'the containment performance occurs. That report also included a factor of 1.4 in the iodine release to allow for other iodines besides I-131 (Evidence p.1300.25 and.28), not discussed in the NZ report.

A further factor not treated in the report Section 9.3 is the range of reactor sizes in the US Navy. Using information from Jane's Fighting Ships it can be estimated that warships in the US Pacific Fleet have reactors varying in maximum power output from 1 L2MW to 97MW compared to 26MW for the submarines treated in Chapter 4. The largest reactors are in aircraft carriers which have not visited us in the past, but could. They have a large draught (see p.147 para 1) and would have to use one of a number of designated outer harbour anchorages, 5 to 6 kilometres off the East Coast Bays for exampl, according to Ports of Auckland. Even so a serious accident in one of their two large reactors could release up to around 3000Ci of I-131, scaling the 1000Ci considered in the report as possible by the difference in reactor sizes. Using fig 9.3, this could produce maximum permissible dose levels on the East Coast Bays coast.

It is argued that the factors discussed throw doubt on the accuracy and reliability of these vital source term calculations in the report. V Eriksen in 'Sunken Nuclear Submarines' also estimates a source term for a serious submarine reactor accident. He suggests that much larger releases are possible than considered in the report, although he is mainly concerned with releases to the marine environment. He does not place such strong faith in the containment systems as in the NZ and Australian reports.

In conclusion, the original input by the Committee to this part of the report was really quite small. They used APS85 as the primary souree for the core content of an operating reactor, and other sources to estimate the reductions from the containment systems. Their main contribution was the questionable figure of 165MW(t) for their postulated reactor size, and a considerable amount of reading.

p.120 top 'Engineered safety systems .... would have a major influence on the cornposition and magnitude of any release'. It has been argued above that detailed information on these systems is not available, and the US and UK navies will not release such information.

p.122 9.4 para 2 last sentence. Rain can also produce increased depositions locally, see APS85 p:S15.

Dose Estimates.
The next important step is to translate the source term into possible radiation doses to the nearby population and environment. This is covered in Section 9.6 and some of the preceding material. Again the Committee did not make the necessary calculations themselves but 'sought two independent studies' (p.125 9.6 para 1). They present the calculations by Dr McEwan of the National Radiation Laboratory MCE92a, but do refer briefly to some results frotn the other calculations ROB92.

pp.126-7 and fig.9.2 There is a misprint in fig.9.2. The solid curve gives the dose in milligrays (mGy) not in grays (Gy). It was simply scaled from a calculation in MCE92a for a 24 hour dose and a SOMW(t) reactor down to a 2 hour dose from a 40MW(t) reactor, the 'was prepared' claim in the report p.126 *. The dashed lines are taken directly from MCE92a.

p.126 para 3 'Figure 9:2 is a summation of the three sets of more detailed curves shown in Appendix 7'. This is quite confusing since fig. A7.1 p.205 shows 8 curves, not in three obvious groups. It is assumed the report means the summation of curves for the three classes of dose labelled 1, 2, 3, in the section marked ** at the bottom of p.l2b. Note the term 'F Weather' fig A7.1 is not defined. Also this ** section introduces the idea of an Automatic Countermeasure Zone, not discussed previously, and only treated in Chapter 11 pp.149-50 in detail.

When examining figs.9.2 and 9.3 it should be remembered that the recommended dose for the public from regulated nuclear installations is 1 millisievert/year.

Since reference is rnade in the report to fig.A7.1, a major omission in the report relating to this figure is discussed here. Fig.A7.l shows 8 curves. But the original fig.4 in MCE92a shows 9 curves, so one curve has been omitted in the report. The curve omitted is for the dose to infant thyroids from milk contaminated with radioactive iodine, and shows doses 200 to 300 times higher than the highest dose curve in fig.A7.1. The report says that it was assumed there would be restrictions on contaminated food and milk (p.126 **) and mentions this problem with infant doses briefly on p.132 para 2 but with no quantitative discussion. It is unfortunate that this possible source of high doses to infants was treated in this way in the report rather than showing the extra curve in fig A7.1 and discussing it adequately. Experience with children near Chernobyl is showing unexpectedly rapid and serious development of thyroid cancers associated with radioactive iodine, but is only referred to briefly in the report p.214, ie. only in Appendix 8. Who knows how rapidly countermeasures would come into effect in the confusion following a reactor aecident in a NZ port, or how effective they would be.

The consequences of these releases and doses are then considered.

p.128 para 2 'There are a number of possible.......' 'This would diminish rapidly in significance...' What does 'in significance 'mean technically here? Presumably the report means 'in magnitude', but this is only a guess.

p.129 fig.9.3 This figure includes a lot of data that is considered outside the terms of reference, and again expresses the Committee's view that exposure to radiation should not be considered as a serious source of concern if the radiation levels are low enough. This is the basis for many of the inter-comparisons in the figure. This approach to radiation exposure has been commented upon in the Introduction and will be discussed again, but others rnore expert than the present author in problems of low level radiation do not share the Committee's views (the Alternative Committee on Nuclear Ship Visits has commentaries on the report to this effect).

To present a complete picture, fig.9.3 should also include the present situation, no dose for any distance since we have no NPV visits. This would again appear as a line at minus infinity on fig.9.3 as a result of the logarithtmic dose presentation chosen, artificial but interesting in highlighting the difference in risk we now face, and that we could face if NPV visits resume.

It should also show the maximwn potential hazard an NPV represents if the most serious accident occurred, the release of the full core contents. On the basis even of the questionable analysis of the report, this would be a curve paralleling those for 10, 100, 1000Ci but labelled 1 or 2 million Ci, ie. scaled up by a factor of 1000 or 2000 from the 1000Ci curve in fig.9.3. This would show doses in the range 30,OOOCi at 0.6km to about 150Ci at l0km for a IMCi core inventory of I-13L While such a release is undoubtedly very improbable, it is not unusual when introducing a new hazard into the region to examine the worst case threat it can represent. Considering the complete lack of knowledge of how naval NPV and their crews would respond in such a disaster, there is considerable margin for unpredicted event sequences and unprecedented behaviour. The true hazard a NPV represents could well lie between the 1000Ci curve shown and this 'maximum potential hazard' curve, **SEE ADDITIONAL COMMENTS P.39 ON.**

p.130 The discussion here is predicated on our present understanding of radiation damage effects. The trend as understanding increases is to impose stricter dose limits. See also the discussion of Appendix 8 and the consequences of Chernobyl below. If a 1000Ci release would produce about 5 extra cancers, a 2MCi release would produce about 10,000. So the actual effect would probably be somewhere between these wide limits. This discussion also ignores the first of the three ICRP principles listed in the Introduction p.5.

p.131 9.9 There is no justification for adding any unnecessary radioactivity to the environment, no matter how little.

p.132 para 2 'The most significant.......' At least the report admits that a NPV accident could have significant economic and social consequences, although what they mean here by the term 'social' is unclear in the context in which it appears. Roberts comments on the increasing sensitivity of authorities and consumers following Chernobyl to the problem of radioactive fallout in the food chain and any possibility of radioactive contamination {ROB92a p.17), and concern has been expressed in recent statements from sectors of the business world here and by some in our farming community that even the presence of NPV again in New Zealand could damage our 'clean green' local and export image.

Roberts in ROB92a p.9 also considers major external events that could 'eliminate elements of the defence-in-depth philosophy and invalidate probabilistic risk analysis assessments based solely on internal reactor systems'. These include collision, stranding, capsize and sinking. While arguing that these are all very improbable under the rules of entry that would apply for our ports, he does state that while it is very unlikely that any situation could arise in which the decay heat from a naval reactor could lead to the core melting through the ship's hull 'this is not totally dismissed in the literature'. Loss of propulsion in a submarine followed by drifting and stranding with consequent loss of water to act as a heat sink could, in the case of a core melt, result in such a melt through. This is only mentioned to show that there are views of the dangers of NPV accidents that differ from those expressed in the report.

pp.132-134 9.10 The discussion in this section is quite meaningless without some accompanying risk-benefit analysis. Note that the expression 'As Low As Reasonably Practicable' ALARP is introduced here. This is not the same as the ALARA prineiple discussed in the Introduction p.5. 'Practicable' and 'achievable' are quite different.

There is reference on pp.133-134. to Appendix 10 pp.223-226. This presents various tables of risk, but the purpose of these tables is not clear since most of the sources of risk listed involve activities fairly essential to normal life, eg. being unmarried at some time, accidents in an average job or in the home, or that we avoid if possible, eg.cancer, burns. In all of these cases society is working to reduce the level of risk,, eg by anti-smoking campaigns, improved work and home environments, medical research. The risk from NPV visits appears quite anomalous in any comparison with these other risks, since NPV visits are quite unnecessary. No disaster has befallen us since 19$4 attributable to the absence of NPV from our harbours.

Much more could be said about Chapter 9.

10. ACCESS AND SAFETY REGIMES FOR NUCLEAR SHIP VISITS.

The title of this chapter uses rather loose terminology since 'nuclear ship' is normally taken to include both NPV and nuclear armed or nuclear capable ships.

p.138 para 1'Since the AEC 500.......' The claim that 'Much more is known about . . . naval reactors and their operating histories' is challenged. No new significant source of such information is known of that was not available in 1981, and the Committee has not, it is considered, demonstrated any such knowledge, in Chapter 4 for example.

Problems With AEC 500.

p.139 10.3 Any revision of AEC 500 will need careful thought and consideration. While the report does recommend some worthwhile changes, there are very basic sections of AEC 500 needing detailed consideration that the report does not examine. These relate to technical aspects of NPV reactors and their operation in port. Further, AEC 500 has as its purpose (p.l Subsection 1.1) 'to recommend guidelines' for NPV visit procedures. This also needs rethinking if NPV visits are to be allowed. A set of regulations, not just guidelines, should be established, with mechanisms for implementing them. Parts of AEC 500 are worded more like regulations at present, but this needs clarification.

1. AEC 500, Trust Our Allies, and the Danish Model.

As it stands our New Zealand Code For Nuclear Powered Shipping, AEC 500, poses an important problem if NPV visits are to resume. It contains statements like that on p.7 Annex I Subsection 1.3, 'The ship's nuclear plant, its associated equipment and all safety and protective devices, must be in full working order and operating without abnormality'. But how is compliance with such requirements by visiting NPV checked? The US and UK navies will not allow inspections of their reactors, see the report p.155 Section e.

Annex I Subsection 1.5 (b) p.8 of AEC 500 does require the US and UK to certify that their visiting NPV will operate in accordance with their own regulations for port visits (see the report pp.154-5) or with AEC 500 if this imposes more stringent conditions. Here, at least, a regulation not a guideline is required. Even so it means taking our allies on trust. It would be far more satisfactory in this era of reduced rnilitary tensions to impose the requirements that Denmark does should we consider relaxing our NPV ban. We should demand details of the safety and other systems incorporated in naval reactors in accordance with the sections of the International Convention for the Safety of Life at Sea that deal with merchant NPV, but apply these requirements to all NPV as Denmark does.

2. Technical Problems:

Another problem the report does not address is the important fact that, as it now stands, AEC 500 should not allow a visit by a 688 class US Navy submarine. AEC 500 p.6 Subsection 9.1 states that 'In this Code the acceptance of NPV is limited to those whose reactor power levels are less than 100MW(t)'. The report Chapter 4 estimates the power of the reactor in a 688 class submarine to be 165MW(t), outside AEC 500 limits. Yet one such submarine visited in 1983, the Phoenix, and there are other US Navy NPV with larger reactors that have visited. This needs clarifying and AEC restriction imposed strictly, or changed, which could have been done when AEC 500 was modified in 1981.

While visiting in accordance with our Code, most naval NPV would have their reactors shut down to a state specified in AEC 500 p.10 Annex I Subsection 4.1(a), well below normal operating conditions. It has to be assumed that compliance with this section is covered by the certification requirement 1.5 (b) discussed above. In some circumstances, possibly in times of crisis for example where flexibility of movement is vital, naval NPV can be admitted without shutting down their reactors. This is covered by Subsection 4.1 (b) p.10 of AEC 500, which poses another problem.

Under condition 4.1 (b) p.10 the Cornmanding Qfficer of a NPV must certify that 'the total I-131 inventory does not exceed 250,000 curies per reactor at the time of entering the harbour'. But how is this level of 250,000Ci or 0.25MCi to be achieved.

In Chapter 9 an inventory of 1MCi of I-131 was assumed for a 688 class submarine reactor operating steadily at 25% of full power. If the reactor I-131 content has to drop from this value to 0.25MCi, a factor of four, the minimum time this would require even if the reactor was shut down completely is two half lives ie. about 16 days. It is obvious that no submarine would sit with its reactor closed down for this time just to get into a New Zealand port. Operation at a low power level would be necessary for a considerably longer time to get the core content down to 0.25MCi.

This seems to be a confusing section in AEC 500, and although it might not be invoked often would be even more anomalous for NPV with still larger reactors. It may have arisen historically since earlier discussion of naval reactors appears to have assumed maximum power levels more like 40MW(t) which, for operation at 25% power would give an I-131 content of around 0.25MCi scaling from the admittedly questionable assumptions m Chapter 9. T'his all needs clarifying if some maximum I-131 level is to be set, since it takes time for the I-131 in a reactor to decay to a prescribed level, and this could affect the conditions of entry in a new version of'AEC 500. This problem was not raised in the report.

Finally, AEC 500 only addresses vlsits by merchant NPV or naval NPV from the US and UK navies at present. Any modified code should also include regulations for possible future visits by NPV from the Russian and other navies.

p.140 10.3.2 para 3 last sentence. This implies that Annex III Section 9.3 (b) of AEC 500 'concentrates on I-131'. But it does not even mention I-131.

p.141 para 2 'A major cansideration.......' The suggestion in l Nuclear Powered Ships General Infornnation, that Annex VII 1-3 be excluded is challenged. This material should go in under category 2 NZ Government Conditions of Entry.

p. l42 tap The references HOB92 and WES86 are not in the Bibliography.

p.142 para 3 'Despite the fact..... and the following para. The report does admit that allowing NPV visits will be expensive in terms of radiation monitoring, and organisational and training costs. As mentioned in the Introduction, Canada has recently granted about $NZ 11 million to upgrade equipment for its Nuclear Emergency Response Teams in ports visited by NPV. The report pp.219-220 states that only three Canadian ports are authorised for NPV visits, so this $11,000,000 would, presumably, be spread over these three ports only. This means a cost of about $3,600,000 for upgrading in each port. Does New Zealand want to face any similar cost? How do our comparable facilities measure up against those planned for Canada? These question will need answering if NPV visits are to be considered. The report gives no estimates of such costs.

pp.142 last para and top p.143. 'It is clear from our investigations that the major justification for requiring that a comprehensive safety plan is in place is reassurance of the public.' This statement, together with the argument in the rest of the paragraph, is considered to display a disturbing faith in its own findings by Committee.

First it assumes that the Committee's analysis of possible accidents is completely reliable, while arguments in this critique suggest strongly that very little in this report can be said to be completely reliable. Even if the report was reliable, a significant safety factor in the level of accident response preparedness would be normal. Are the Canadians spending $11,000,000 merely to reassure their public?

Second it seems to assume that the public are fairly gullible, and easily reassured by a show, of safety preparations in this case. A recent NRB poll showing a majority disbelief in the report and its findings seems to refute this view of the public.

The reason for a comprehensive safety plan is that the possibility of a NPV reactor accident, even more serious than the contained accident considered possible by the Committee, cannot be ruled out. Further, there are plans for dealing with accidents on LPG and bulk chemical tankers in place, in the port of Auckland for example as documents supplied to the author by Ports of Auckland show. And there are clear economic associations with LPG and bulk chemical tankers, but not with naval NPV.

p.143 10.3.3 paras 2-3 OPNAVINST 3040.5B Examination of this document suggests that there is room for ambiguity in its interpretation, and does not support the strength of the claims in the report.

Note: The Danish regime is omitted from this chapter and is only mentioned briefly in Appendix 9 p.218 with no discussion of its consequences, no NPV visits since 1964.

11. SUITABILITY OF NZ PORTS FOR NPV VISITS.

Again the problems with AEC 500 relating to the 100MW(t) limit and the 250,000 curies I-131 are not discussed. How suitable are our ports for visits by NPV with reactors of the size the report calculates, 165MW(t) for a 688 class submarine, or up to about 235MW(t) for the nuclear powered cruisers CGN39 Texas or CGN41 Arkansas in the US Pacific Fleet, calculated following the method of the report Chapter 4.

pp.145-6 11.2 The conditions a to f are essentially identical to those in the Australian report pp.l7-18 except in condition e relating to vessel removal. The NZ report says 'if an accident should occur'. The Australian report says 'if an incident should occur'. This is a less serious level of problem than an 'accident' in US Navy terminology, and its use seems more appropriate. It is defined in AEC 500 p.16 as 'an unexpected event involving a nuclear reactor plant which could lead to a reactor accident unless controlled'. AEC 500 defines a reactor accident as 'an unexpected event involving a nuclear reactor plant which results in a radiation hazard external to the reactor'. The report only defines the term 'accident via 'Reference Accident' in the Glossary. There is no mention of the term 'incident, or discussion of the difference from 'accident'.

p.l .3 The report in the section 'Demographic Information' uses 550 metres as compared with 600 metres in AEC 500 but offers no justification. This follows UK practice.

p.147 para 1 'A physical.......' The Texas visited in 1983 not 1982, see the report P.183.

p.147 para 2 There is evidence that the Bay of Islands is also being considered for NPV visits, and anchorages off Great Barrier Island. Further the Committee clearly had no experience with protest fleets. Police kept these well away from NPV in more recent visits as noted in para 3, but which applied as the NPV entered the harbour as well as when it was anchored or moored. This contradicts the last sentence of para 2.

There is no discussion here of the need for specially equipped tugs and tug crews, appropriately trained to deal with a NPV accident or incident, see AEC 500 pp.28-31, but this would appear to be a very important aspect of safety preparedness for NPV visits. They also add to the costs of these visits.

pp.148 11.4 From memory, and Ports of Auckland agree, many of the NPV that visited Auckland most recently anchored in the harbour and did not tie up at wharves. Certainly submarines did. For safety reasons they should never be tied up at wharves in the hearts of cities like Auckland and Wellington. A ship at anchor can presumably be much more readily moved to a remote anchorage in an emergency.

p.148 11.5 para 2 The reliability of the report's estimate of the source term has been discussed.

p.149 top Response mechanisms should be in place at all times not just when the reactor is operating in case some unforeseen circumstance arises. Monitoring should be continuous anyway.

p.149 Exclusion Zone If people in this area may get 'unsafe doses' (which assumes that there are safe doses) what does accounting for them do, except to ensure they are checked for radiation effects? Strange wording.

p.149 Automatic Countermeasure Zone This refers to taking measures automatically 'as soon as a reactor accident occurs'. But it may take some time to establish reliably that an accident has occurred, panic etc could make this difficult. So what does 'as soon as' mean here? Direct doses could be higher than in fig 9.2 if the NPV had a larger reactor than allowed for or if other factors in the source term calculation were wrong.

pp.148-50 11,5 The discussion of berth assessment in this section is difficult to reconcile with the statement on p.142 that the major need for a safety plan is to reassure the public.

p.150 fig 11.l This is badly presented. The Automatic Countermeasure Zone extends to 550 metres, but the Preplanned Countermeasure Zone extends to several kilometres. Yet they are shown as almost the same size.

p.151 11.6 para 1 last sentence. A new term 'severe accident' now appears, with remote likelihood. But we have been told that the likelihood of any of the accidents considered in the report is remote. So what is a 'severe aecident'? What level of accident does dictate planning?

p.151 para 2-3 NPV have in the past remained at anchor in Auckland Harbour, so do we deduce that they continued to operate their reactors then? If so, did they comply with the AEC requirement of less than 250,000 curies I-131 in their reactor cores? NPV anchored are more remote from people, and are easier to move in an emergency. Also the physical shape of large submarines and the size of naval NPV favour anchoring according to Ports of Auckland.

12. COMPENSATION.

As with other sections of the report, the Australian report covers this question much more completely, pp.501-518. The worry with present arrangements is that it has proved difficult, in some cases at least that are known about, to obtain compensation from the US Navy, and the process has been very long winded even for relatively minor claims. See the Australian report p.511 para A4.22, other details are available.

p.157 para 1'We are of the opinion....' The suggestions here seem very sensible.

13. MYTHS AND CATCH-CRIES.

This is considered a most unfortunate chapter to find in a report prepared by a group of supposedly impartial academics. It is considered to show the pro-nuclear bias and the inadequacies of discussion commented on in the Introduction to this critique. It also shows the Committee's tendency to assume that its findings are unassailable, commented on there. Other technically competent people echo these concerns. It also contains in places a level of argument not expected in such a report. It does not quantify the extent of support in the submissions it received for the supposed 'myths' it discusses. This would have been easy to do at the time of reading the submissions by simply noting how many presented each myth. Further comments are presented following examination of the chapter.

p.159 para 1 'Concerns based on.......' This assumes that the Committee reached a better level of understanding of the points discussed than others had. This supposition will be examined.

p. 159 13.1 It would be interesting to know how many submissions made this claim and where they came from. In the author's experience, people in the peace movement do not generally make this claim that a reactor can become a bomb.

On the other hand, as pointed out by Dr J Miller in the United States, this has happened on three occasions. In correspondence with Greenpeace, Dr Miller, who served as a Nuclear Engineer/Submarine Officer in the US Navy for four years on the USS Seawolf SSN 575, discusses this 'myth'. He states that just because reactors cannot explode with the force of a nuclear bomb does not mean they cannot have a nuclear explosion at all. The Chernobyl explosion in 1986 and the SL-1 reactor explosion in Arco, Idaho in 1961 were nuclear explosions, and an explosion on a Soviet Echo class submarine in 1985 is thought to have been nuclear in origin.

p.160 13.2 This is not a myth. DOE90 and DOE91a from the US Naval Nuclear Propulsion Program group (see p.13 above), and evidence to the Australian report by Royal Australian Navy Commander M K Gahan all suggest strongly that US naval reactors do have high core power densities, even if not extremely high. The report itself shows that they also have high fuel power densities. This is just the the thermal power per unit mass of fuel in the reactor core, in MW(t)/tonne for example. Appendix 6 p.201 gives this figure as about 35 MW/tonne for a commercial reactor and about 73MW/tonne for the report model reactor, and 73 is high compared to 35, even if not extremely high.

The second paragraph reflects the confusion in the report discussed under Chapter 4 over fuel burnup and the atomic composition of the U-Zr alloy assumed in the report as the fuel form.

p.161 1;3.4 This is not considered to be a myth. Even the flawed report model quotes a coolant pressure of 2000 psi (see Appendix 6) which for most people is high. Also their operating temperatures at the centre of their fuel plates of 320 degrees is high in terms of everyday experience. This is considered to be completely incorrect in any case, and the uranium dioxide fuel elements favoured in the alternative model would operate with central temperatures of more like 1800 degrees centigrade. This is extremely high but not abnormal for commercial PWR.

p.161 13.5 The public do not have ready aecess to all the sources made available to the Committee, and the report admits that good diagrams of naval PWR are hard to find. So this concern is not surprising and scarcely warrants the label 'myth'.

pp.161-2 13.6 Again a reason is given for this concern so why label it a myth. Also while evidence is presented here for the reliability of the containment, the Australian report in its considerations of accident consequences was ready to allow for containment failure as a factor dictating the seriousness of a reactor accident.

pp.162-3 13.7 While the bulk of the statements here may be correct, the claim that the low fuel temperature is a factor in the low emission of certain radionuclides in naval PWR is contested on the grounds that the report has the wrong fuel form and fuel temperature regime in its reactor model. See comments regarding 13.4 above. It is surprising that people say the amount of radioactivity emitted is 'dangerously' high.

pp.163-4 13.8 This is quite understandable. The report has not established how carefully or fully engineered ECCS systems for naval PWR are, just as the Australian report could not. Commercial PWR have active ECCS with extensive fail-safe systems, see sg. GLA81, quite different from relying on sea water around the vessel, a passive system. In this sense, naval NPV do not have normal ECCS. So the last sentence p.164 in this section, 'We are able to state without reservation that ECCS are an integral part of the design and construction of all naval nuclear propulsion reactors' is speculation. See ROB92a p.8, 'No firm information is available on the arrangements to provide emergency coolant to the core'. The Australian report p.102 concluded that the information relating to ECCS in naval PWR 'was not sufficient to enable the Committee to come to any firm conclusion on whether naval reactors have effective equivalents to land-based reactor ECCS's'. Dr Miller, referred to above (see comments regarding 13.1), supports these arguments and extends them. This is one of a number of instances where the NZ-Comrnittee adopted a rather extreme position when they had evidence suggesting that this was not fully justified.

p.164 13.9 The Australian report pp.117-8 discusses this problem of ageing and concludes, 'In the absence of evidence, a conservative assumption should be made and a 20 year old reactor design regarded as less safe than the latest design'. They do go on to say 'Of course, less safe is not the same as unsafe'. See also p.18 of this critique.

p.165 13.10 It would be interesting to know how many submissions raised this quite technical point. It is also difficult to imagine single interest groups trying to interest the public in such an esoteric point about naval PWR so as to have an opportunity to misinform them, compare the claim p.12 of the report.

p.165 13.11 Evidence to the Australian report p.1300.55 from the Australian Department of Defence says that 'Nuclear powered submarines are equipped with a switch to override the automatic emergency reactor shutdown; procedures for its [the battle short] operation are classified. The switch is used at the direction of the commanding officer only in operation situations'. This lack of information on a device vitally related to the reactor operation makes concern over its use or accidental or dangerous misuse, eg. in tense situations, understandable. The Australian report pp.108-111 is atnbiguous about the battle short representing an extra danger.

pp:165-66 13.12 The sentence at the top of p.166 regarding concerns about radioactive waste disposal, 'This concern is without foundation', illustrates the Committee's tendency to treat its own position as unassailable. There is much evidence that contradicts this claim, and the Committee must have been aware of it.

Reports concerning cleaning up radioactive waste contamination from US military nuclear installations alone estimate the cost involved as between 20 and 100 billion dollars. Serious concerns about radioactive contamination of the environment by US facilities associated both with the manufacture of nuclear weapons and fuel for NPV have been expressed for some time now. The situation is described in an article in the magazine Time, 31 October 1988, entitled 'They Lied to Us', by E Magnum.

Writing about practices at these plants the author says, 'Far too belatedly, the whistle has been blown on Government complacency, recklessness and secrecy. Under assault from Congressional critics, citizen lawsuits and probing reporters, the private contractors and their see-no-evil federal supervisors have admitted to shocking practices and promised to clean up after their predecessors. That effort could cost as much as $100 billion and take up to 20 years. Unwilling to keep their ageing equipment in repair or to plan for orderly replacements, they have allowed their network of plants to become so disabled as to threaten their very reason for their creation: the maintenance of a credible nuclear deterrent'.

The four biggest nuclear weapons plants in the US have now been shut down. Energy Secretary John Herrington admitted that safety fell by the wayside in the past as 'things got too-cozy' with the plant contractors. A recent article by T W Lippmann in the Guardian Weekly reports costs as high as $20 billion to clean up and decontaminate just three obsolete US uranium enrichment plants. Highly enriched uranium is used in NPV reactors. See also 'The Contamination Factory', by P A Johnson, E L Govan and T O'Toole in The Bulletin of The Atornic Scientists, October 1991, p.34.

D Lowry writing in New Scientist 6 March 1993 pp.30-33 '2010: America's Nuclear Waste Odyssey' reports on the unsolved problems of finding satisfactory storage sites for spent reactor fuel and high level waste in the US and UK. A conference organised by the International Atomic Energy Agency (IAEA) on 'The Safety of Nuclear Power: Strategy for the Future' in September 1991 discussed the question of final disposal of radioactive waste, and high level waste. The conference report p.87 says, 'programmes for the disposal of long lived highly radioactive waste have not reached the stage required for the licensing of repository construction . . . . There is a continuing need for agreement on how to interpret the period of time for which it is necessary to demonstrate that the basic radiation protection criteria are met', and recommends continuing research into the final disposal of waste, 'matters on which opinions differ should be studied further . . . . work towards international arrangements should be undertaken with a view to aceepting obligations and harmonizing safety objectives for final disposal . . . . safeguard approaches for spent fuel repositories should be worked out'.

And the conference agreed that 'The IAEA should develop international safety objectives . . . . with regard to the implementation of waste management and disposal . . . . There is a need to consider an integrated approach to all aspects of nuclear safety, including safety objectives for radioactive wastes, which would be adopted by all governments'. This does not support the claim in the report p.166 top.

To get high level waste into a form suitable for disposal it is generally proposed that it be imbedded in glass, a process called vitrification. The Bulletin of Atomic Scientists November 1992 in an article entitled 'Vitrification - how booming a business?' by J Isaacs discusses the present state of development of this process and reports that the US General Accounting Office, a US Governrnent oversight body, in June 1992 asserted that the vitrification project has been in serious difficulty since it began, a result of a 'fast track' approach, and expressed serious concerns about technical aspects of the project.

Thomas W Lippmann, well known US commentator, writing in the Guardian Weekly of' 23 May 1993 on the problem of demolishing the Hanford plant on the Columbia River used to supply plutoniurn for nuclear warheads, reports that 'a mesa in the center of Hanford known as the 200 Area, where the waste tanks and plutonium factories are, cannot be fully cleaned up and made available for public use for generations, if ever, because of limitations of money and technology'. Referring to the vitrification of Hanford waste he says that the problem is that 'the vitrification plant has not been designed'.

Discussing a meeting of concerned parties he says the group 'accepted the fact that no disposal solutions exist for much of the waste and that other programs have higher claims on the Federal dollar . . the US has no permanent disposal site for radioactive waste or plutonium'.

Other sources could be quoted that suggest the problem of radioactive waste is far from solved. While not all such reports are necessarily completely reliable, a more scientific approach to the concern over radioactive waste expressed in this so-called 'myth' would have been to discuss the state of the problem in a more balanced manner, ackowledging the Committee's own views and views expressed in sources like those cited.

Also the claim in para 4, 'High level waste....' that a long lived isotope must have a low level of radioactivity is incorrect. The level of activity associated with a given sample of radioactive material depends on its half life or lifetime, but also on how much of it is present. No matter how long the lifetime is, if enough of the radionuclide is present the activity will be high since the activity is directly proportional to the number of radioactive nuclei present, see Box 3.4.

The sentence in which this claim occurs is also scientifically incorrect as it is worded. It says the radioactive decay at any time is calculated by dividing the amount of isotope present by its lifetime. The radioactive decay of a given isotope is characterised by its lifetime or half life and these are independent of time. The report means that the activity is calculated in the manner described.

p.167 13.13 Regardless of what the report states on p.167, the Chemical Rubber Corporation in its internationally recognised CRC Handbook says, 'Because of the high rate of emission of alpha particles and the element being specifically absorbed by bone marrow, plutonium is a radiological poison and must be handled with very special equipment and precautions. Plutonium is a very dangerous radiological hazard'.

The recent book 'Plutonium; Deadly Gold of the Nuclear Age' by a special commission of International Physicians for the Prevention of Nuclear War (IPPNW) and the Institute for Energy and the Environment p.8 states that 'plutonium is amongst the most dangerous of substances'.

p.1b8 13.14 Strong refutations of the Committee's position concerning the danger of low level radiation and radiation hazards generally are given in other critiques by people more technically competent to comment on these topics than the present author. For access to these, and some other critiques, contact the Alternative Committee on Nuclear Ship Visits.

Some cornments are presented, nevertheless. The Committee's position goes completely against the ICRP principles stated in the Introduction. Also Dr B Lambert in 'How Safe is Safe? Radiation Controversies Explained' 1990 referred to earlier says pp.247-9, 'The general thesis of this book has been 'How safe is safe?' ie. can we believe 'official' reassurances that the risks associated with exposure to radiation are 'negligible', 'insignificant', 'small compared to other risks', or 'no cause for concern'. It is hoped that the main conclusion the reader may derive [from reading the book] is that there is such a dearth of evidence and so much uncertainty about environmental predictive models and radiation effects at low levels that it behoves the administration and regulation makers to be conservative'. 'He criticises official sources for constant changes of policy or having no policy, and pressure groups for exaggerated claims, and calls for a more scientifically reasoned attitude towards radiation risks.

C Vaughan reported in New Scientist 6 January 1990 that the US National Research Council has concluded from studies of Hiroshima and Nagasaki victims that the risk of cancer from low levels of radiation from x-rays or gamma rays is 3 to 4 times higher than previously thought - and there is no threshold dose. See also the comments on the report's treatment of Chernobyl p.212 Appendix A8.4, and the unexpected development of early thyroid cancers in children p.214 of the report.

Again a rnore balanced treatment of this concern over low level radiation would have been expected from a scientifically impartial group.

p.169 13.15 There have been earthquakes that killed many hundreds of people and resulted in extensive damage. These are rare but are catastrophic. The frequency of these would have been sensible to discuss relative to naval reactor accidents. So the claim listed as Myth Fifteen is not considered to be a myth but a very reasonable qualitative comparison since the report's estimates of reactor accident frequencies are not regarded as reliable (see pp,18-,19 above). It should be noted that recent estimates of the damage from a major earthquake in Wellington put the monetary cost alone at more than $6 billion (see my submission p.2). This is another case where any reasonable course of action to reduce the risk would be given very high priority. We have already reduced the risk from NPV to zero.

p.169 13.16 This claim about the Wahine is not considered to be very sound scientifically, and is not one the present author would support. However, the report's approach to it is also considered confused. The statement does not refer to a naval NPV of large size, or to AEC 500, it makes a statement about the consequences if the Wahine had been nuclear powered and had suffered the disaster it did suffer.

pp.169-70 13.17 It is considered that the Committee has misunderstood submissions that made this claim, which were probably saying that in a complex system like a reactor, a possible event will occur some time, especially if the number of these systems is large as for naval reactors and they are ageing as for naval reactors.

p.170 13.18 This so-called 'catch-cry' seems to have 'caught' a number of members of the business and farming community who are concerned that the mere presence of NPV in New Zealand, with the associated small but non-zero probability of some radioactive contamination of parts of our environment, could damage the export attractiveness of some of our products. We are remote from the pollution suffered in Europe from Chernobyl, and we have no history of nuclear power or a military nuclear infrastructure, - so we are 'clean' nuclear-wise at present, and this is benefiting us it seems. Roberts in ROB92a p.17 supports this view (see the comments relating to p.132 on p.26 of this critique), contrary to the position of the Committee.

pp.170-71 13.19 This is the most unpleasant section to find in this generally very unsatisfactory chapter, coming as it does from three scientists. The term 'nuclear free' is generally understood to mean free from nuclear weapons and nuclear reactors (not just NPV) as the section suggests in its first sentence. Some of extreme view have argued that the continuation of practices, in hospitals for example using nuclear technology invalidate this claim, but one would not expect thls position to be discussed, let alone supported, in the present report. If 'New Zealand is a nuclear free country' is a catch-cry , it certainly has 'caught' on widely world-wide. Polls in New Zealand appear to show that our general public has no difficulty in knowing what they mean by the term 'nuclear free', even if the Committee did.

The world does not appear to have any difficulty in understanding what the Latin American Nuclear Free Zone is or what the South Pacific Nuclear Free Zone is, and what the names imply, even though the use of nuclear technology is more widespread in some of the countries these zones cover than in New Zealand.

If one wishes to be completely rigorous, there is no such thing as a 'nuclear free' region anywhere in the world we know, since all atoms contain nuclei and everything is made up of atoms. This is considered a more scientific argument against the claim than the one presented in the report, but a meaningless argument in cornmon-sense terms. The Committee seems to be trying to override a common-sense anti-nuclear interpretation with weak pro-nuclear argument.

p.171 13.20 This presentation ignores the strong public resistance to NPV visits in Sydney and New York, and some other US port cities, which is possibly a factor in the non-use of Sydney and New York, alternatives being available.

The comparison between Auckland or Wellington and Sydney is interesting. Whether access to the open sea from normal berths in Sydney is really more difficult than in Auckland where a vessel has to be outside Rangitoto to be in the open sea, or in Wellington with its narrow entrance, is very debatable. Also while the population of

Sydney (3,656,500 in 1990 according to official statistics) and Melbourne (3,080,900 in 1990) are much greater than in Auckland (896,200 at 31/3/1992) or Wellington (325,700 at 31/3/1992), all four cities have high inner city harbour shore population densities, and Sydney and Melbourne have similar populations: Sydney does not have naval NPV visits, but Melbourne does, most recently by the US Navy submarine Omaha SSN 692, a Los Angeles 688 class submarine, in November-December 1992. So the criteria presented in the report to differentiate Sydney fromAuckland or Wellington seem very debatable.

This section 13.20 should be considered in relation to the claim on p.142 of the report that the major justification for safety plans for naval reactor accidents is to 'reassure the public'. If this is generally true, it would seem that there should be no difficulty in using either Sydney or New York for NPV visits, since the danger they pose is minor according to the report p.143, and the public would be reassured. The Committee would, it is thought, support this analysis from the wording of 13.20.

Finally regarding this chapter, it is worth noting that almost every one of the 16 'myths' it discusses appeared in submissions to the Australian report. Any orchestrated campaign of misinformation must be at least Australasian in scale. Or could it just be that people in both countries without access to technical information on, or extensive understanding of, naval reactors and naval vessels share common concerns about these systems?

I4. FINDINGS.

Comment on these is scarcely necessary, they are covered in the comrnents already given. It is worth repeating that in the present author's opinion the report adds nothing of substance to the discussion of NPV safety, so the findings have little weight. The situatian in New Zealand has not been changed by the production of this report.

APPENDIX 1: NUCLEAR POWERED VESSELS.

P,175 Al.l para 1 'Each of the five major nuclear powers operates naval ships and submarines that are nuclear propelled . .' This is incorrect, see Table A 1.1 p.176. Only the US and the former Soviet Union operate surface NPV.

p.175 A1.1 para 2 'The Japanese vessel Mutsu was on a trial voyage . . . in 1991 before being decommissioned in 1992' this is misleading as it suggests the Mutsu was a modern ship. It was commissioned in the early 1970's but was a technological failure.

p.175 A1.1 para 3 Projections for the rate of reduction in naval NPV are uncertain. Both the US and Russia face severe economic constraints, and these vessels are expensive.

APPENDIX 4: SUBMISSIONS.

p.194 Table A4.3 The author's submission was from the Centre for Peace Studies not SANA, and was not invited.

APPENDIX 6: THE "MODEL REACTOR".

See the detailed comments pp.10-14 above.

APPENDIX 7: **RADIATION DOSES.**

p.205 Figure A7.1 See the comments on p.25 above in relation to p.126 of the report regarding fig A7.1, and the omission from fig A7.1 of the highest dose curve in the original 9 curve set from which the 8 curves in fig A7.1 were copied. There is no acknowledgment of the source of the curves and other data used in Appendix 7, Dr McEwan in MEC92a, and F Weather is not defined.

APPENDIX 8: RADIATION DOSE AND CANCER.

Valuable criticisms of this appendix are contained in critiques subrnitted to the Alternative Committee on Nuclear Ship Visits by well informed people, and refute many of the claims made in this appendix. This is again a presentation of the on-going debate about the risks from low levels of radiation. The report here presents one perspective, but gives little discussion of differing or conflicting views. It does admit that radiation will produce some additional cancers, so why accept this unless societal benefit in so doing is demonstrated. Remember the three ICRP Principles given in the Introduction p.5.

p.214 Table A8.2 This, for example, shows that even on the basis of the report's own figures, the estimated increase in cancer deaths resulting from Chernobyl, 6942 against 232,000 expected from all causes, is a 3% increase, not insignificant.

p.214 last para The report does not quote the most significant statements from the studies of unexpected thyroid problems in children in the Gomel region. Baverstock et al (BAV92) state, 'We believe that the experience in Belarus suggests that the consequences to the human thyroid, especially in fetuses and young children, of the carcinogenic effects of radioactive fallout is much greater than previously thought. . . . The accident and its impact on Belarus poses a challenge to the international comtnunity to help, both in dealing with the extensive present and future public health consequences, and in promoting research for the understanding of the basic processes underlying the phenomenon. Understanding Chernobyl will provide an important basis for preventive action in the future'. It seem possible that we do not understand everything about the effects of low level radiation.

See also the comments regarding Myth 14, p.34 above.

Official Russian reports now suggest much larger scale problems from Chernobyl than previously reported. Official statistics now put the number of deaths to date at about 8000, and the picture of the overall effects on the surrounding regions in terms of contamination of land, crops and livestock is very grim.

Dr Lambert in 'How Safe is Safe? Radiation Controversies Explained' referred to earlier says p.137, 'There now seems little doubt that within areas close to certain [UK] nuclear establishments there are increased-incidences of certain cancers. These 'clusters' of cases are very unlikely to have occurred by chance and contemporary radiobiological knowledge predicts cancer at a very much lower level. So what then could be the cause?' He does not pin-point a cause, but he does say on p.142, referring to preceding material, 'It can be seen that the association between local increased incidences of cancer and radiation exposure, particularly childhood leukaemia, is still a very open question'. He emphasises the need for further research on the relationship - if any - between low level radiation and cancer.

A more balanced treatment of this question of radiation dose and cancer than given in Appendix 8 would have been appropriate.

p.214 last para Reference ICP91 is not in the Bibliography.

APPENDIX 9: REGUL.ATORY CODES ETC.

p.219-20 A9.2 The discussion of the Canadian situation given here is interesting since other accounts of it, particularly of the October 1991 agreement to allow US nuclear powered submarines to use the Dixon Entrance, tell a quite different story. Documents presented in my submission p.47 and pp.53-69 show that this decision was greeted with anger by some Opposition members of the Canadian Government, environmentalists and the local fishing community. Documents marked 'Secret' state that a public review of the environmental risks associated with this use of the Dixon Entrance was 'unacceptable' to National Defence. Canadian Government Ministers and the Prime Minister are being sued by citizens asking that the Supreme Court order a public environmental review of the berthing of NPV in Canadian harbours. The picture is not quite as satisfactory as presented in the repart.

pp.220-21 The US Navy has regulations for port visits by its NPV that captains are assumed to follow. An attempt to verify how closely these had been followed during the most recent NPV visits to our ports using the Freedom of Infonnation Act and lodged in October 1991 was finally answered in July 1992 after nearly nine months of delays and refusals. The answer was that the relevant records were only kept for two years, so none were available for visits before 1985. A similar request relating to very recent US NPV visits to Australian ports lodged by Dr P R Wills has had no success. He was refused the relevant documents under FOIA rules after a long delay. An appeal has been lodged.

p.221 para 1 The reference COA8.8 is not in the Bibliography.

Note: The Danish situation (see p.218 para 1) is not discussed at all, the fact that it has had no NPV visit since 1964 and the reasons for this. See the Introduetion p.5 above.

APPENDIX 10: COMPARATIVE RISKS.

This has been commented on, see p.26 above, comments relating to pp.132-34. The material in it is regarded as of little relevance to the question of NPV safety.

APPENDIX 11: SYMBOLS AND UNITS.

This must be a very confusing appendix for the average reader, and one which the Australian report did not find necessary. There is no explanation of how 1230,000 converts to 1.23×10^6 or what 10^6 means, for example. The use of symbols throughout the report is considered unnecessarily excessive in a report to the general public, and is not seen in the Australian report.

APPENDIX 12: GLOSSARY OF TERMS.

There are some strange definitions in this Glossary as has been mentioned, see p.8 above and the comments regarding p.24 of the report, for example. The definitions involved there were copied from the Australian report, as were others in this Glossary. The complete Glossary has not been checked.

APPENDIX 13: BIBLIOGRAPHY.

Unfortunately, despite its length, the Bibliography omits a number of references given in the text, and there are several confusing presentations in the text and the Bibliography. These are listed below, the number in brackets give the report page number on which the particular reference is given, some missed references occur on more than one page.

AUS89 (31, 40, 203); COA88 (221); COP81 (48); DAA78 (34); FOC78 (34); HOB92 (142); IAE85 (110,111) there are two IAE85, a/b, but neither refer to IAEA Technical Report 247; ICP91 (213,214); JAN91 (58); KEM80 (53); LOK90 (258) there are two such entries; M0086 (165); NUC57 (54); PAR86 (121); PRN88 (101); REN78 (34); 5WI88 (113); SWI92 (113) these appear to be incorrectly quoted as the text discusses polonium-210 but the references relate to plutonium; UKA91 (54); UNE82(114); UNS82 (101); WES86 (142); WHI88 (269) there are two WHI88 but by different authors; YUT69 (34).

This is a total of 24 missing or confusing references compared with around 620 listed, a 3.9% error rate, not acceptable in scientific documents or documents that include extensive bibliographies generally.

CONCLUSION.

Little needs to be said in conclusion. It has been argued that this Government report on 'The Safety of Nuclear Powered Ships' is not authoritative and lacks credibility in many parts, and that it adds nothing significant to the debate about nuclear powered ship visits to New Zealand. All this at considerable cost to the taxpayer. It is considered a very disappointing report coming as it does from three eminent scientists, and of poor academic quality.

This is unfortunate as the opportunity for a really worthwhile contribution did exist. This opportunity was lost partly by the Government restricting the scope af the investigation through its choice of the Terms of Reference so as to exclude examination of economic, military and other factors in an impartial way, and partly, it is claimed, by the poor quality of the Comrnittee's work.

As stated in the Introduction, the report could have technical and political significance, so it was considered necessary to assess it and comment on it in detail. Readers must decide for themselves about validity of the comments that have been presented.

MATERIAL ADDED FOLLOWING THE SEMINAR ON 'THE SAFETY OF NUCLEAR POWERED SHIPS' HELD BY THE CENTRE FOR PEACE STUDIES, 3 JULY 1993, TO DISCUSS THE GOVERNMENT REPORT.

CONTENTS FIGURE 3.1 'LARGE DRY' PWR

There is clearly a misprint in the report, since the entry in the Contents section for fig.3.1 p.30, and the caption under this figure on p.30, disagree (see p.4 above), This figure in the report appears to be a copy of fig.III.A.4 p.S23 of APS85 which has the caption 'Schematic of a typical (large dry) PWR. The authors of the report presumably changed this caption to read 'Schematic of a Typical Land-Based PWR for Power Production' far fig:3.1 p.30, but failed to make the same change in the Contents section. The 'large dry' refers to the containment having 'sufficient volume to contain the pressure of the Design Basis Accident LOCA' (see APS85 p.S90). This terminology is not discussed or explained in these terms in the report. The only association one can make there with 'wet' or 'dry' is in relation to the presence or absence of the primary coolant, its absence being a LOCA. So the claim made on p.4 above that a'dry' PWR would be a disaster is considered valid in the context of the report. These comments have been included following some discussion of the terminology 'large dry'.

P.58-64 5.8 ACCIDENT FREQUENCY AND CONSEQUENCES

Referring to the comments on this section and its subsections pp.18-19 above, a discussion is presented on p.19 concerning why the Safety Record point in fig 5.2 should have a release of 10 curies I-131 associated with it. The reason suggested there is that this is about the release calculated from a contained accident in the report Chapter 9.

In his discussion at the seminar, Professor Poletti explained that 10 curies I-131 was the minimum release that the Special Committee considered would be detectable from a contained accident, detectable by independent authorities or other monitoring agencies, see the discussion p.57 top in the report. A smaller release would probably not be detected, and larger releases would definitely have been detected. Since no such releases have been reported, any releases that have occurred could not have exceeded about 10 curies I 131, so the Safety record point was set at this release as the maximum likely to have ever occurred, but escaped detection. This is a different argument from that presented on p.19 above.

The Safety Record point represents a theoretical estimate of the frequency of contained accidents based on the existing official record for US Navy NPV, no such accidents in 4000 reactor years of operation. So this point does not relate to any actual accidents. The 10 curie minimum detectable release is also an estirnated value, and does not relate to any observed release. However, the real concern in the report is with possible releases in a contained accident, not with whether or not releases have been, or would be, detected. It seems quite sensible, therefore, to show on this graph the releases estirnated in the report Chapter 9 for such an accident. In assessing the consequences of a contained accident, the report allows the possibility of releases of 10, 100 and 1000 curies I-131, and Roberts considers a 5000 curie I-131 release for about the same contained accident frequency. A rnodified version of fig 5.2 including these points, and other changes discussed on pp.18-19, is shown in fig 5.2a below.

CHAPTER 9 ACCIDENT CONSEQUENCES

This chapter concentrates on the consequences of contained accident in which only a very small fraction of the radioactive contents of the reactor core escape to the environment. The consequences of a much more serious uncontained accident in which almost all the core contents escape is not discussed, presumably because the probability of this type of accident is considered to be much lower than for a contained accident.

Yet, as pointed out by John Gardenier, a Wellington based risk analyst, the risk from these two types of accident is very comparable on the basis of the report's own figures. The report, p.i, defines the risk frorn an event as the chance or probability of that event occuring multiplied by the consequences of the event. On p.62 the report cites an estimate of the probability of an uncontained accident as 100 times less than for a contained accident, but also cites the resulting release of I-131 and other volatile radioisotopes as l00 times greater than in a contained accident. So the product of probability and consequent release, the risk, is the **same** for both types of accident.

Fig 9.3 p.129 should, therefore, at least include a curve for a release of 100,000 curies I-131 corresponding to an uncontained accident, since we face the same threat or risk from this as frorn a contained accident. This release is already about 10% of the core content of 1 million curies I-131 given in Table 9.1. Particularly for an uncontained accident, any such additional curve could well lie at higher dose levels corresponding to an inclusion of factors like the release of non-volatiles and different core histories for naval and land based PWR ignored in the report's treatment of the source term, see pp.22-24 above, and would then be approaching a significant fraction of the full core inventory.

A modified version of fig 9.3 is presented below including this 100,000 curie curve, and it is seen that very high doses would then result from such a release, doses ranging from several thousand mSv to some tens of mSv, compared to the recommended maximum of 1 mSv per year for the general public.

FINAL RECOMMENDATION: In the light of what has been presented above, and considering other criticisms of the report presented at the seminar 3 July 1993, the Safety of Nuclear Powered Ships report should now be withdrawn from circulation. It should at least be rewritten, but if this question is to be considered again a much more wide ranging investigation of all the issues involved relating to NPV visits should be undertaken.

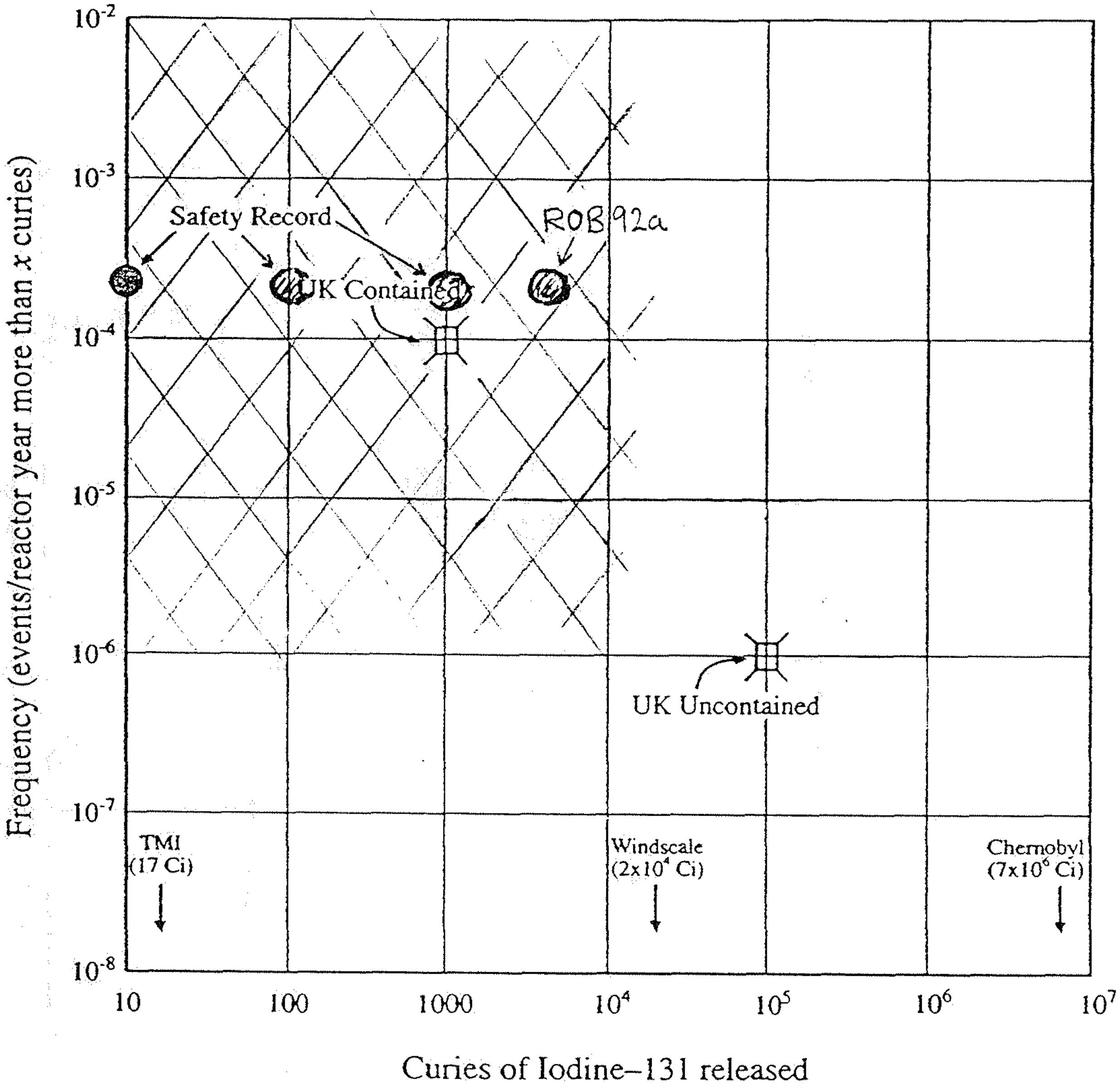
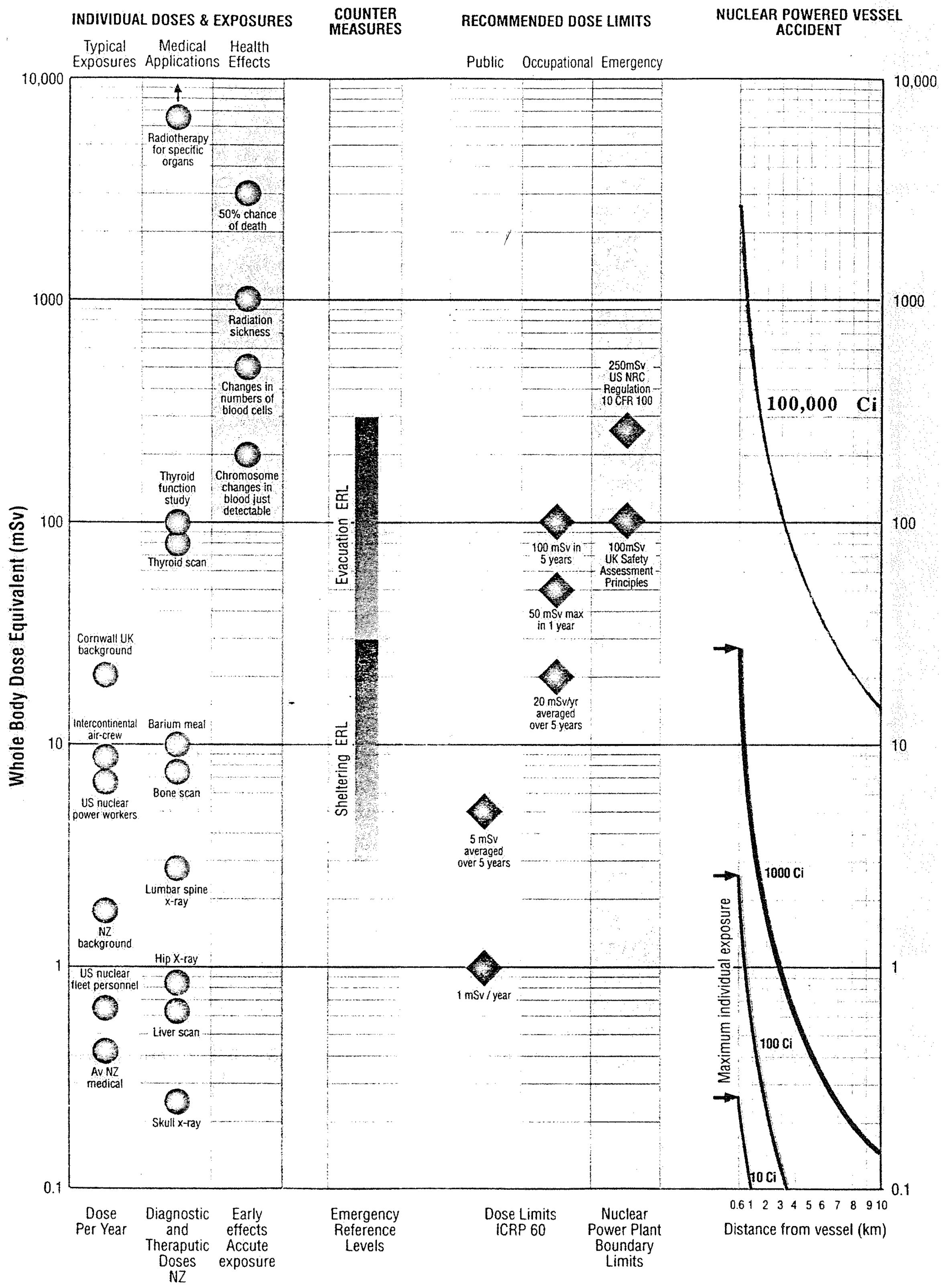


Figure 5.2a The hatched region is meant to indicate what is considered to be the large uncertainties in the accident frequency and associated release of I-131 plotted in figure 5.2 of the report. See pp.18-19 and pp.39-40 above for details.



COMPARATIVE RADIATION DOSES

Figure 9.3a This version of figure 9.3 of the report shows the estimated doses associated with the release of 100,000 curies I-131 plus other volatiles from an uncontained accident. See p.40 above for details.

TABLE II.B.3. Radioactive inventories and whole-body dose conversion factors (3200 MW$_t$—PWR).

Radionuclides	Half-life $t_{1/2}$ (days)	Shutdown inventory (10^6 Ci)	Cloud D_c/X_0 (rem m^3/Ci s)	Inhalation, κ_i (rem/Ci inhaled) (0–50 yr)	Ground D_g/S (rem m^2/Ci)
Noble gases					
Kr-85	3950.0	0.56	0.475E −03	0.310E +00	
Kr-85*m*	0.183	24.0	0.364E −01	0.260E +00	
Kr-87	0.0528	47.0	0.181E +00	0.100E +01	
Kr-88	0.117	68.0	0.467E +00	0.230E +01	
Xe-133	5.28	170.0	0.906E −02	0.700E +00	
Xe-135	0.384	34.0	0.567E −01	0.120E +01	
Iodines					
I-131	8.05	85.0	0.872E −01	0.600E +03	0.708E +03
I-132	0.0958	120.0	0.511E +00	0.700E +02	0.107E +03
I-133	0.875	170.0	0.154E +00	0.200E +03	0.311E +03
I-134	0.0366	190.0	0.533E +00	0.300E +02	0.414E +02
I-135	0.280	150.0	0.419E +00	0.150E +03	0.285E +03
Cesiums and rubidiums					
Cs-134	750.0	7.5	0.350E +00	0.470E +05	0.369E +04
Cs-136	13.0	3.0	0.478E +00	0.590E +04	0.410E +04
Cs-137	11 000.0	4.7	0.122E +00	0.360E +05	0.131E +04
Rb-86	18.7	0.026	0.207E −01	0.660E +04	0.185E +03
Telluriums and antimony					
Te-127	0.391	5.9	0.936E −03	0.340E +02	0.813E +00
Te-127*m*	109.0	1.1	0.110E −02	0.240E +04	0.584E +02
Te-129	0.048	31.0	0.147E −01	0.980E +01	0.198E +01
Te-129*m*	0.340	5.3	0.783E −02	0.300E +04	0.246E +03
Te-131*m*	1.25	13.0	0.314E +00	0.550E +03	0.960E +03
Te-132	3.25	120.0	0.475E −01	0.150E +04	0.308E +04
Sb-127	3.88	6.1	0.151E +00	0.790E +03	0.920E +03
Sb-129	0.179	33.0	0.268E +00	0.110E +03	0.104E +03
Alkaline earths					
Sr-89	52.1	94.0		0.410E +04	
Sr-90	11 030.0	3.70		0.240E +06	
Sr-91	0.403	110.0	0.169E +00	0.310E +03	0.205E +0
Ba-140	12.8	160.0	0.444E −01	0.190E +04	0.365E +0
Volatile oxides (Ru)					
Co-58	71.0	0.78	0.216E +00	0.420E +04	0.244E +04
Co-60	1920.0	0.29	0.600E +00	0.820E +05	0.588E +04
Mo-99	2.8	160.0	0.364E −01	0.420E +03	0.325E +0
Tc-99*m*	0.25	140.0	0.306E −01	0.980E +01	0.162E +02
Ru-103	39.5	110.0	0.111E +00	0.190E +04	0.116E +04
Ru-105	0.185	72.0	0.179E +00	0.660E +02	0.794E +0
Ru-106	366.0	25.0	0.431E −01	0.620E +05	0.456E +0
Rh-105	1.50	49.0	0.182E −01	0.960E +02	0.567E +0
Nonvolatile oxides (La)					
Y-90	2.67	3.9		0.780E +03	
Y-91	59.0	120.0	0.625E −03	0.560E +04	0.591E +01
Zr-95	65.2	150.0	0.162E +00	0.560E +04	0.177E +0
Zr-97	0.71	150.0	0.422E −01	0.520E +03	0.538E +0
Nb-95	35.0	150.0	0.166E +00	0.190E +04	0.164E +0
La-140	1.67	160.0	0.567E +00	0.920E +03	0.180E +0
Ce-141	32.3	150.0	0.183E −01	0.110E +04	0.182E +0
Ce-143	1.38	130.0	0.681E −01	0.340E +03	0.224E +0
Ce-144	284.0	85.0	0.431E −02	0.320E +05	0.120E +0
Pr-143	13.7	130.0		0.820E +03	
Nd-147	11.1	60.0	0.314E −01	0.790E +03	0.305E +0
Np-239	2.35	1640.0	0.308E −01	0.250E +03	0.202E +0
Pu-238	32 500.0	0.057	0.525E −04	0.730E +08	0.620E +0
Pu-239	8.9E +06	0.021	0.230E −04	0.820E +08	0.263E +0
Pu-240	2.4E +06	0.021	0.464E −04	0.830E +08	0.547E +0
Pu-241	5350.0	3.4	0.417E −09	0.150E +07	0.221E −0
Am-241	1.5E +05	0.0017	0.465E −02	0.860E +08	0.143E +0
Cm-242	163.0	0.50	0.500E −04	0.190E +07	0.546E +0
Cm-244	6630.0	0.023	0.142E −02	0.430E +08	0.346E +0

Table 9.1a The full core inventory from APS85. See p.23 above for details.

AN OLD ANTI-NUKE'S PERSPECTIVE ON THE POLITTEE

Robert Mann

Some of the older hands in the NZ anti-nuclear movement boycotted The Polittee, Poletti's special political committee on nuclear propulsion: we declined to make submissions to it: Our main reasons were as follows.

(1) There was (and there still is) no need whatever to review the matter; to insist on doing so creates a cynical distraction and a waste of public resources.

(2) The review was presumably at foreign (USA) initiative.

(3) Prime Minister Bolger rejected the request by NZ's main environmental groups to include at least one anti-nuclear scientist on the committee.

(4) The inclusion of Prof. Alan Poletti, who had taken a position of vigorous public advocacy that n-ships are OK, therefore constituted a deliberate bias in the committee.

Such a biased exercise does not deserve the legitimising participation of anti-nuclear experts, or non-experts for that matter. It should have been ignored. The tiny turnout for this seminar may indicate that others have come, belatedly, to see this basic truth.

What I have heard of the Polittee's behaviour toward those naive hopefuls who appeared before it in person compounds the above already crippling drawbacks.

On several other levels the Polittee is unsatisfactory and should be boycotted - along with other associated activities, of which this seminar is one. I am therefore not bothering to prepare what would in the past have provided - a fully-referenced text. In any case that is presumably not needed, because an alternative committee on the subject, chosen, the convener says, for maximum expertise, is expected to write a comprehensive critique of the Polittee's report.

The refusals by 3/4 of the Polittee members to discuss their report by participating in this seminar should prompt to reconsideration any who still think it was a scientific, rather than a political, exercise. A further sign was the Polittee's listing, in its bibliography, of my most recent-writing (with Dr Wills)[1] on the subject while refusing to allude to any substantive scientific content of that article.

A thorough scientific investigation of the purported subject would also have mentioned such authors as R E Webb (one of the few PhDs in nuclear engineering to have 'blown the whistle'); R Pollard (a retired submarine reactor operator now employed by the Union of Concerned Scientists); and the Committee for Nuclear Responsibility, led by Prof. John Gofman, a leading source of careful science regarding radiation risks. Some or all of those should also have been visited during the Polittee's overseas tour, which was instead predictably unbalanced.

Major Hazards

Here I merely sketch mainstream understanding of the hazards and corresponding risks of marine propulsion reactors. This is an expanded version of a summary requested in Oct '91 by Peter Lorimer for SANA to use in revising their Fact Sheet, the first edition of which I had also drafted.

At the seminar I outlined, from notes, the peculiar history of NZ arguments about marine reactors. This is not the place to detail those fascinating if sordid matters.

Nuclear fission reactors are used by several governments to propel submarines, and a few ships. All are military - experiments with nuclear-propelled freighters (USA, Japan, W. Germany) have proved costly failures.

Marine propulsion reactors are only 1/100 - 1/10 the rated power of typical nuclear power-station reactors. Nevertheless, they are capable of melting themselves in the event of various operator errors, materials failures, or sabotage. In the unlikely event of a meltdown, harbour water will be seriously contaminated for at least a year. The Politee's marine biologist appears to have made remarkably little contribution.

The distribution of radioactive material between air and water will depend on the mode of failure. I remind you that the reactor runs at about one ton weight per square inch, i.e. about 160 atm. Pollard has pointed out that brief excursions into overpressure are a real fear during startup. Neutron embrittlement of the pressure-vessel walls is an acknowledged problem, a main reason why the reactor pressure-vessel can burst, or blow off its lid. In such case the boat's hull will be ripped open by the flying fragment(s), and the proportion of the core material which is sent skyward may be relatively large. If the core melt is initiated by a leak in the reactor's primary cooling system (a contingency against which, as the Politee misrepresented, the marine reactors have no emergency core-cooling system corresponding to those on typical modern nuclear pawer stations), the fuel may melt its way down through the bottom of the hull. The Politee quietly evaded the question of melt-thru, scarcely elaborating (p.51) on the o1d Ministry of Defence claim that a molten reactor will not do so. When the white-hot tons of material meet the sea, there may ensue a steam explosion such as has been recorded from accidents at metal foundries; but on the other hand the bulk of the debris may just be relatively quietly dispersed into the sea.

In any case, some airborne radioactive debris will fall out downwind; if the fraction airborne of the emitted materials is about 1/2, this could (depending on the state of the weather at the time) render much of Auckland or Wellington uninhabitable for decades. The amount of accurnulated radioactive materials in such a reactor is smaller than that in a power station, but the proximity to people, if the vessel is in a harbour such as Auckland or Wellington, outweighs that factor with respect to attempted evacuation. The Politee's assertion that only half-a-dozen could be killed relies on pretending that only a tiny fraction, represented by 10^{-5} of the radioiodine inventory, could be released. This write-down by 4 orders of magnitude is unjustifiable and misleading. The NZ' government's so-called 'code' for nuclear-powered shipping was bad enough in this regard, but the Politee has been emboldened to go even further! The USSR emergency plan for Murmansk appears to be based on a much more realistic assumption about this 'source term' and envisages scores of thousands of people potentially exposed to serious radiation doses.

No official NZ scientific study has been published of the possible scope for harm. Independent scientists have calculated that evacuation could be required 20km (or more) downwind - not a mere 0.6 km as claimed by NZ pro-nuclear publicists based in the NZ National Radiation Lab (NRL). To accomplish evacuation in the short time available is so extremely difficult as to be, for most of the city's people, impossible. No effective treatment exists for the most of the cancers, mutations and malformations which would be then expected over ensuing decades. Modelling the dispersal downwind is done with minimal scope for scientific dispute by using the model of the Rasmussen report as revised by J. Beyea at Princeton. This represents the mainstream of such applied maths. However, the Politee did not refer to this approach but preferred a novel model created in apparent isolation by Smyth of NRL (an organisation with a consistent history of apologetics for the nuclear industry). Symth's original untested model postulate a 'drop-kick' effect whereby thermal lofting prevents significant fallout within a zone of many km downwind. This may be one possible outcome, but by no means representative of the more plausible range of fallout patterns[1].

Writing down the hazard (the scope for harm) is only one of the biased policies of groups such as the Politee. The probability of severe mishap is also written-down far beyond what science can justify. The Port of London refused admission to the Germa' nuclear-pawered freighter *Otto Hahn* for lack of adequate insurance. To that authority at least, as later to the NZ dernacratic process, the risk (i.e. the probability) of a major mishap was not negligible.

The only plausible estimate of this probability is readily formed, as an approximate upper limit: about 6,000 reactor-years of operating experience with marine propulsion pressurised-water reactors is known to have produced one meltdown. (The CIA has reported that the USSR nuclear-powered icebreaker *Lenin* suffered a reactor meltdown. This is also stated in Zh. Medvedev's 1990 book, *The Legacy of Chernobyl* which the Politee lists as a reference; but their dismissal of the meltdown (p.55) does not rnention that evidence) This permits the inference that the risk of a meltdown in future is unlikely to be much larger than one in 6,000 per reactor-year. The Politee writes down this figure also by 4 magnitudes (or more, depending on which of their suggestions you take; my favourite is "lower than any number I could put my confidence on").

The Polittee's leader on risk, Prof. Elms, adopted without discussion the language-tampering of the USAEC's Rasmussen Report, misusing the word risk to mean the product of probability and consequences, which is properly called instead the expected loss value. This multiplication corresponds to no reality and is to be deprecated, and the word risk should not be hijacked for the purpose of such confusion. Suppose a recalculation of hazard led us to expect, say, one order of magnitude more damage. Would this worse hazard be completely compensated, for planning purposes, if the probability could be written down by one more order of magnitude? Even if the probabilities were calculable with any useful accuracy, which they are not, this phoney 'compensation' must be rejected,

Instead, planning should concentrate on disaster-prevention.

Minor Hazards

Auckland Harbour Board management 1ed by Mr Lorimer in the late '70s opposed nuclear visits because of interference with normal port operations.

Routine radioactivity releases are very much smaller than the possible catastrophes, but are not easily monitored and have been the subject of systematic forgeries in Japan.

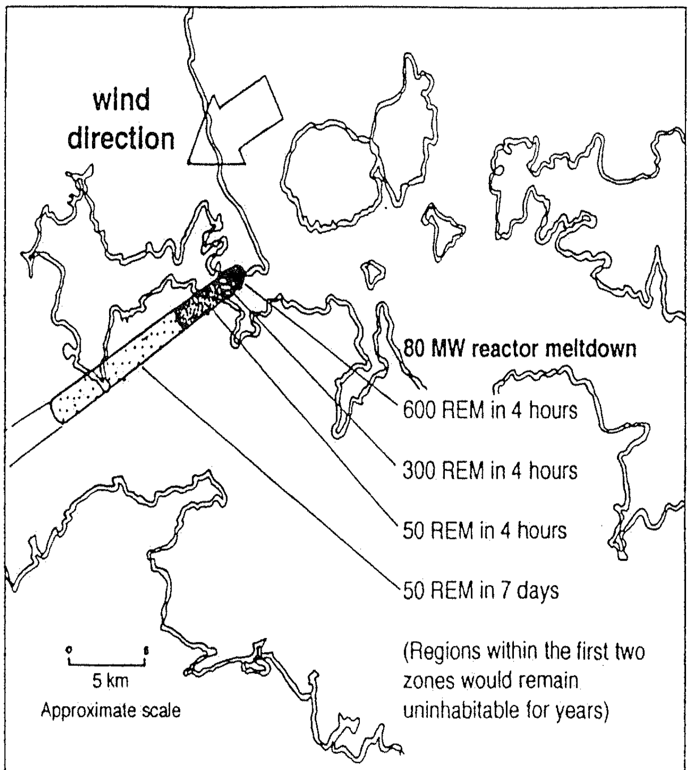
Another hazard created by the Polittee is little known but could even have been listed as 'major': the recent request to Poletti by a government agency to compile (as if the rewards of $700/day already paid had been insufficient) a wish-list of what would be needed as infrastructure for New Zealand's research establishment to move seriously into the modern nuclear era.

Conclusion

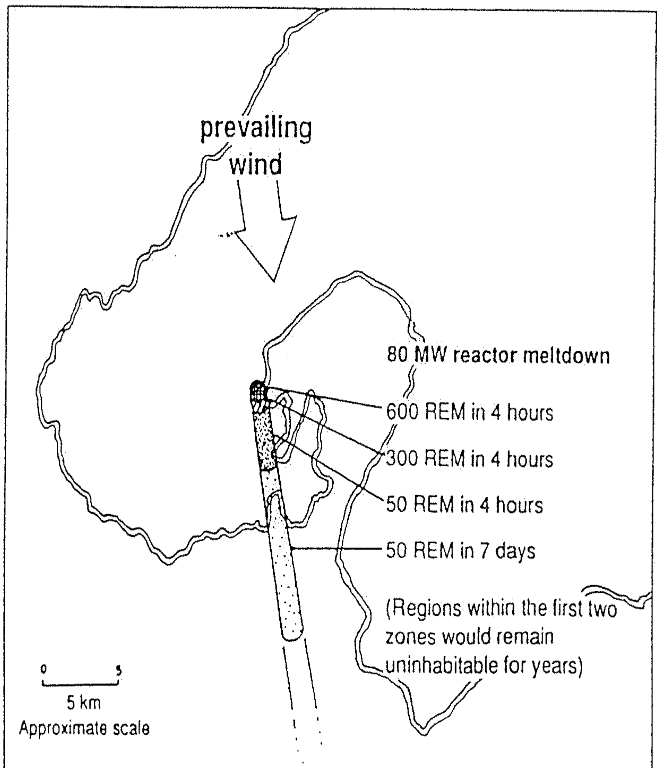
The point is that any further detailed discussion of this topic is, like the Polittee itself, superfluous - a wasteful distraction. Our country has, by a uniquely participatory process, evolved a democratic policy, and a law to give it expression, to exclude not only nuclear power stations but also marine reactors, as stated by the then largest petition to the NZ parliament (in 1976 – over 300,000). There is, as I began by pointing out, no reason to reconsider this policy.

1. P Wills, E Sinton, R Mann. 'Giants Can Fade: hazards of nuclear-powered shipping.' *NZ Envir.* **68** 25-30 (1991)

Dr Mann taught biochemistry, environmental studies, and planning in the University of Auckland, over two decades. He is now an inventor of appropriate technology, and a writer.



Possible outcome of a nuclear accident in Auckland



Possible outcome of a nuclear accident in Wellington Harbour

SOME SOCIOLOGICAL COMMENTS ON THE 'SAFETY OF NUCLEAR SHIPS' COMMITTEE REPORT

Charles Grothers
Department of Sociology
University of Auckland
June, 1993

INTRODUCTION:

On reflection, I am sure that we must all recognise that - whatever the technical standards and knowledge involved - in the end the decision about whether or not nuclear ships are to be accepted into our ports is **social** decision. Indeed, the Committee themselves recognise this on p132 when they note that social considerations are likely to outweigh public health concerns. While scientists should provide advice, the moral decisions still rest with the people, since it is they who must bear the risks involved. Of course, the people may very well exercise their choices through `'representatives' rather than in the form of 'direct democracy' but the point still stands.

There is a ream of commentary - much stemming from issues surrounding the development of nuclear weapons - about the role of scientists in society which I could invoke to support this position, but it is surely so evident that I can surely spare you a rendition of my scholarship on this matter (see endnote).

Neither, of course, is it the job of the sociologist to attempt to adjudicate on these issues, although it may well be that techniques sociologists are often associated with (eg surveys), might be pressed into service to assist in the cumulation of social opinion on this question. I seek only to provide a sociological commentary on the work carried out by the Cornrnittee of Inquiry. In doing so I recognise that the task of the Committee was restrained to investigating technical issues (rather than social judgements) - which is quite different to the terms of reference of an earlier (and slightly related) government investigation into Defence Policy which was specifically enjoined to ascertain the weight of public opinion.

COMMENT 1: RELEVANT KNOWLEDGE

There are a couple of bodies of 'knowledge' or views which are at least potentially pertinent in this matter which the Committee did not seemingly tap into. One is that of the 'ethicist'. Such people are trained to address issues which involve weighing up moral choices involving conflicts and risks. However, their work seems largely confined to the medical area, or research more generally. No ethicist seems to have been involved in this report.

A second area of expertise are those social scientists studying environmental risk (eg Dr Ericksen at University of Waikato) or the various planning cases which have involved estimating damage risks (eg concerning the siting of LPG stations). In this (admittedly poorly developed) area of study, people's values, attitudes and actions concerning environmental risks are studied within real-life situations. Although direct studies of the environmental risk perceptions relating to nuclear ship visits probably have not been carried out, there are undoubtedly general principles which could be extrapolated into this area. Again, the committee appears to have made no effort to tap into this body of expertise.

COMMENT 2: PUBLIC KNOWLEDGE

Given the centrality of people's judgernent, compared to scientists' views, on this question l have some concerns with the Committee's approach. In commenting on the release of the report Professor Poletti vigorously attacked the ignorance of public views on nuclear ships and a feature of the report is a long listing of the 'myths' which the public is held to share. That the term 'myth' is clearly used in a derogatory way is pointed up by the contrasting of the many myths with the **one '**valid' questiorn (p171) which is allowed (and it is interesting that this appears last in their list.) It seems in the committee's eyes that not only are the public ignorant, but are 'negligently ignorant' - they are to be blamed for their ignorance. To overcome this, the committee feels that it not only must give out factual information (which is after all its task) but to do so in an aggressive style.

While one might be appreciative of the 'politics' surrounding this question and therefore have some immediate sympathy with the committee in this respect, this approach seems mainly a strategy to clearly lay down the 'scientific authority' of the committee. I did not appreciate their approach of attacking the public. My objection is two-fold. First, I just do not know how the Committee knows that the public holds these views. They say (p159):

> Concerns based on misconceptions or information which was incorrect were expressed to us by a large number of those making submissions ... It became clear that there was a serious lack of understanding and much misinformation in the minds of a considerable portion of the public and rnany who claim to be knowledgeable.

Maybe it is a reasonable supposition, but the Committee has **no** systematic evidence what the public knows or thinks on this issue. They do say that they are basing their views on some of the submissions made to them, but this is an insufficient base. What the Committee guesses about public knowledge on this issue may very well be right, but they do not know, and it seems to me that they should refrain from comments on this issue - let alone making it the centre of their 'public relations' approach.

Secondly, I object on the ground that their approach is arrogantly disrespectful of the central role of the public in making choices on this issue. The correct stance of a government scientific committee is to respectfully offer their best advice: not bite the hand that feeds them. Moreover, taking this approach seems to me to fuel the concern of the many suspicious 'conspiracy theorists' that the Committee is merely performing a Government-driven hatchet job on this issue.

Nevertheless, my second comment is not overwhelrning in its censure since it concerns more the aesthetics and good manners of the committee report, rather than its substance.

COMMENT 3: PUBLIC VIEWS ON RISK

In everyday life people constantly face risk of damage, and since avoidance (or diminution) of risk of damage is often costly they adjust their lives accordingly. One of the roles of environmental planning is to endeavour to develop community standards of acceptable risk from various types of land use, and to ensure that industries or other land-users do not exceed these standards. More generally, agencies which darnage can be sued to compensate victims, so that there are legislative and court-irnposed standards and remedies. This is a complex area since damage may come from suddenly-occurring damage from accidents, or on the other hand from the more invidious long-term cumulation of negative effects through quite invisible and even minute processes: not to mention the range of the continuum in-between. It is not an easy area of work! Knowledge is required of the likelihood of unfortunate events happening, of the effectiveness of monitoring and controlling mechanisms and then of the likely effects over both the short-term and long-term. Not only are these often complex scientific matters but they are often subject to dispute (and even suspicion that non-scientific motives have become mixed with technical judgements).

And at the end of the day, people have to make decisions on the acceptability of the risk. This in turn is a difficult task, partly because it is difficult for many people to grasp the fullness of scientific evidence, and partly because it is difficult to understand the judgements which people wish to make concerning risk. Clearly, a process of arguing by analogy from commonly experienced areas of life must be used.

The Cornmittee does indeed attempt this approach, albeit with great brevity: see pp49,50. Data is provided on deaths from various causes in NZ (eg 100 deaths a year from drowning) and it is suggested that the deaths from cancer from medical x-rays could be around 51 per year across the whole population. In contrast "... because exposure of the general public to nuclear powered ship operations is so small statistically, predicted deaths due to this cause would be almost vanishingly small". This passage with its concentration on x-ray deaths seems quite odd to me, although I suppose it does illustrate something of the methodology that might be employed in coming up with estimates.

Another pertinent figure is noted in passing on p69 where it is estimated that patients of Auckland hospital "every day release more then twice as much radioactivity into local waters as the entire US nuclear fleet and support facilities release annually into harbours and coastal waters around the world" (I could track down where these data were discussed in more detail.)

'Finally', on p64 we are told that the risks might amount to somewhere between one accident per 30,000 years of visits and one per 3 million years, and that this might lead to a prediction of up to 5 hypothetical late cancers in a population of 190,000: compared to the 30-40,000 of this population that might be expected to die of cancers from all other causes. This seems to be the core estimate of risk. But where does a population figure of 190,000 come from? Does this measure imply something like 20 late deaths for a population the size of Auckland?.

The Committee has certainly failed to provide a readily comprehensible measure of risk – their key risk estimate is buried (poorly documented and badly explained) in the middle of the report. In their findings they argue that 'The likelihood ... is so remote it cannot give rise to any rational apprehension" (pvi). This may very well be so: but their approach to this matter inevitably sequesters the issue from public decision, and I cannot see why the p61 estimates could not have been provided in a more accessible form.

In sum, the committee claim that the likelihood of risk is so minimal that estimates of it can't be put to the public for them to judge. And yet, it does in fact come up with some estimates, but then does not draw attention to them.

COMMENT 4: PUBLIC VIEWS ON NUCLEAR SHIP VISITS

One area where we do have information is on public views concerning nuclear ship visits, especially in relation to the trade-off this may require in terms of our relationship to the US, let alone the complexities of nuclear-weaponed v propelled ships. This has often been a controversial area of polling since public opinion is often split on a knife-edge between acceptance and rejection. The most recent polls indicate a change towards lower public opposition to nuclear ship visits.

Although the public has not been queried (to my knowledge) concerning the safety aspects of such visits, this is pertinent background information to help put the whole issue in a public context and I do not see why the committee did not refer to such studies.

COMMENT 5: POLITICAL HANDLING

In the past, inquiries were often handled at a distance through 'properly' institutionalised Royal Commissions, etc. Over the last decade, more are run out of Ministerial offices. This risks contamination by the political tasks of such offices, so that servicing this inquiry from the PM's office has an unfortunate appearance - however neutral in fact such servicing may well have been.

COMMENT 6: SOME PROCEDURAL POINTS

My last two points are quite minor. I wrote, although late, to the committee (through Professor Bergquist) briefly raising the above issues, but (despite a written acknowledgment) there is no record of my submission in the report. Finally, in following up my interest in this area, I found that there was no copy of the Committee's in the University of Auckland Library (at least on the main campus! There is a copy out at Tamaki!). While I concede that this may be a fault of the Library, one just hopes that the distribution of the report is in fact rather more widespread then my personal experience suggests.

CONCLUSION:

Whatever the technical merits of the report, I feel the handling of social and rnoral issues in it - which are at the centre of the issue - was more clumsy than this issue deserved.

REFERENCES:
The classic work is C P Snow, *Science and Government* (Oxford University Press, 1961). A more recent collection is Keith Lehrer (ed), *Science and Ethics* (Rodopi, 1987).

Defence Committee of Enquiry, *Defence and Security: What New Zealanders Want* (Government Printer, 1986).

An example of New Zealand work in relation to environmental risk is Neil Erickson, *Creating Flood Disasters? New Zealand's Need for a New Approach to Flood Hazard* (Ministry of Works, 1986).

WHO WON?
The Special Committee or the Anti-nuclear Movement?

A contribution to
the CPS seminar on safety of nuclear powered ships
by Owen Wilkes July 1993

Before starting I want to make it clear that in my opinion this debate about the safety of nuclear propulsion is quite unnecessary: Regardless of whether nuclear propulsion is safe or not, there are overwhelmingly important reasons for keeping out of miiitary alliances with the US. I think that by setting up his inquiry into nuclear propuision safety Jim Bolger was brilliantly successful in diverting the anti-nuclear movement into a campaign which is unwinnable - the campaign to convince everyone, against all the evidence, that US nuclear propulsion is somehow unsafe.

Today, however, we are trying to poke holes in the report of Jim Bolger's Special Committee on the Safety of Nuclear Powered ships. Before going into nit-picking mode we need to define just what are the major questions that we, and the Committee, are supposed to answer. These are:

1. Has nuclear propulsion been safe in the past?
2. If so, how come?
3. Will nuclear propulsion be safe in the future?
4, If, against all the odds, something does go wrong, how bad will it be?

Having answered these questions there is one other question that is much less important, but which the anti-nuclear movement has made quite a fuss about

5. If something goes wrong, will the US authorities try to hide it from us?

In trying to answer these questions I presume it is US and British nuclear propulsion we are concerned about, and that Russian nuclear propulsion is unlikely to be an issue in this part of the world. And I will refer to Nuclear-propelled ships and submarines as 'nuclear vessels' - since US warships no longer carry nuclear weapons this simplification should not cause confusion. I will also refer to the anti-nuclear movement, by which, on this occasion, I mean those sectors of the peace and environmental movements which think nuclear propulsion is unsafe.

Has nuclear propulsion been safe in the past?

This is really no longer an issue. The answer to this question is clearly yes, and the Special Committee quite correctly wastes little time or space on this issue.

The facts of the matter are that the US Navy proudly claims it has so far accumulated 4000 reactor-years of safe operation, and none of us has managed to produce any evidence which indicates the Navy is lying. I am one of those who have tried, totally without success.

The US Navy claims that ships the total gamma radioactivity it has released into harbors has been less than 0.002 curies per year. This is an incredibly small amount, but no-one has been able to challenge it so far. To most of us the figure is meaningless by itself, so let's put it in context. See fig 1.

Fig 1: Some radioactivity releases compared

2 mCi	Released by ALL US nuclear ships / year
130 mCi	Released by Wairakei per day (Radon 222)
2,000 mCi	Released in NZ's worst radioactivity accident.[1]
17,000 mCi	Released from Three Mile Island.
50,000,000,000 mCi	Released by Chernobyl.

US subs are also very safe on the inside. In fact, for anyone phobic about radiation probably the best job they could ever find would be on board a US nuclear submarine. The seawater above shields everyone on board from cosmic radiation, the seawater below shields everyone frotn the background crustal radiation. There is no opportunity to get melanomas from sunlight. US nuclear submariners actually do receive lower radiation dose-rates than other US citizens, and have slightly lower cancer rates. Luminous watches are banned aboard US nuclear submarines because the radium in the dial sets off the radiation alarms on board the submarine. Not a single sailor or dockyard worker has ever received the maximum dose allowable by international safety standards,

Lots of people don't believe this of course, and point to the dozens of accidents that nuclear vessels have been involved in. Greenpeace in particular has uncovered 261 such accidents between 1945 and 1988 [2]. But the significant and usually ignored point about all these accidents is that in none of them has there been any significant release of radioactivity. Not even for the subs which exploded and dived into the deepsea floor. Their list demonstrates quite conclusively, although Greenpeace fails to point this out, that you can flood, sink, burn, crash, collide, wreck and blow up nuclear vessels without any radioactivity release.

It turns out that the situation is even better than the Greenpeace evidence indicates, because there have been far more accidents than Greenpeace was able to track down. An enterprising Norwegian researcher has used the US

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1 In 1959, when the Institute of Nuclear Sciences accidentally released 2 curies into the Waiwhetu stream, Lower Hutt. Described in old NZ Institute of Nuclear Sciences files in NZ National Archives.

2 Neptune Papers no 3, "Naval Accidents 2945-1988", by William Arkin & Joshua Handler, June 1989.

Freedom of Information Act to get data on 198 submarine 'mishaps' in the North Atlantic in the years 1983-1987. This is about 8 times as many as Greenpeace identified in the same peiod and the same area. See figure 2. So accidents do happen, but they are apparently not a problem as far as radioactivity releases are concerned.

From the Greanpeace data we can even discover that nuclear propulsion is seemingly safer than oil-burning propulsion. In the 1980s nuclear vessels made up 40% of the US combat fleet. Scanning the Greenpeace accident list indicates that in that decade nuclear vessels made up only 257 of the US vessels involved in accidents. So nuclear vessels are less likely to have accidents than oil-burning vessels. The reason for this is also evident in the Greepeace lists - a significant proportion af the accidents suffered by the US Navy happen during underway refuelling operations, when warships are being refuelled at sea from tankers. This is quite a dangerous operation and the warships and tankers often collide. Oil-fired warships are undoubtedly also causing worse oil pollution of the ocean than nuclear vessels are causing radioactivity pollution, insofar as it is possible to compare these forms of poliution.

It has been clear for several years to any reasonable person that the US nuclear navy has clocked up a magnificent safety record. But back in the 70s this was not so clear at all, and I think the anti-nuclear movement was quite correct then in raising concerns about safety. We didn't know enough then to be sure one way or the other. And it turns out now that for a while in the 60s the US Navy was having problems with both occupational and environmental exposures to radioactivity. Fig 3 compares the total number of nuclear vessels with the total personnel exposures, and you can see that things were getting fairly shonky in the mid 60s - probably as the first generation of submarines were starting to come in for mid-life overhauls. It seems that the Navy realized thare was a problem developing and took effective steps to correct it. We can ses that since then, even as the number of nuclear vessels continued to rise, the occupational exposure levels fell to and then stayed at an acceptably low rate. The same thing applies for nuclear wastes, as shown in figure 4. From the top right hand corner of the graph we can see that the number of nuclear vessels in the US Navy is now starting to decline -- something which I am sure will please us all. At first sight there seems to be cause for alarm in the sharp upturn in the amount of low level waste that had to be disposed off in 1991. The explanation is, according to the US Navy, that they had more radioactive bits and pieces to dispose of because they were retiring a greater number of vessels than in previous years. The Navy claims that the grand total annual volume of all low-level radioactive waste from the entire nuclear Navy is normally equal to a cube about 12m square.

I want to make one other comment about these graphs. They are taken from official US Navy reports on environmental and occupational radiation which are submitted to the US Congress every year and which are available in the Parliamentary Library down in Wellington. The US Navy is not as secretive about these things as some people like to pretend.

2 If so, how come?

We come now to the second question. Given the incredible safety record so far clocked up by the US Navy, can we discover how it was achieved? Was it good luck or good management?

It is at this point that we, and the Special Committee, start to run into a wall of official secrecy. The US Navy is able to sail totally submerged submarines anywhere around the blobe with near-total immunity to detection - and it wants to make darned sure that no other nation, not even an ally, can develop the same capability. Therefore it jealously guards all the technical details of how to build and operate a safe reliable propulsion reactor. The Special Committee has attempted to get around this secrecy by extrapolating from o1d 1950s US Navy technical data, because for some reason the US Navy was much less secretive in those days. The Special Committee has also used data from better known civil reactor technology. For this the Committee has been roundiy criticized by Bob White and others, who think it better to work out the safety parameters from the basic principles of physics.

The situation is a bit like that in the old joke about the drunk who has his car keys down a dark drain but is searching for them on a well-lit pavement under a streetlight. When asked why he doesn't search in the drain he replies, quite reasonably, that it is easier to search under the streetlight, where the light is better. With all respect, I think the Special Committee has chosen to look under the streetlight, because it's easier, while Bob White, me, and others are all poking round in the dark drain, where we are hoping to stumble on the dark truth. Neither strategy has been particularly successful.

There was a way out of the drunk's dilemma, of course, but the Special Committee chose to ignore it. Given the expertise, the clout and the resources available to the Special Committe, it could have shone a strong torch down the drain and produced much better answers than it did. There is no evidence anywhere in the report of the Committee even attempting to use the very powerful torch known as the US Freedom of Information Act. They should have done that, and they should have spent some of their vast budget on a computer search of the vast data base managed by the US Department of Energy (DoE), which designs, builds and tests the US Navy's propulsion reactors.

Personally I think that overall the Norwegian researcher Viking Eriksonhas done a better job of investigating a slightly different topic - the hazards of sunken submarines. And he wrote a much more readable book.([2])

Even without using the US Freedom of Information Act, there is a vast amount

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2 Viking Olver Erikson, *Sunken Nuclear Submarines*, Norwegian Unversity Press, 1990.

of information easily accessible in Wellington, which the Special Committee didn't try to use. For example

1 There is about 200 pages of testimony to US Congressional Committees per year on the Naval Reactors Program of the DoE, all indexed and available on microfiche in the Parliamentary Library. The Special Committee only looked at some of the testimony for the last few years. In looking through older testimony I was able to resolve several af the questions left-unanswered by the Special Committee.

2 There are hundreds of technical papers on US naval reactors indexed and abstracted in old US Atomic Energy Commission publications kept in the library of the NZ Institute of Nuclear and Geological Sciences. The papers can be ordered from the present US Department of Energy. The Committee made no use of these.

3 The Special Committee spent a large amount of taxpayers going to visit the HQ of the International Atomic Energy Authority (IAEA) in Vienna. Yet they didnt bother to consult the excellent IAEA data-base held on CD-RCM, which is supplied by IAEA to all member states including New Zealand. Using this database I found more up-to-date information about metallic fuel burnup than the Special Committee was able to find, and I located several teehnical papers on British nuclear vessels that are not listed in the Special Committee's bibliography.

all the same, after acknowledging these limitations, I find the conclusions of the Special Committee to be quite reasonable. Some things are quite obvious of course, and didn't need a Special Committee to point them out. For instance, shipboard reactors are quite tiny compared to civilian power reactors, and there is no justification at all for referring to them as floating Chernobyls going somewhere to happen. A naval reactor has only a fraction as much hot nasty radioactive stuff as Chernobyl did to spill all over the place. It would need about one third of the US nuclear navy to explode simultaneously to produce an effect like that of Chernobyl.

Without going into all the technical detail - it's on pages 38-46, - I think the Special Committee has made a reasonable case for the proposition that naval reactors operate at lower power densities, lower pressures and lower temperatures than do civilian reactors, and that this wi11 if anything, make them safer than civil reactors. Naval reactors are made much stronger than civil reactors, because they have to withstand all the stresses of battle, such as depth charges exploding nearby, and this means that they are unlikely to be damaged in peacetime mishaps.

Anyone who has read the report (and not many have, I suspect) can find a multitude of things they disagree with. I reckon I can find three 'errors' in the report which result in an exaggeration of the hazards of nuclear propulsion:

1) Their (ie the Special Committee's) assumed thermal efficiency of 0.20 (p 41) is too low. There are strong incentives for the navy to maximize this figure (a) to reduce the risk of the submarine being detected by infrared monitoring of its heated wake (b) to extend fuel core life.

2) Their assumed load factor of 20% (p 41) is too high. Submarines, in particular, spend 50% of their lifetime in dock, mostly in 'cold iron' status (using shore power) and when at sea cruise quite slowly to avoid detection. They rarely use full power except for short high speed dashes. Fully submerged submarine hulls possess suffer amazingly little hydrodynamic drag.[4] US Navy data[5] indicates the load factor is only 10% or less.

3) Their assumed core loading of 320 kg is too high. Tom Cochran, who is an assiduous investigator of these sorts of things, has calculated (by dividing the number of fuel cores fabricated into the amount of highly enriched uranium consumed in fuel fabrication) that it is 200 kg,[6] and that figure is accepted by SIPRI.[7]

I can also find two 'errors' which tend to minimize the dangers of nuclear propulsion.

4) They assume a core lifetime of 12 years, when the US Navy quite plainly says it has achieved 15 year lifetimes. Since the Committee is supposed to be looking toward the future they should have used the 15 year figure, even if it has not yet become general in the nuclear fleet.

5) They assume a burn-up of 60%, ignoring Eriksen's strongly- stated claim (based on Cochran) that US subs start of with 200 kg of 97% U-235 and finish up with 47 kg of 78% U-235 (the difference being made up of U-236 formed by neutron capture). This indicates a burn-up of 79%, which of course would produce a greater quantity of nasty fission products than would a 60% burn-up.

The important thing is that these two sets of 'errors' tend to cancel each other out, as follows:

* If a higher thermal efficiency and a lower load factor are assumed, then a 15 year rather than 12 year lifetime is achieved without any greater or lesser producbion of dangerous fission'products assumed. So' 'errors' (1) and (2) are counterbalanced by 'error' (4).

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4 The US submarine Albacore needs only 137 shaft horsepower, ie 1% of its maximum power setting, to do 7 knots submerged.

5 In particular their frequently repeated claim that a sub can do 400 000 n miles on a 15-year core.

6 T B Cochran et al, *Nuclear Weapans Databook, Vol II, US Nuclear Warhead Production,* Natural Resources Defence Council, 1991.

7 David Albright et al, *World Inventor,y of Plutonium and Highly Enriched Uranium 1992,* Sipri, 1993.

A 79% burn-up of 200 kg of 97.3% U-235 (as assumed by Eriksen)) will generate 1.46 x 10^5 MW(t) days of energy, while a 60% burn-up of 360 kg of 93% U-235 (as assumed by the Committee) will generate 1.99 x 10^5 MW(t) days.[8] The sum total of fission products available for a catastrophic release will be about the same. Thus 'error' (3) is partially counterbalanced by 'error' (5).

My conclusion from all this technical nitpicking is that the Special Committee has produced a reasonable description of how a naval reactor works, and that the fine details don't really make much difference to the big picture.

My reading of several reams of US Navy testimony to US Congressional Committees leaves me reasonabiy convinced that the US Navy has achieved its present safety record by good management rather than good luck. They (and the DoE) have gone to enormous trouble to design safe reactors, and they spare no expense in acquiring the highest quality material, and they spare no effort in training their personnel. The US nuclear navy is intensely conservative, and having found a safe design they are sticking with it. Maintaining safety and reliability seems to be more important to them than increasing efficiency or output.

Will nuclear propulsion be safe in the future?

In attempting to answer the question of whether the US Navy will be able to maintain its exeellent safety record into the future we are getting into more difficult territory. Predicting the future is more risky than analyzing the past. Just because they have achieved 4000 years of safe reactor operation in the last three decades far doesn't mean that over the next four decades they will achiave another 6000 years of safe reactor operation, and thus prove the experts right when they claim the chances of a serious reactor accident happening are less than one every 10 000 reactor years. An accident could happen tomorrow.

However if we assume that it is good management rather than good luck that is responsible for the excellent safety record, then it seems safe to assume that the good record will continue. One factor possibly working against this is the diminishing size of the US nuclear navy. The number of manufacturers of reactor components is declining as the market for them shrinks, and this may mean a decline in the pool of expertise available to ensure the highest possible quality of all components in the future. Complacency could be another problem. Having done so well so far, they may let their standards slip.

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8 I have used the energy equivalents for fission of U-235 as quoted by Eriksen (1.05 gm = I MW day}. This is the usual textbook figures. The Special Committee has used a figure of 1.24 gm = 1 MW day which seems to be based on the mistaken assumption that the kinetic energy of the fission fragments (167MeV) is the sole contributor to the thermal output of a reactor calculations. The total energy from a fission is 205 MeV. This is one of the multitude of small errors in the Special Report uncovered by Bob White.

This topic leads us to what I think is the weakest part of the Special Committee report - chapter 7 on 'Quality assurance and Safety Management'. Basically what they say in this chapter is 'We could find out nothing about US quality assurance and safety management, but it all looks OK anyhow.' However, I have to acknowledge that some other commentaors think this is one of the better and more innovative parts of the report.

Despite all this, I think it is safe to conclude that the current semi-official prediction of a serious accident once every 10 000 years of reactor operation is and will remain reasonably valid. Assuming that nuclear ships are unlikely to ever be in our ports more than 3 $^{1}/_{2}$ days a year, this works out to one accident every million years in New Zealand. If we are worried about this prospect, then we should be far more worried about the prospect of Lake Taupo erupting the way it did in 185 AD, when an area 90 km in diameter centred on Taupo was devastated. If we are worried about low-level releases, then Wairakei geothermal field gives us more cause for worry than US nuclear ships. We should start campaigning for a volcano-free zone.

Given that the primary mission of the US Navy is to kill and destroy, it might be asked why they go to so much trouble to make their reactors safe. There are three obvious answers. The first is that the US Navy has difficulty getting qualified crew for submarines as it is, without the added disincentives of radioactive bunks and periodic meltdowns. The second is that the US Navy is well aware that they have only got to accidentally irradiate one single foreign citizen, or even irradiate one foreign oyster maybe, and they will end up losing access to half the ports of the world. The third answer is that the most important 'leg' of the US strategic 'triad' - Trident missiles - are on submarines, and the US Navy doesn't want to lose them.

As the Navy told Congress

> The navy's ability to man nuclear-powered warships and to enter the world's ports rests largely on public confidence bassd on performance.[9]

4 If, against all the odds, something does go wrong, how bad will it be?

The Special Committee did not, as many have alleged, discount the possibility of serious accidents happening. They accept that there is a very small yet finite possibility of a bad accident. They then try to calculate

- what quantities of which radionuclides are available for release,
- what quantities will actually be released,
- how far and how densely these radionuclides will be distributed, and,
- what the ultimate environmental and health consequences will be.

In my opinion the Committee does a reasonable job of all this. The bottom line to all their assumptions and calculations is that under all but the worst possible circumstances a maximum of 5 people might eventually die from cancer induced by radiation from the sort of nuclear accident that might

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9 House Aprrориations Committee, EWDA Hearings, fy 1990, pt 6, 89-H-181-18, p. 1050.

happen once every 10 000 reactor years. No-one would receive an immediately lethal dose. Such an accident could involve a release of up to 1000 curies. People in the immediate vicinity of the accident would receive doses about equal to that of a barium meal or a bone scan.

The Committee then goes on to recommend changes to the precautions planned for dealing with nuclear ship visits and accidents in this country - in particular the document known as AEC 500. I my opinion the precautions are extravagantly cautious given the low probability and low consequences of an accident.

One interesting thing in all this is that thanks to the Three Mile Island accident, we can see that previous predictions of radioactive hazard from nuclear accidents were exaggerated. Three Mile Island was a fairly massive accident with all sorts of failures in equipment and mistakes by personnel, yet only 17 curies of radio-iodine escaped. This has led to same downsizing of the predictions of consequences from future accidents. Similarly the Chernobyl accident showed that less radio-caesium was released than previously predicted. And on top of all this, some recent re-working of Hiroshima data is indicating that radiation is less ef'fective at causing human cancer than previously assumed.[[10]]

The Committee has been criticized for not concentrating on the very worst possible accident that can be imagined. I think that is a trivial objection, given the almost infinitesimal chance of such an accident happening. More reasonably, they have been criticized for basing their 'source term' on a fuel core which has been in service for only 3 years. However this is not as unreasonable as it seems, since after three years the rate of accumulation of hazardous fission products starts to level off as radionuclide decay comes to equilibrium with production.

5. If something goes wrong, will the US Navy try to hide it from us?

There is a lot of worry that if a serious radioactivity spillage did take place in a New Zealand port the US Navy would attempt to conceal it from us.

The US Navy in fact has very strict instructions about this sort of thing, contained in a document generally referred to as OPNAVINST 3040.5B, the actual wording of which is quite different from what Peter Wills has made it out to be. It instructs commanders that they must in all circumstances "issue an immediate notification to [local] civil authorities" if an accident happens or even seems likely to happen, and an accident is defined as including 'any' radioactivity release which 'presents a hazard to life, health or property, or which may result in any member of the general public exceeding exposure limits'.[[11]]

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[10] This information has only become available since the Special Committee finished its work. See 'Study casts doubt on Hiroshima data°', *Science,* 16 Oct 1992.

[11] I have analyzed this document exhaustively in a submission to the Special Committee.

We have one example of how careful the US Navy is about cooperating with NZ authorities in this sort of event.

On 15 February 1969 the NZ National Radiation Laboratory (of the Department of Health) in Christchurch received a telephone call from the USN's Operation Deepfreeze asking for assistance down at Lyttelton. The USNS Wyandot had just berthed at Lyttelton after a stormy trip up from McMurdo. Radioactive cargo from the USN nuclear reactor at McMurdo[[12]] had broken loose in the hold during the storm, and radiation fields in the hold were higher than they had been when the cargo was loaded. The USN wanted help in tracking down the radiation.

The NRL team took their monitoring equipment to the ship. Down in the bottom hold where they found three 15 ton shipping casks. These casks were specially designed for transgorting radioactive material, and were each lined with 7 inches of lead. One of the casks had braken loose, smashed into other consignments, destroyed part af the ship's tween-deck flooring and buckled one of the tween-deck support beams running athwart the ship. The NRL people found slightly higher levels of radioactivity around the lid of the flask, which they reported may have been due to leakage from the battering which the flask had received on its journey back from Antarctica.

The National Radiation Laboratory informed the Department of External Affairs and the Marine Department about the incident, but decided not to inform the Lyttelton harbour Board, and the story never leaked to the wharfies or to the media.[[13]] So, in this instance the US Navy was quite open to our local authorities about the affair, and it was our local authorities who hushed the affair up. Granted the levels of radiation found were quite tiny, and posed no risk to health, but surely the public should have been told at the time about the incident?

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Conclusion

The Special Committee and the Anti-nuclear movement have each been trying to prove that port visits by nuclear-powered-vessels respectively are/are not safe. In my opinion the Special Committee has won hands down, despite the dozens of silly errors that Bob White has found in their report, and which make the Committee look pretty damned silly. I think it is high time the anti-nuclear movement conceded that safety of nuclear shipping is a non-issue and re-directed its energy to real issues.

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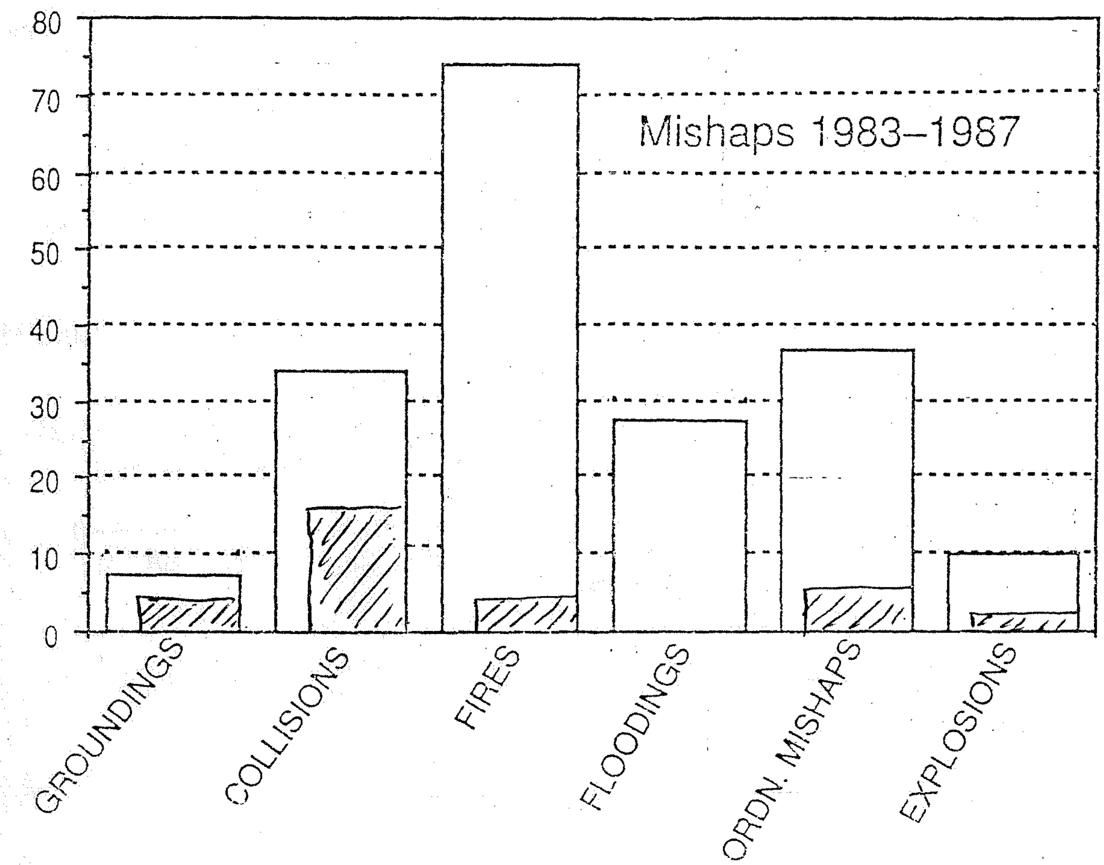
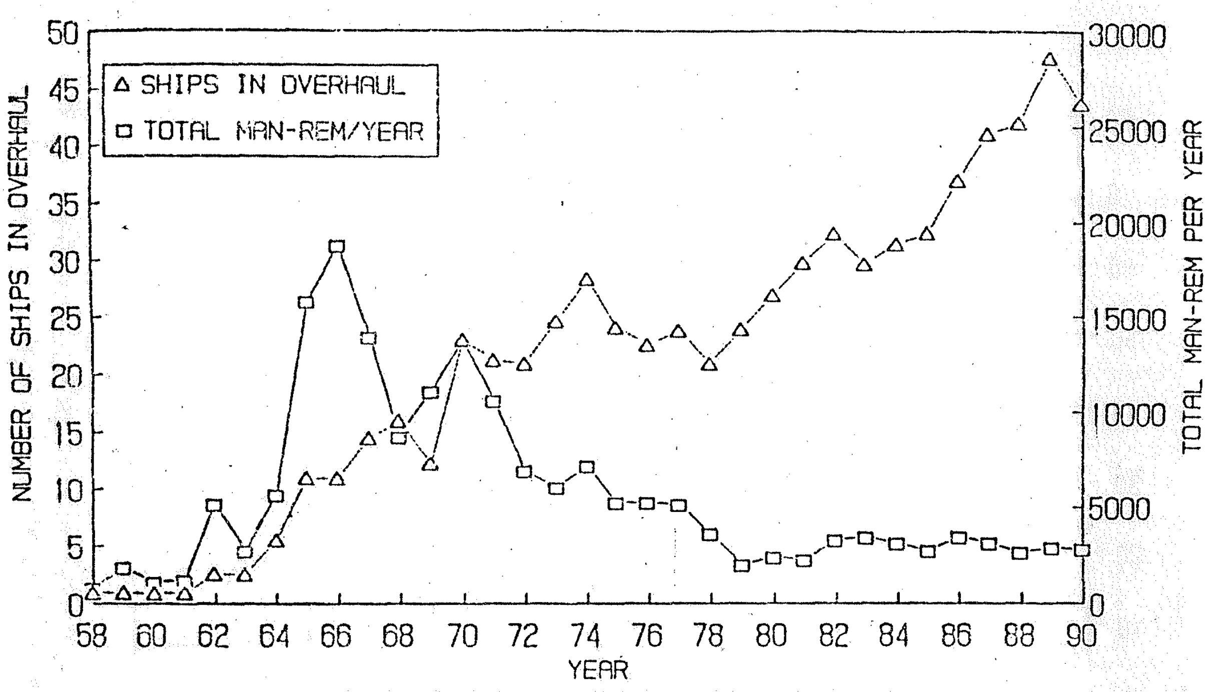
[12] The history of this reactor, nicknamed Nukey Poo (from NPU, USN Nuclear Power Unit) was described in *Peacelink,* no 85.

[13] The incident is described in old National Radiation Laboratory files held in the Christchurch branch of the NZ National Archives, in particular CH 56 23/20/1.



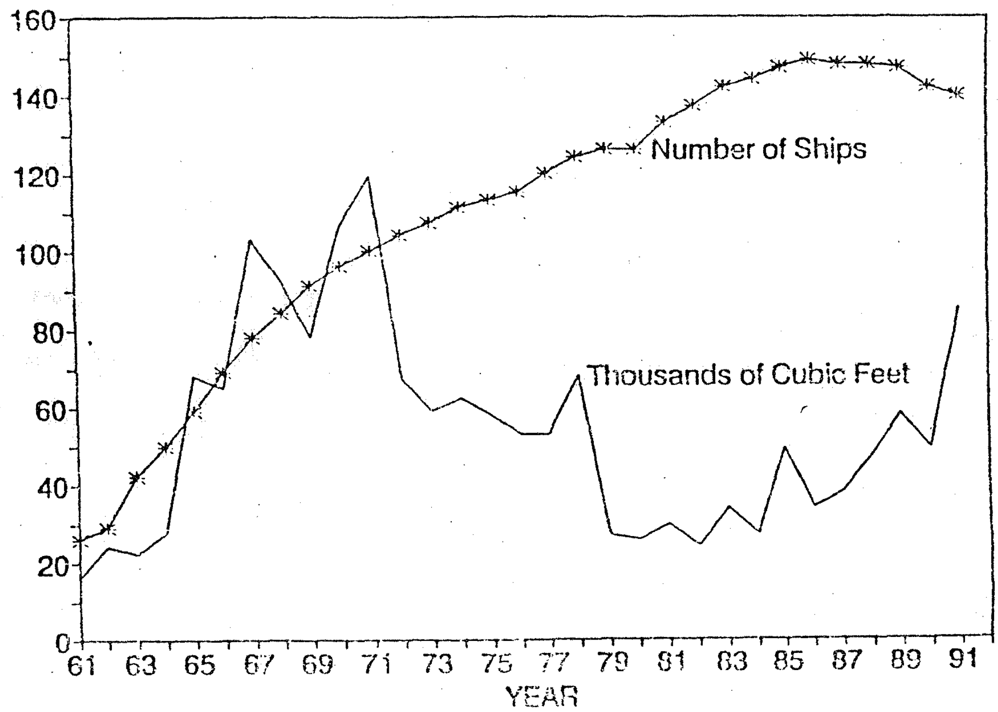
Submarine mishaps in the Atlantic, 1983–1987 (Naval Safety Center).

Naval Safety Center. 'Submarine Force: Mishaps Statistical Summary, Calender Years 1983 thru 1987' (n.d.) (released under the Freedom of Information Act).



TOTAL RADIATION EXPOSURE RECEIVED BY SHIPYARD PERSONNEL FROM WORK ON NAVAL NUCLEAR PROPULSION PLANTS 1958-1990

RADIOACTIVE SOLID WASTE DISPOSAL VOLUMES IN THE NAVAL NUCLEAR PROPULSION PROGRAM, 1961-1991



RADITATION DOSE AND CANCER:

A CRITICAL REVIEW OF APPENDIX 8 OF THE REPORT OF THE SPECIAL COMMITTEE ON THE SAFETY OF NUCLEAR PROPULSION:

Dr. Simon Hales, Christchurch

Last year, the government set up a committee to examine the safety of nuclear powered ships and submari.nes. The committee produced a report, which was released in December. This article focuses on the section of the report concerning recent evidence of the effects of ionizing radiation in humans . One of the principal conclusions reached by the Committee is that current estimates radiation risk can be relied on:

> ". . . the relationship between radiation dose and cancer induction as given for instance, in ICRP 60 [[1]] is soundly based and that no recent studies give cause to question the findings of this document."

However, there undoubtedly are recent studies that conflict with the findinqs of ICRP 60, as I shall show. The question is whether, taken together, such studies give sufficient grounds to increase the estimates of disease resulting exposure to low dose ionizing radiation. The Committee have been at best highly selective, and at worst misleading or inaccurate, in their interpretation of the scientific evidence. I will substantiate this conclusion by considering the evidence presented under the headings used in the report.

A8.2 Background:

On p210, the Committee state:

> "The radiation dose to members of the general public from all normal activities associated with the nuclear industry is a very small fraction of the radiation of the radiation dose from all other sources. This means that only the most careful and heroic epidemiological study which seeks to establish a relationship between a dose from this activity and subsequent late cancers may just succeed. There have been no such studies to date."

In fact, there are several studies showing a significantly increased incidence of cancer in the viciniay of nuclear installations [for example, [2],[3],[4], [5]].

It can be argued that these "excess" cancers are not caused by exposure of the public to radiation from the nuclear industry, because the estimated doses involved are too low to account for them. However, the true doses are not known, and the population exposed is very large. Thus even if, as the authors state.

> " . . . at low doses, only a very few of the exposed individuals will develop cancer."

the number of people affected may still be very significant. In the past, it was thought that low doses of radiation were completely safe. However, this is considered unlikely to be the case [[6]].

Subsequently, referring again to epidemiological studies suggesting a link between radiation and cancer the Committee state

> ". . . none of the recent studies has been able to conclude categorically that an effect does or does not exist."

This is misleading, because it is <u>never</u> possible to "conclude categorically that an effect does or does not exist" from a single study. A study either shows an effect which is statistically significant, or it does not. Causation [or lack of it] is inferred from an evaluation of all the available sc:ientific evidence .

Further, the study by Kendall et al. [[7]], which the Committee comments on, does show a statistically significant effect for leukaemia. Other studies, which the Committee do not mention, also show statistically significant increases in cancers associated with low dose exposures to radiation [see below].

<u>A8.3.1: Studies related to nuclear radiation workers:</u>

The Committee were apparently unaware of the problems of trying to compare data from nuclear workers and atomic bomb survivors [i.e. differences in radiation type, dose rate, and timing of the dose in relation the conception of children] . The Committee quote a comment that the Gardner study [[8]]

". . . seems to violate all plausible biological mechanisms of reproductive biology and genetic transmission." [9]

However, faced with a discrepancy between theory and the epidemiological evidence, it is prudent to assume that the theory is inaccurate rather than discount the empirical evidence.

There is considerable scientific debate about the proportion of childhood leukaemia which is attributable to ionizing radiation. Contrary to the view of Smith [10], quoted by the Committee, some researchers estimate that this proportion may be about 50%. [See [11] for some recent debate on this issue].

The Committee now turn to the most recent epidemiological studies on nuclear workers. Commenting on "healthy worker effect" in the U.K. study by Kendail et al, they state

> "The 6612 deaths recorded among the radiation workers compare favourably with the expected number of 8010 <u>if the workers were a representative sample of the population</u> . . . This effect, shared by workers in all safe industries, is well known in studies such as this ." [my emphasis]

The point, of course, is that workers are generally healthier than the rest of the population- they are <u>not</u> a "representative sample". It is this that leads to the healthy worker effect, not the safety of the industry. The Committee imply that it can be concluded that the nuclear industry is safe on the strength of this type of comparison. This is misleading . So is the selective reporting of the evidence of the U.K. study. We are not told one of the main conclusions, that

> "There is evidence for an association between radiation exposure and mortality from cancer [12]."

The Committee only tell us that

> "Kendall et al. concluded that their study does not provide sufficient evidence to justify a revision in risk estimates for radiological purposes."

In support of this, the Committee compare the findings of this British study those of a similar American study, and with the current risk estimates of the ICRP [their table A8.1, p212].

LIFETIME RISKS FOR DEATHS FROM CANCER AND LEUKAEMIA:

[Lifetime risk expressed as Percent per Sievert.
C.L. stands for confidence limits] .

	ICRP	UK Study	American Study
All cancers	4	10	<0
90% C.L.	3 to 5	<0 to 26	<0 to 8.2
Leukaemia	0.4	0.76	<0
90% C.L.	0.3 to 0.55	0.07 to 2.4	<0 to 0.60

Several points arise from this table. Most importantly, the most recent follow up of American nuclear workers , [those at Oak Ridge National Laboratory ,[13]], are not showrn. This study gave risk estimates an order of magnitude greater- giving very good reason to question the current ICRP estimates.

The Committee apply confidence limits to the ICRP estimates. This is incorrect, and gives a false impression of the accuracy of these estimates. True confidence limits are derived by statistical calculation , and indicate the range of values which could be expected as a result of chance. The ICRP risk estimates are an extrapolation based on the results of several studies- not the simply the outcome of a statistical calculation. The "confidence limits" given by the Committee do not reflect the uncertainty involved in this extrapolation .

The ICRP estimates are extrapolations from studies of populations exposed to high doses at high dose rates . One of the assumptions made by the ICRP is that low dose, low dose rate exposure will be relatively less harmful . However, this assumption is not supported by the present evidence from populations that have had this type of exposure. It is just this type of exposure that occurs as a result of nuclear discharges or accidents.

A8.3.2: Studies of populations living near nuclear facilities:

Only one example of this type of study is mentioned . This particular study [14] did not show an association between living near to a nuclear facility and cancer. However, several other studies have shown such an association , for example [3-5]

A8.4 Health consequences of the Chernobyl accident:

Regarding the Chernobyl accident, the Committee comment that

> "Except for the workers involved at the very early stages of the accident, and who suffered from acute radiation effects, essentially the only physical effects expected will be those due to late cancers."[15]

This is incorrect, as diseases other than cancer are also expected to occur in children conceived by adults who have been exposed. There is evidence that this has happened. [16,17] These studies are not mentioned. The Committee then go on to estimate the number of cancers expected to occur in people directly involved in the accident, evacuated from the surrounding area, or living in the zone studied in the International Chernobyl Project, They do not estimate the effects expected to occur in people further away, merely commenting that, in these people:

> "No physical effects due to the Chernobyl accident will ever discernible . . . " [18]

This is incorrect- evidence of such effects has already been found, [see above] . In fact, the health impact of the accident is predicted to be much greater in populations <u>other than</u> those considered by the Committee. A conservative estimate of the global population dose by the US Department of Energy is 1.2 million person-Sv [to 50 years after the accident, [19]]. Multiplying this by the ICRP risk estimate of 5%s per Sv used by the Committee in their table gives an estimate of 60 000 excess fatal cancers. It is quite possible that both these estimates [of global population dose, and the cancer risk], are too low. Thus much higher estimates of total deaths are quite plausible. The comparison given by the Committee between their "total figure of 7000" the Greenpeace estimate of up to 500 000 deaths is misleading, since these figures apply to different populations .

The Committee comment on an article by Baverstack et al. [20] regarding thyroid cancer in children exposed to fallout from Chernobyl.

> "[Baverstock et al.] comment that the short time between the accident and the observed increase is surprising in comparison with other studies. They point out further that there is no evidenice that the diagnostic or therapeutic use of radio-iodine in man carries a carcinogenic risk and that Iodine-131 has provided a safe and effective treatment of Graves' disease in adults ."

From this, the impression is given that the Chernobyl accident is unlikely to have been the cause of the childhood thyroid cancers. The Committee do not mention the conclusions of the authors :

> "We believe that the experience in Belarus suggests that the consequences to the human thyroid, especially in fetuses and young children, of the carcinogenic effects of radioactive fallout is much greater than previously thought."

Of course, this directly contradicts the assertion that no recent studies give cause to question current radiation risk estimates.

Ionizing radiation is arguably the most thoroughly studied of human carcinogens. The effects of radiation on health have been the subject of intense debate for nearly 50 years- and probably will be for at least another 50. Unfortunately, this debate has become very polarized. Because of this, selective reporting of the facts is to some extent inevitable in any review such as that undertaken by Committee. However, there is a fine line between being selective, and deliberately misleading .

The Committee conclude that

> ". . . people's fears are far greater than the scientific facts warrant."

Despite all the research, our knowledge of the health effects of exposure to low doses of ionizing radiation is incomplete. Historically, scientists have consistently underestimated radiation risks. The ICRP estimates have repeatedly been revised upwards over the past 50 years. As a result, dose limits for workers and public have been lowered on four occasions [21].

These dose limits have always been a compromise between the needs of the nuclear industry, in particular the military, and the need to minimise health effects. In the end, we must each decide for ourselves whether or not we believe this compromise is justified .

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6. ICRP 60, p17, paragraph 68.

7. Kendall et al . Mortality and occupational exposure to radiation: first analysis of the National Registry for Radiation Workers. British Medical Journal 1992; 304: 220-5.

8. Gardner M. et al. Results of case control study of leukaemia and lymphoma among young people near Sellafield nuclear plant in West Cumbria. British Medical Journal 1990; 300: 423-429.

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10. p 211 of the report, quoting Smith P. Case control studies of leukaemia clusters . British Medical Journal 1991; 302: 672-673 .

11. Letters to the Editor, Lancet 1990; June 2: 1336-1340.

12. Kendall et al., p220.

13 . Wing S. et al. Mortality among workers at Oak Ridge National Laboratory. Journal of the American Medical Association 1991; 265: 1397-1402. [Editorial comment p1437-8.]

14. Jablon S. et al. Cancer in populations living near nuclear facilities: A survey of mortality nationwide and incidence in two states . Journal of the American Medical Association 1991; 265: 1403-

15. p213 of the report.

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18. Their table A8.2, p214

19. U.S. Department of Energy, June 1987. Health and Consequences of the Chernobyl Nuclear Power Plant Accident. DOE/ER-0332

20. Baverstock K. et al. Thyroid cancer after Chernobyl. Nature 1992; 359: 21-22.

21. Caufield, C. Multiple Exposures, Penguin 1989.

REPORT ON NUCLEAR POWERED SHIPS
PROBABILISTIC PROBLEMS

John Gardenier

Late last year the report *Safety of Nuelear Powered Ships* was presented to the nation as a Christmas present [1]. Conceived in a sensitive political atmosphere, the report was arguably the most eagerly anticipated risk study produced in New Zealand. Prepared by a government appointed Special Committee consisting of Professors Patricia Bergquist, David Elms and Alan Poletti under the chairmanship of Sir Edward Somers, its major finding was that *"the presence in New Zealand ports of nuclear powered vessels of the navies of the United States and the United Kingdom would be safe".*
Media reactions immediately following the publication of the report were mainly sceptical, generally observing that those already in favour of such visits would be happy with the report and those against not convineed. Nevertheless, few would doubt that the report presents excellent value, although, without having to take sides, we will draw attention to some contradictions in its interpretation of probabilistic infornnation, an uneasiness which may have contributed to the adversarial style of the report.

A first impression when browsing through the report is that the Committee had little sympathy which arguments brought forward by those opposing visits of nuclear powered ships. In its findings the report complains about "the serious lack of understanding and knowledge and much misinformation in the minds of the public". For *public,* read *those who made submissions.* Appended to the report is a list of submissions - from informed and misinformed alike - which makes interesting reading: A full chapter entitled *Myths and Catch-cries,* dedicated to "rnisconceptions and (incorrect) information ... expressed to us by large nurnber of those making submissions" [pages 159 - 171], deals not very tactfully with sensitive popular topics on the perceived dangers of nuclear reactors, radiation, plutonium, nuclear free New Zealand etc. A separate appendix contains detailed calculations on potential consequences of the Chemobyl disaster [pages 212 - 215], for no other apparent reason than to prove Greenpeace wrong [2].
This attitude to take sides in a politically sensitive adversarial situation, seems to conflict with the Committee's status as an independent body. As will be seen below, such an argumentative approach seems to be a fall-back position, when probabilistic facts are not allowed to speak for themselves.

Wealth of information. The value of the report cannot be argued about. For many years to come the report will be used as a valuable New Zealand reference source on nuclear matters. The Committee travelled widely and, to its surprise and notwithstanding military secrecy, it uncovered a vast amount of informative facts on nuclear powered ships. These facts have been presented clearly and carefully, although it is understandable that readers will find some topics more difficult to understand than others. The importance of risk reductions in the design, construction and management stages of nuclear vessels under US and UK command has been dealt with in considerable detail. The chapter on quality assurance and safety management, inspired by the managerial philosophy of the famous Adrniral H.G. Rickover, is most enlightening - deserving to be compulsory reading for everyone involved in quality management.

Regarding probabilistic risk assessment information, the Cornmittee managed to find much more data than, for instance, the Institution of Professional Engineers had anticipated. The Institution in its formal submission had urged the Comrnittee to conduct its own probabilistic risk assessment of a typical nuclear ship. The Committee considered this impractical, and was fortunate in finding that sufficient probabilistic information could be deduced from publicly available sources. *Significantly, the Committee substantially based its conclusion regarding the safety of nuclear ships on probabilistic information thus collected.* This critique concentrates on the Committee's interpretation of this probabilistic information.

Three scenarios. The report carefully explained that risk assessment starts with a tentative identification of a great number of hazard scenarios before these can be systematically grouped and simplified into a limited number of representative scenarios for detailed further study, each one carefully based on conservative assumptions.

Three such representative scenarios were proposed. Scenario I considered the risk to public and environment of radioactive waste routinely or accidentally spilled in port. It appeared that measurements to date had nowhere been able to detect radioactive waste around the ship against the background of natural radiation. This scenario, therefore, presented no assignable risk to population and environment. Scenario II concerned a so-called contained accident, whereby only a very small amount of radioactivity would escape to atmosphere. This turned out to present a barely but - in the Committee's opinion- just credible risk of a small amount of radiation to escape with an annual likelihood of no more than 1 in 10,000. Scenario III related to a worst-case accident where many things went wrong with substantial escape to atmosphere. This scenario was reported to have an estimated likelihood below 1 in 1,000,000 per year, an event considered so unlikely to happen, that it was declared a negligible risk. However, in terms of information provided in the report , this appears to be a rash conclusion.

Worst-case scenario riskier. The Committee's own definition of risk was the familiar formula that *"risk is the product of the chance of an event occurring and the consequences*

which may ensue if it does" (page i), which is also the traditional basis of probabilistic risk analysis. This means that the risk of scenario III would only be smaller than the risk of scenario II if the vastly increased potential consequences of III were matched by an even faster corresponding reduction of its likelihood.
Note that in terms of this definition of risk it is not unusual that worse-case accidents are less risky than more likely ones with smaller consequences. This is clearly demonstrated in the "steep" probability / consequence curves of figure 5.1 on page 49 of the report, which show that (in the US) for increasing consequences of fires, aviation disasters, LPG transport crashes and nuclear reactor accidents, corresponding likelihoods are falling even faster, meaning that the risk (consequence times probability) also drops. On the other hand, dam failures seem to constitute a "flat" probability / consequence curve implying increasing risk for failures with more serious consequences, a fact the Committee draws special attention to (Page 48).
Figures 5.2 and 9.4 (pages 61, 133) feature such curves tentatively construed by the Committee for nuelear powered ships from available information. These so-called indicative probability / consequence curves appear to be at least as "flat" as the curve for dams: this means that the more serious the consequences are of nuclear ships accidents, the more the risk will increase. With scenarios II and III presumably somewhere located on or near these indicative curves, III, therefore, is riskier than II. For civil defence contingency planning purposes the report deals at great length with details of scenario II. Contingency planners would have been better served with a detailed description of scenario III, which according to the Committee's own definition of risk is riskier.
In order to reach the conclusion that scenario II is riskier than III, the committee did not use its own definition, but by implication applied another definition not necessarily based on the product of a large amount multiplied by a small amount, but in critical situations determined only by the smallness of the small amount.
This approach is often used by promoters of hazardous schemes, in anticipation of expected environmental objections, which tend to focus *only* on the seriousness of potential consequences. A notable characteristic of this adversarial approach is not only to prove the opposition wrong, as noted in the introduction of this paper, but also by punctuating the text by subjective qualifiers such as *insignificant, negligible, non-credible, highly improbable, extremely unlikely, extraordinarily remote, totally inconsequential,* etc., instead of letting enumerated facts speak for themselves. Most extraordinary is the warning, which goes with figure 5.2, that an event with a chance of 1 in 10,000 per year corresponds to one event in the period of time from the last ice age. Quite unimaginable, compared with the information given elsewhere, that such a chance corresponds to the daily-felt risk of death in a traffic accident (page 226)!. Such rhetoric was apparently sufficient to convince the Committee

that scenario III would be less risky than scenario II, which therefore could be withheld from civil defence contingency planners.

Overseas risk acceptance standards. So far we have not suggested that the information shows that visits of nuclear powered ships are too risky. That is a matter of professional or societal consensus, formally documented in quotable risk acceptanee standards, whether in the form of voluntary guidelines or mandatory regulations. In the absence of official risk acceptance criteria for New Zealand, the Committee had to rely on standards applied overseas. Risk target levels aimed for in the United States, Britain, Austria, Australia and the Netherlands and by various international agencies were duly reviewed. However, these tend to concentrate on in*dividual risk* to apposed populations, a concept hardly touched on in this study.
Meanwhile not many countries have yet adapted *societal* risk acceptance standards, required to adjudicate on probability / consequence curves. The Committee used those recently formulated by the UK Royal Society which are plotted in figure 9.4 This showed that major risks from nuclear *ships* would (just) safely comply with these guidelines. The UK guidelines are based on principles of risk acceptance standards developed for the Netherlands govemment in the nineteen eighties. However, when we sketch the Dutch standards in on figure 9.4, compliance appears to be problematical.
The significant difference between the British and the Dutch requirements is not only that the Dutch aim for a lower societal risk than the British, but also that for *n*-times larger consequences they require the likelihood to be at least *n-squared* times smaller [3], [4]. The Dutch requirement is in response to *catastrophe aversion,* listed in the Glossary of the report the term *risk aversion,* depicted as an oddity only. The Dutch aim to make their risk acceptance criteria to conform to "steep" curves, such as those of fire, aviation disasters, transport crashes, and nuclear reactor accidents- that is, unlike the "flat" probability / consequence curves of dams and of nuclear powered ships. It is disappointing that the calculated risks of visiting nuclear ships do not easily comply with the Dutch standards, sincethe Dutch, like New Zealanders, endeavour to live up to a clean and safe image. The Dutch criteria were for instance applied in the risk assessment audit of a proposed gamma irradiation plant in South Auckland in 1987, which showed that its probability / consequence curve would comfortably comply with the severest known risk acceptance criteria used overseas [5]. Such information has the power of convincing doubting Thomases, a fact not lost on the planning committee of Manukau City.

To summarise, the Special Committee on Nuclear Propulsion is to be commended for collecting a veritable wealth of valuable information on nuclear powered ships. This included a generous amount of probabilistic data, on the basis of which final conclusions were drawn regarding the safety of such ships visiting New Zealand ports.

However, by not applying its own definition of risk, the Committee did not let the facts speak for themselves, but adopted an adversarial attitude, with the implied danger of subjective overkill.

More seriously, rash conclusions were drawn regarding the risk of an identified worst-case accident scenario, resulting in civil defence contingency planners being provided with details of a much smaller accident scenario than was warranted.

The study showed also that the risk of visiting nuclear powered ships could be judged negligible in terms of risk acceptance guidelines used in the UK, but not so in terms of widely tested similar but more severe Dutch risk acceptance standards, which better suit the New Zealand image of cleanliness and safety. This is frankly disappointing.

Revised 20 August 1993

John Gardenier is a Wellington risk assessment consultant and a member o f the Standing Committee on Engineering Safety of the Institution of Professional Engineers.

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[1] Special Committee on Nuelear Propulsion, *The Safety of Nuclear Powered Ships,* Department of the Prime Minister and Cabinet, Wellington, December 1992.

[2] Concerning the Chernobyl disaster, the report refers to 31 immediate radiation-related deaths and estimates up to 7,000 long-term casualties, compared with Greenpeace casualty estimates of between 280,000 and 500,000. It is interesting to compare this with other estimates of 8,000 deaths to date, with possibly 10,000 more to come [Time magazines of 19 April 1993 and 7 December 1992 respectively].

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