CHAPTER 5

NUCLEAR POWERED WARSHIP SAFETY RECORD

Risk Assessment Based on Historical Data

5.1 Two broad approaches are possible in assessing the likelihood of an accident. One involves theoretical consideration of possible accidents. The ways in which this might be done were outlined in chapter 3. The second approach involves considering the historical record. This chapter takes this approach. The historical approach is familiar because it is widely used by insurers to assess the risk of everyday accidents such as house fires, road accidents and industrial accidents.

5.2 It is important to note that reference to the historical record can never prove in any absolute (as opposed to probabilistic) sense that an accident will not occur. Rather surprisingly, some witnesses attempted to argue from this point to the proposition that the accident record was simply not relevant. As the Committee understood it, the argument was that even if the past had been accident free, this did not establish anything significant as to accident likelihood in the future.[1] The fact that equipment had operated accident-free for, say, 3,000 machine-years allowed no statement as to the probability that an accident would not happen tomorrow.

5.3 The Committee does not accept this argument. In the Committee's view it rests on a mistaken or unacceptable notion of what is meant by proof. Once it is allowed that all the links in an accident scenario are physically capable of occurring, the

----

1. Evidence, p. 865 (Scientists Against Nuclear Arms); p. 935 (Mr M. Lynch); pp. 995-96 (Mr R. Bolt).

only relevant statements are ones that relate to the probability of occurrence. In other words, a demand for proof that an accident will not occur can be interpreted as a request that occurrence of the accident be shown to be physically impossible. Once this interpretation is ruled out on the particular facts, the only alternative interpretation of the demand for proof is that what is sought is proof according to probability.

5.4 Broadly speaking, the best evidence of probability lies in the relevant historical record, as a number of submissions pointed out.[2] To be sure there are never enough relevant historical data: reliable use of the past record requires that the relevant activity has occurred frequently over a period of time and that a large amount of data exists on any accidents that have occurred during that activity. It is a question of fact whether for any accident scenario the data base is adequate.

5.5 Within limits, however, the question of adequacy is one of degree. The better the data, the greater the confidence can be placed in predictions based on that data. The degree of confidence the Committee considers can be placed in prediction based on the historical data relevant to the likelihood of serious naval reactor accidents is examined in this chapter. But the Committee rejects the suggestion put to it that it should place no value whatsoever on what is known of the naval reactor safety record, or that the historical record proves nothing.

5.6 A further issue in making predictions based on historical data is that no guarantee can be given that one or more of the relevant conditions surrounding the accident scenario under study will not alter in the future, thereby affecting the reliability of any prediction. The Committee recognises this as a valid point. But it is also relevant to note that experience

----

2. e.g. see the submissions from Prof W. J. Davis, p. 121 (Evidence, p. 568); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822).

gained in operating civil and naval reactors has led to increased rather than decreased safety.[3] Moreover, the Committee has confined its consideration to existing United States, and to a lesser extent, Royal Navy reactors. It makes no statement on whether its conclusions would apply to naval reactors which may be developed in the future.

The Safety Record - Official Views

5.7 The radiation monitoring in place during nuclear powered warship visits to Australian ports since 1976 has never detected any release of radioactive material from the vessels.[4] Nor was there any incident involving the release of radioactivity during the visits prior to 1976.[5]

5.8 The 1987 statement to Congress by the United States Naval Nuclear Propulsion Program director indicated that there were 179 reactors operating under the program. There were 149 nuclear powered vessels, some having more than one reactor, and 8 land-based prototypes. This was nearly twice the number of operating reactors in the civil nuclear power industry in the

----

3. cf. submission from Prof W. J. Davis, p. 121 (Evidence, p. 568): as the nuclear industry matures, accident probability may decline (with better safety standards) or increase (with aging components).
4. See the annual reports of radiation monitoring described in paras. 2.28-2.31. It was alleged to the Committee that the USS Sea Dragon, while in Hobart in 1983, 'suffered a leak from its reactor coolant into its secondary coolant system in excess of 300 rads ... The Sea Dragon went from Hobart to Hawaii where the whole vessel was sealed, decommissioned immediately and either sunk or scrapped or buried somewhere at Santiago': submission from Miss E. Ruzicka, p. 5. The Committee followed up this undocumented allegation and found it to be false: letter from Cdre N. J. Stoker RAN, 19 April 1988 (Evidence, p. 238.324). It should be noted that the submarine called at Jervis Bay after leaving Hobart, but radiation monitoring at Jervis Bay detected nothing abnormal: Department of Home Affairs and Environment, Visits by Nuclear Powered Warships to Australian Ports: Report on Radiation Monitoring during 1983, (DHAE, Canberra, 1984), pp. 9 (Hobart) and 11-12 (Jervis Bay).
5. Australia, Environmental Considerations of Visits of Nuclear Powered Warships to Australia, (May 1976), p. 2 (Evidence, p. 119).

United States.[6] A 1988 statement declared that these:

> 149 nuclear powered warships continue to have a remarkable record of safety and operational effectiveness. The safety record has been validated in over 75 million miles - 3,200 years of reactor operation - without a reactor accident or any radioactivity release having a significant environmental effect.[7]

5.9 There appears to be no formal United States Navy definition of what constitutes a reactor 'accident'.[8] However, annual reports by the United States Navy state:

> No civilian or military personnel in the Naval Nuclear Propulsion Program have ever exceeded the Federal limit which allows five rem exposure for each year of age beyond age eighteen. Since 1967 no person has exceeded

----

6. US, H of R, Committee on Appropriations, Subcommittee on the Department of Defense, Hearings on Department of Defense Appropriations for 1988, 30 April 1987, p. 964 (Admiral K. R. McKee).
7. US, H of R, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1989 - Hearings, 23 March 1988, p. 1360 (Admiral K. R. McKee). See also US Congress, Joint Committee on Atomic Energy, Subcommittee on Legislation, Naval Nuclear Propulsion Program - 1976, 18 March 1976, p. 16 (Admiral H. G. Rickover): 'To date there has never been an operating occurrence, casualty, incident, accident, or whatever you want to call it, which has resulted in damage to naval fuel and the subsequent release of fission products from the fuel'.
8. In US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984; Hearing on H. R. 5263, 28 February 1984, p. 195, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"'), the Navy explained:

   > The statement by the Navy that no nuclear reactor accidents have occurred in the U. S. Naval Nuclear Propulsion Program is based upon the widely accepted definition of a nuclear reactor accident. Such an accident, as occurred at Three Mile Island in 1979, is an event in which there is damage to the reactor causing the release of radioactive fission products from the reactor core. The Navy has never had such an accident since the inception of the Naval Propulsion Program.

   Compare this with the formal US definitions of 'accidents' and 'incidents' to nuclear weapons, discussed below at paras. 11.97-11.98; and UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.), p. 1-3:

   > A reactor accident is defined as an unexpected event involving a nuclear reactor plant which is likely to lead to or has resulted in a radiological hazard external to the reactor plant.

> the Federal limit which allows up to three rem per quarter year, nor in this period has anyone exceeded the Navy's self-imposed limit of 5 rem per year for radiation associated with Naval nuclear propulsion plants.[9]

5.10 It seems reasonable to assume that had any sort of reactor accident or incident occurred (other than radioactive waste discharge) of any degree of seriousness these limits would have been exceeded for at least one of the reactor operators on board the vessel at the time. Waste discharges are considered separately below. But apart from the possibility of these discharges, the quoted passage strongly suggests that the United States Navy has never had any reactor problem which, were it to occur during an Australian port visit, would pose any health or environmental concern.

5.11 British nuclear powered vessels have had less than 300 reactor-years of operation.[10] In response to a Parliamentary question in 1988 relating to British nuclear powered submarines, a British Government spokesman stated that 'there has never been an incident involving such submarines where there was any radiological hazard to service men, base personnel or members of the

----

9. US, Department of the Navy, Occupational Radiation Exposure from U. S. Naval Nuclear Propulsion Plants and their Support Facilities 1987, (NT-88-2, February 1988), p. 1. Similar statements appear in previous annual reports in the series. In the context of this reporting program, 'abnormal occurrences' are reported 'if the Navy evaluation determines that they meet either the Department of Energy criteria for Type A radiation exposure incidents or the Nuclear Regulatory Commission criteria for quarterly report to Congress as abnormal radiation exposure occurrences': p. 48. There were no abnormal occurrences in the period 1978-1987: p. 48. The report in this series for 1978 states that there were no abnormal occurrences in the period 1974-1978: see Table 8 of the report.
10. UK, Ministry of Defence, Devonport Public Safety Scheme, (1982 edn.), p. 1-3 states that 'the total number of RN reactor operating years to date is less than 200'. It seems reasonable to add a figure approaching 100 for the years of operation since 1982.

public'.[11]

5.12 The Canadian Government issued a White Paper in June 1987 in which it was proposed that Canada acquire a number of nuclear powered submarines. In the ensuing debate, a Canadian Department of Defence officer wrote:

> The British, French and U. S. navies, taken together, operate about 210 submarine-propulsion reactors of basically similar design. There has never been a reactor accident in any of these naval programs.
>
> It is apparent that in the Western world, naval-propulsion reactors are either inherently safer than their civilian counterparts, or are operated in a safer manner, or both.
>
> Specifically, Britain operates 42 power-generation reactors and 17 naval-propulsion reactors. One serious accident has occurred in the civilian program, none in the military. In the United States, there are 127 power reactors and 179 propulsion reactors. In spite of the greater number of naval reactors, none has ever caused an accidental release of radiation; one civilian reactor has. The French naval experience is equally impressive.[12]

The Safety Record - Other Views

5.13 A number of submissions took issue with the accuracy of

----

11. UK, Parliamentary Debates (Commons), 6th series, vol. 129, Written Answers, 9 March 1988, col. 216. See also ibid., vol. 143, Written Answers, 9 December 1988, col. 345; and 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared by the Australian Department of Defence for the Committee, July 1988), para. 11 (Evidence, p. 1300.15): 'There has been no accident to any Royal Navy reactor resulting in any release of fission products since the start of the Royal Navy's nuclear propulsion programme.'
12. H. A. Robitaille, 'No Reactor Accidents Have Stained the West's Nuclear Subs', the Globe and Mail (Toronto), 26 June 1987, p. A7. The International Atomic Energy Agency, Bulletin, 1987, vol. 29(2), p. 65 states that only 99 civil nuclear power reactors were operating in the US and 38 in the UK at the end of 1986.

official statements on naval reactor safety. Mr Richard Bolt stated in his 1986 submission:

> It is true that no evidence exists that any reactor accidents - serious or minor - have occurred on NPW's. This is almost certain to be a result of the tight secrecy surrounding sensitive military information. It is only in recent years that a reasonably complete record of the large number of accidents in civilian nuclear power plants has come to light. It would take blind faith to believe that disasters and near-disasters, as yet undisclosed, have not occurred in NPW reactors.[13]

5.14 Any simple inference from events in land-based civil reactors to naval reactors is questionable, as the material in the previous chapter illustrated. Moreover, the Committee does not consider it likely that United States officials have consistently lied to Congress over the years.[14] If for no other reason, this would be so because concealment of accidents of the types most relevant to the Committee's inquiry would be difficult in an open society such as the United States. These accidents, core meltdowns or other accidents involving serious core damage to reactors of United States vessels, would leave the reactor disabled and the ship out of service for lengthy and costly repairs. Yet Soviet authors,[15] United States investigative

----

13. Submission from Mr R. Bolt, p. 8 (Evidence, p. 958). See also the submissions from Prof W. J. Davis, pp. 13-14 (Evidence, pp. 460-61); Greenpeace Australia (NSW) Ltd, p. 18. When Mr Bolt appeared before the Committee he withdrew his reference to 'disasters' having occurred, but maintained his view with respect to 'near-disasters' (Evidence, p. 996).
14. Contrast Evidence, p. 935 (Mr M. Lynch) referring to the US Navy's statement to Congress on reactor safety: 'there is no proof that that statement is true'.
15. A book whose title translates as Design of Nuclear Submarines by V. M. Bukalov and A. A. Narusbayev was published in 1968 and contains tables purporting to show various types of accidents that have occurred to US and British nuclear powered submarines. None of those listed involve a meltdown. The tables are reproduced in N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), pp. 683-87.

reporters and authors,[16] and those making submissions to the Committee have not suggested the existence of even a serious rumour that such an accident has ever occurred.

5.15 Accidents involving serious core damage during port visits would be particularly difficult to conceal (unless containment and shielding was 100 per cent effective) because of the independent monitoring that often occurs during such visits.[17] Even where there is no routine monitoring of visits as such, the effects of a major release of ionising radiation as a result of an accident would risk being detected by the sort of routine environmental monitoring that occurs in many countries. It was monitoring of this kind that first indicated to Western observers that the 1986 accident to the Soviet Union's nuclear power station at Chernobyl had occurred.[18]

----

16. e.g. D. Kaplan, The Nuclear Navy, (Fund for Constitutional Government, Washington, 1983); N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982).
17. For the US, see US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, p. 200, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, p. 1300.67): independent monitoring of the radiological effects of nuclear powered warships in US ports has been done from time to time by federal, state and local authorities. For the independent monitoring occurring around the US submarine base in Scotland see UK, Parliamentary Debates (Commons), 6th series, vol. 146, Written Answers, 2 February 1989, col. 405. For the monitoring by local authorities that takes place during nuclear powered submarine visits to Japanese ports see M. Kuramoto, 'Some Considerations on the Safety of Nuclear Ships' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 459. In New Zealand, the National Radiation Laboratory monitored the visits of all nuclear powered warships: S. McMillan, Neither Confirm Nor Deny: The Nuclear Ships Dispute between New Zealand and the United States, (Allen & Unwin, Wellington, 1987), p. 39. For the monitoring during Australian port visits, see paras. 2.28-2.31 and chapter 8 in this report. Contrast, 'Round-the-clock check on Snook', West Australian, 16 August 1976: captain of visiting USS Snook cited as saying monitoring not usually carried out in other parts of the world, except for Japan.
18. M. Eisenbud, Environmental Radioactivity from Natural, Industrial, and Military Sources, (3rd edn., Academic Press, Orlando, Fla., 1987), p. 378.

Loss of USS Thresher and USS Scorpion

5.16 Some submissions referred to the loss at sea through accident of the United States nuclear powered submarines Thresher in 1963 and Scorpion in 1968.[19] The implication was that these accidents refuted the official position on safety or were otherwise relevant to safety during port visits. In neither accident were there any survivors, and relevant wreckage of the vessels has not been recovered from the deep waters in which they lie. As a result no-one can say with certainty what caused either accident.

5.17 From the information publicly available, it is impossible to refute or confirm the various plausible accident causes, including those involving reactor accidents, that have been put forward unofficially over the years.[20] The official position is that the loss of neither submarine was related to reactor failure, and that subsequent environmental monitoring of the accident sites supports this conclusion.[21]

----

19. e.g. see submissions from Assoc Prof P. Jennings, p. 2; Balmain People for Nuclear Disarmament, p. 4; Medical Association for Prevention of War (Vic), p. 1; Medical Association for the Prevention of War (NSW), p. 2. See also Evidence, pp. 862-63, 865 (Scientists Against Nuclear Arms).
20. See footnote 150 in the previous chapter for references to these theories in the context of reactor scrams. For the theory that the loss of the USS Scorpion was caused by the accidental detonation of a conventional warhead on one of its torpedoes see Jane's Defence Weekly, 5 January 1985, p. 6, 'Lost US submarine caused by torpedo damage'. See also US, Committee on Appropriations, Subcommittee on Energy and Water Development, Energy and Water Development Appropriations for 1988 - Hearings, 11 March 1987, pp. 895-96, where the then head of the US Naval Nuclear Propulsion Program, Admiral McKee, gave a detailed personal theory on the cause of the loss of the USS Thresher. This does not involve a reactor accident. His response to the question 'Was the Scorpion incident nuclear related?' has been deleted from the published transcript on security grounds.
21. See for example US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, pp. 209-10, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, pp. 1300.79-80): monitoring has revealed no radio-activity from the reactor fuel elements and the presence of only very low levels of cobalt-60 from the reactor coolant systems.

5.18 Even if the official view of the causes of these accidents is rejected, it has to be shown what relevance these accidents have to safety during visits to Australian ports. The suggested causes that involve the reactor either could only happen while the submarine was submerged, or would only affect reactor safety while in that position. Thus they could not occur during a port visit.

Alleged British Accidents

5.19 The Committee's attention was drawn to what was claimed to be a meltdown that almost happened as a result of a fault in the reactor coolant system on board HMS Resolution while it was berthed at the base in the Clyde.[22] One media report quoted unnamed 'nuclear experts' as describing the incident as 'potentially catastrophic'.[23] A government spokesman, however, stated:

> The electrical malfunction which occurred on board HMS Resolution on 26 January posed no danger to the submarine's reactor, its crew or the public.[24]

5.20 The Committee was unable to draw conclusions as between the two views of what happened.

----

22. Evidence, p. 1198 (Senator J. Vallentine).
23. 'N-sub minutes from disaster', Observer (London), 14 February 1988, p. 1. Another press report on the same incident claims that 'one man had to be scrubbed down for 24 hours after exposure to radiation': 'Catalogue of faults in UK nuclear subs', Guardian (London), 3 March 1988, p. 1.
24. UK, Parliamentary Debates (Commons), 6th series, vol. 127, Written Answers, 19 February 1988, col. 759. To the question how many military personnel or civilian employees were exposed to levels of radioactivity greater than the permitted dose as a result of the emergency on HMS Resolution on 26 January, the Government's answer was none: ibid., col. 758. To the further question whether any release of radioactivity occurred within the vessel, into the atmosphere, or into the sea as a result of the incident, the Government answer was no: ibid., col. 758. See also ibid., vol. 133, 10 May 1988, col. 297, where a Government spokesman described the press allegations relating to the incident as 'quite erroneous and alarmist' and stated that 'we have never had an accident to a Royal Naval submarine resulting in the release of radioactive material to the environment'.

5.21 The Committee's attention was also drawn to a recent press report stating:

> The reactors which power Britain's nuclear submarines were involved in more than 700 'incidents' during their first 16 years of operation ... . Captain Jim Bush, a nuclear veteran now working at the Centre [sic] for Defence [sic] Information, a private US think-tank frequently critical of Pentagon policies, said that of the 700 incidents 'probably no more than a dozen were significant in that they resulted in the release of radioactive material'.[25]

5.22 In contrast, the report upon which this media report is apparently based refers to 'some 700 "incidents"' and states:

> In all these "incidents", the remedial actions taken have been successful; no British nuclear submarine has been lost, although a major fire has required the lengthy withdrawal from service of one boat, and it must be emphasised that no incident has occurred which has caused a radiological hazard to the public.[26]

Accidents Involving Radioactive Wastes

5.23 In considering naval radiation accidents it is important to bear in mind the distinction between release of fission products following reactor core damage and the release of radioactive wastes.[27] A significant number of submissions that referred to the United States safety record failed to make or

----

25. 'Catalogue of faults in UK nuclear subs', Guardian (London), 3 March 1988, p. 1. The report is based on 'an internal Royal Navy analysis' obtained by the Guardian. It also states that RN analysis of 435 of the 712 incidents showed 205 were caused by mechanical problems, 107 by operator error, and 123 by primary or secondary electrical faults. 'Incidents' are 'defined as events requiring operation away from the norm and which include all occasions when emergency drills have been initiated': J. Edwards and Cdr K. F. Tucker RN, 'Royal Navy Requirements and Achievements in Nuclear Training', Journal of Naval Science, 1978, vol. 4(4), p. 207.
26. J. Edwards and Cdr K. F. Tucker RN, 'Royal Navy Requirements and Achievements in Nuclear Training', Journal of Naval Science, 1978, vol. 4(4), p. 207.
27. The distinction is discussed in paras. 4.14-4.30.

appreciate this distinction.

5.24 Associate Professor Philip Jennings, for example, described the leaking of radioactive coolant water as having the potential to 'lead to far more serious consequences than those predicted for the reference accident'.[28] The much greater quantity of radioactivity available for release in the reference accident than in waste discharge makes this view difficult to credit.[29] A number of submissions referring to allegations of accidents referred to allegations which, even if correct, involved only the release of radioactive wastes.[30]

5.25 Many submissions referring to the accident record involving radioactive wastes, and a number of submissions referring to accidents generally, relied on a 1983 report by an investigative journalist, David Kaplan, entitled 'The Nuclear Navy'.[31] In view of the reliance placed on this report,[32] detailed examination is merited.

5.26 One submission contained what purported to be a quote from Kaplan's report: 'U. S. Navy ships have leaked radiation at

----

28. Submission from Assoc Prof P. Jennings, p. 2. The context makes it clear that he is referring to low-level waste, not coolant contaminated by a meltdown or major fuel element failure.
29. See above, para. 4.30, footnote 35, where a very approximate indication of the comparitive quantities is given.
30. See for example the submissions from the Albany Peace Group, pp. 2-3; Waterside Workers' Federation of Australia (Melbourne), attachments 1 and 2; Ms E. Milne and Mr P. Lockyer, p. 1; Manly Warringah Peace Movement, p. 2.
31. D. Kaplan, The Nuclear Navy, (Fund for Constitutional Government, Washington, 1983). This report also was published in an edited version, without tables or accompanying footnotes, in the July 1983 issue of Oceans.
32. Submissions referring to the report include those of the Albany Peace Group, pp. 2-3; Waterside Workers' Federation of Australia (Melbourne), attachments 1 and 2; Ms E. Milne and Mr P. Lockyer, p. 1; Manly Warringah Peace Movement, p. 2; Illawarra People for Nuclear Disarmament, p. 3; the Medical Association for the Prevention of War (Vic), p. 1; Mrs L. Van Geloven, attachment 2; Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376); People for Peace, p. 1; Prof W. J. Davis, p. 14 (Evidence, p. 461).

least 37 times since they began using nuclear reactors ... '.[33] The report contains no such wording and makes no such claim. The press release issued by one of the report's sponsors states that the report contains a table of 37 accidents involving the reactors (ie. not necessarily involving significant radiation leakage) aboard nuclear powered ships (ie. of all countries, not just the United States Navy).[34] This statement is not accurate either.

5.27 The report refers to 37 'incidents' involving ships' nuclear power plant.[35] This again is not accurate, assuming (as appears reasonable) the statement is supposed to be supported by the 37 items in an appended table. This table is headed 'Reactor-Related Accidents and Incidents Involving Nuclear Powered Vessels 1954-1983'. The heading is inaccurate, in that one of the 37 items identified relates to a land-based non-naval reactor and another relates not to an accident, incident or vessel but to the intentional disposal at sea of a decommissioned reactor.[36]

5.28 It is relevant for the purposes of this inquiry to note that of the remaining 35 items in the table two relate to non-naval ships,[37] five relate to USSR submarines,[38] and twelve

----

33. Submission from Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376). The same quote is attributed to the report in the submission from the Waterside Workers' Federation (Melbourne), attachment 2; and in material tabled in the Senate by Senator McIntosh on 5 May 1986, and provided to the Committee as an attachment to the submission from Action for World Development. None of these gave a page reference to the report from which they were purporting to quote. Without quoting directly, the same proposition was attributed to Kaplan's report by the submissions from the Manly Warringah Peace Movement, p. 2; People for Peace, p. 1. It appears that all these sources relied on the media, not the report itself, for their information as to its contents.
34. Press release of the Fund for Constitutional Government, 20 July 1983, p. 2.
35. At p. 16.
36. Items 5 and 6. Numbering was not supplied in original but has been added to facilitate reference.
37. Items 12 (NS Lenin) and 18 (NS Mutsu).
38. Items 11, 15, 17, 25 and 32.

others relate to activities at naval dockyards or submarine tenders.[39] At least three more relate to reactor types no longer in service,[40] and a further one relates to the USS Nautilus in 1954, prior to its commissioning.[41] Thus at least 23 of the 35 items are not directly relevant to port visits to Australia.[42] This is not, of course, a criticism of Kaplan's report but of the use made of it in submissions to the Committee.

5.29 Kaplan's table is more accurately described as one listing alleged accidents and incidents, in that it contains items which, in the official view, have been investigated and found to be without basis.[43] It also operates on the basis of a broad (but never defined) view of what constitutes an accident or

----

39. Items 7, 16, 19, 20, 21, 22, 23, 24, 28, 33, 35 and 36.

40. Items 2 (reactor type S2G) and items 3 and 4 (reactor type S2W). In items 21, 23 and 35 the identity of the vessel is not given.

41. Item 1. The incident relating to the NS Mutsu (item 18) also occurred during its first sea trial. Nuclear powered vessels undergoing pre-commissioning tests or sea trials will not, of course, be visiting ports in Australia.

42. Items 10 (loss of USS Thresher) and 14 (loss of USS Scorpion) are also best viewed as not relevant to Australian port visits for the reasons given in paras. 5.17-5.18.

43. e.g. see item 13, high readings on radiation monitors during May 1968 visit of USS Swordfish to Sasebo, Japan. US Atomic Energy Commission personnel investigated. Their report, presented to Congress, concluded:

> that USS Swordfish did not at any time while in or near the port of Sasebo during the period May 2 through May 11 discharge radio-activity of any kind to the atmosphere or to the surrounding waters. ... If one assumes that the abnormal readings were, in fact, caused by some form of radioactivity, the radiation levels and radio-activity concentrations would be of the order of one thousand times less than those considered acceptable for the general public by such recognized authorities as the International Commission on Radiological Protection and the U. S. Federal Radiation Council.

Quoted in US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, pp. 199-200, Appendix D, ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, pp. 1300.66-67). A number of submissions referred to the Sasebo incident as evidence of lack of safety, but none indicated awareness of the results of the investigation. See also M. Kuramoto, 'Some Considerations on the Safety of Nuclear Ships' in Organisation for Economic Cooperation and Development, Nuclear Energy Agency, Symposium on the Safety of Nuclear Ships: Proceedings, Hamburg, 5-9 December 1977, (OECD, Paris, 1978), p. 459: 'no accident whatsoever has ever occurred to date' during visits by nuclear powered warships to Japanese ports.

incident.[44] Many of the items listed relate to spills of small amounts of coolant almost certainly having very little radioactive content. For many years the United States Navy has prepared and provided to Congress an annual report on discharges of radioactivity from its vessels. Referring to liquid waste, these reports state;

> if one person were able to drink the entire amount of radioactivity discharged into any harbor in any of the last fourteen years, he would not exceed the annual radiation exposure permitted for an individual worker by the U. S. Nuclear Regulatory Commission.[45]

5.30 None of the authors of the submissions citing Kaplan referred to, or appeared to be aware of, the fact that Kaplan's report had been subject to a detailed and persuasive rebuttal by the United States Navy[46] and a critique by another journalist.[47] The Navy described Kaplan's report as containing 'many inaccurate statements' and told a Congressional Committee that after

----

44. e.g. item 9 refers to an incident in which USS Thresher was in port with its reactor shut down. Shore power was unavailable and the diesel generator supplying the hotel load developed a fault. In working on the generator the crew let the electricity batteries run down to the extent that there was insufficient power left to provide the current to start the reactor. An external power source had to be used. See N. Polmar and T. B. Allen, Rickover, (Simon and Schuster, New York, 1982), pp. 425-26 for what seems to be a far more balanced account of the incident. Kaplan cites this work in his table as his source. He does not explain how the events constituted a nuclear hazard of any sort or could ever have led to such a hazard.
45. US, Department of the Navy, Environmental Monitoring and Disposal of Radioactive Wastes from U. S. Naval Nuclear-Powered Ships and their Support Facilities 1984, (NT-85-1, February 1985), p. 2 (Evidence, p. 238.297). The reports for other years contain similar statements.
46. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, pp. 195-212, Appendix D ('Discussion of Allegations Contained in Article "The Nuclear Navy"') (Evidence, pp. 1300.60-83). The substance of this response appeared in Oceans, September 1983.
47. V. C. Thomas jr, 'Setting the Record Straight: Allegations and Reactions', Sea Power, September 1983, vol. 26(10), p. 52. The text of this article has also been incorporated at pp. 213-17 of the transcript of the Congressional hearing cited in the previous footnote. The article draws heavily on the Navy's rebuttal.

receiving the Navy's response, 'news media interest quickly subsided, presumably because of the complete lack of substance to the claims contained in the report'.[48] As far as the Committee can discover, Kaplan has not made any published response to the Navy's critique of his report, although he has since repeated parts of his original allegations.[49]

5.31 This apparent lack of response would incline the Committee to prefer the Navy's version. The Committee, however, did not find it necessary to come to any conclusion as to the truth of Kaplan's allegations. This was because they concerned events not relevant to future port visits to Australia, or at best related only to waste discharges containing minimal amounts of radioactivity.

5.32 With respect to waste discharges from British nuclear powered warships, the Committee was informed: 'there have been no accidental discharges of radioactive waste, other than totally trivial amounts'.[50] The British Government has stated that, in respect of radioactive waste discharge, the Royal Navy's maintenance, operation and safety standards are no less exacting that those of the United States Navy.[51]

Relevance of the Soviet Accident Record

5.33 Some submissions referred to the Soviet Union's nuclear

----

48. US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1984: Hearing on H. R. 5263, 28 February 1984, p. 19 (Admiral K. R. McKee).
49. e.g. D. E. Kaplan, 'Naval Reactors: The Silent Proliferation', Technology Review, April 1987, vol. 90(3), p. 10; D. E. Kaplan, 'A Chernobyl at sea haunts countries with nuclear subs', Globe and Mail (Toronto), 8 June 1987, p. A7.
50. 'UK Nuclear Powered Warships Safety Procedures', (Paper prepared for the Committee by the Australian Department of Defence, July 1988), para. 10 (Evidence, p. 1300.15). See also UK, Parliamentary Debates (Commons), 6th series, vol. 93, Written Answers, 11 March 1986, col. 426: absence of hazardous waste discharges at Holy Loch.
51. UK, Parliamentary Debates (Commons), 6th series, vol. 135, Written Answers, 17 June 1988, col. 347.

ship safety record as evidence of the lack of safety of ships visiting Australian ports.[52] The Committee did not regard this record as of assistance. In part this was because Soviet nuclear powered vessels do not visit Australian ports. In part it was because these vessels appear, on the limited information available, to be of different design and built to different standards than those of western navies.[53]

5.34 In part also it was because, while there are many references to purported Soviet accidents, the information remains fragmentary and often of doubtful accuracy.[54] It seems to be generally accepted that Soviet nuclear powered vessels are much

----

52. e.g. see submissions from the Medical Association for Prevention of War (NSW), p. 2; Balmain People for Nuclear Disarmament, p. 4.
53. It seems to be generally accepted that some Soviet submarines use liquid metal as reactor coolant, a coolant-type that was rejected by the US after experience with the sodium coolant used in the USS Seawolf in the 1950s showed it suffered from safety and reliability problems: N. Friedman, Submarine Design and Development, (Conway, London, 1984), p. 134. It also seems to be generally accepted that in striking a balance between safety and reliability on the one hand and speed and deep-diving ability on the other, the Soviets emphasised the latter more than the US.
54. See for example, J. E. Oberg, Uncovering Soviet Disasters: Exploring the Limits of Glasnost, (Random House, New York, 1988), p. 69, where it is noted that many reports of Soviet nuclear powered submarine accidents derive from secondhand accounts by émigrés and 'the reliability of such hearsay reports is a major concern ...'. See also US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1982: Hearing on H. R. 6151, 29 April 1982, p. 19 (Admiral K. R. McKee): with respect to less-than-major reactor accidents:

> There is virtually no independent means of verifying Soviet nuclear submarine performance in releases of radioactivity to the environment, since these ships do not visit foreign countries where unbiased observation is possible and there are essentially no external, independent facts on which to judge their safety in port. This is in stark contrast when compared to the extensive U. S. nuclear powered warship record of port entry which is a matter of worldwide public knowledge. The Soviet Union has never made public any information on its its nuclear ship operations in port, occupational radiation exposures or the handling of radioactivity associated with their ships.

less safe than their western counterparts.[55] Even so, the Soviet accident record appears to contain one probable meltdown,[56] together with a further possible meltdown.[57] The uncertainty about both of these suggests that if they occurred they were contained rather than uncontained meltdowns. One might expect international monitoring to have detected the consequences of a massive uncontained accident. Moreover, if the meltdowns did occur, it seems that they did not occur during a port visit.[58]

5.35 The Committee noted the shipboard fire and sinking in international waters north of Norway on 7 April 1989 of a Soviet

----

55. e.g. see N. Polmar, 'Soviet Nuclear Submarines', US Naval Institute, Proceedings, July 1981, p. 37; J. Bussert, 'The safety of Soviet nuclear submarines', Jane's Defence Weekly, 18 April 1987, p. 719. See also W. Arkin, The Nuclear Arms Race at Sea, (Neptune Papers No. 1, Greenpeace/ Institute of Policy Studies, Washington, 1987), p. 32, where it is claimed that 'the Soviet record for operations with nuclear propulsion is well-known and scandalous'.
56. The more common view is that the NS Lenin suffered a meltdown at some time in the 1960s, location unknown; e.g. J. Bussert, 'The safety of Soviet nuclear submarines', Jane's Defence Weekly, 18 April 1987, p. 718. Others take a more cautious view of the evidence of the accident, noting that a meltdown 'may have occurred': J. E. Oberg, Uncovering Soviet Disasters: Exploring the Limits of Glasnost, (Random House, New York, 1988), p. 249. See also US, H of R, Committee on Armed Services, Subcommittee on Procurement and Military Nuclear Systems, Naval Nuclear Propulsion Program - 1982: Hearing on H. R. 6151, 29 April 1982, p. 18 (Admiral K. R. McKee): 'there is strong evidence that this ship [ie. NS Lenin] experienced a nuclear related casualty [ie. not necessarily a meltdown] in the late 1960's ...'.
57. It has been suggested that the first 'Alpha' class submarine suffered a meltdown in 1970: e.g. see Bussert, ibid., p. 718. But US intelligence sources have apparently failed to confirm this: R. Hutchinson and A. Preston, 'Soviet submarine accidents - new details', Jane's Defence Weekly, 19 January 1985, p. 85; J. E. Oberg, Uncovering Soviet Disasters: Exploring the Limits of Glasnost, (Random House, New York, 1988), pp. 73, 281.
58. According to press reports, a loss of coolant accident occurred on the Soviet icebreaker, NS Rossiya, on 11 November 1988: Associated Press news dispatch, 6 March 1989 citing a report in the Soviet newspaper Vodny Transport. The accident occurred while the ship was undergoing maintenance in the port of Murmansk. One of the ship's two reactors was shut down. Coolant was mistakenly drained from the other reactor, which was still operating. According to the reports, a 30 or 40-minute supply of backup coolant was available for use before a melt down would have occurred, and remedial action was taken within 4 minutes. The incident is not relevant to nuclear powered vessel visits to Australian ports, as no reactor repair or maintenance activities take place during these visits: see condition (a) of the Australian conditions of entry (see para. 2.20).

nuclear powered and armed submarine.[59] The Committee also noted the reported comments of Norwegian scientists that their tests had not detected any increased radioactivity in the water or atmosphere where the sinking occurred.[60] Norwegian experts are also reported as saying that there is little chance of a radiation hazard from the sunken submarine.[61] It appears from reports that the fire was not related to either the reactors or the nuclear weapons, and the reactors were safely shut down before the crew abandoned the sinking vessel.

5.36 The reported circumstances of this accident[62] have not led the Committee to alter its conclusions expressed elsewhere in this report, which addresses matters associated with periodic visits to Australian ports by nuclear armed ships from the navies of Australia's allies.

5.37 However, the Committee takes the view that the Australian Government should seek the most comprehensive information available on this accident both from its allies and

----

59. According to reports the submarine was a one-of-a-kind attack type, designated by western analysts as a 'Mike' class. It was used for experimental purposes, was powered by two reactors, and used liquid metal for reactor coolant, unlike the pressurised water used as coolant in western naval reactors. Western experts regard the use of liquid metal as entailing greater accident risks than pressurised water: e.g. see footnote 53 in this chapter.
60. e.g. see 'Radiation tests after super-secret Soviet sub sinks', Sydney Morning Herald, 10 April 1989, p. 13; 'Up to 60 die as Soviet N-sub sinks', Age, 10 April 1989, p. 9.
61. ibid. cf. 'A Soviet Nuclear Sub Catches Fire And Reportedly Sinks Off Norway', New York Times, 8 April 1989, p. 5: retired US admiral E. J. Carroll jr cited as saying that the sinking should pose no immediate environmental hazard, but the danger of contamination in the longer term was greater, as the reactor vessel and fuel covering deteriorated due to the effect of sea water. See also 'Radiation leak is inevitable: report', Sydney Morning Herald, 3 May 1989, p. 10 for a similar claim.
62. e.g. that it occured at sea rather than during a port visit; to a vessel of a Navy whose nuclear powered vessels do not visit Australian ports; to an experimental vessel; to a vessel whose reactors are cooled in a way that experts recognise entails a greater accident risk than the system used on vessels likely to visit Australian ports; that the cause of accident is reportedly not nuclear-related; that the reactors were safely shut down following the accident; and that no increase in background radiation levels occurred as a result of the accident.

from the Soviet Union. If information emerges that requires alteration of Australian arrangements, the Australian plans should be amended accordingly.

Non-Nuclear Mishaps to Nuclear Powered Warships

5.38 An approach taken in some submissions was to refer to mishaps involving United States nuclear powered warships but not affecting their reactors.[63] Publicly reported examples include events such as collisions with other ships,[64] strandings or

----

63. e.g. see the submission from the Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376), discussed in Evidence, pp. 1393-94 (Coalition Against Nuclear Armed & Powered Ships).
64. According to media reports, in 1969 the nuclear powered submarine USS Gato was struck at a 90 degree angle on the reactor compartment while submerged by a Soviet submarine travelling at about 7 knots: 'A False Navy Report Alleged in Sub Crash', New York Times, 6 July 1975, pp. 1, 26. Collisions serious enough to sink the other vessel have also been reported: e.g. 'Submarines of U. S. Stage Spy Missions Inside Soviet Waters', New York Times, 25 May 1975, pp. 1, 42 (North Vietnamese minesweeper sunk); 'U. S. Sub Rams, Sinks Japanese Cargo Vessel', Los Angeles Times, 12 April 1981, section 1, pp. 1, 34; Stockholm International Peace Research Institute, World Armaments and Disarmament: SIPRI Yearbook 1977, (MIT Press, Cambridge, Mass., 1977), p. 69 (merchant ship sunk) and p. 70 (tug sunk). For reports of other collisions not involving sinkings see for example, SIPRI, ibid., pp. 68-70; 'Collision of U. S. and Soviet Subs off Siberia in 1974 is Recounted', New York Times, 4 July 1975, p. 21 (following 'almost head-on' collision, repairs to USS Pintado took 7 weeks in dry-dock). The extent to which these reported events have been officially acknowledged varies.

groundings,[65] shipboard explosions and fires,[66] and other incidents.[67] The only one of these reported to have occurred during an Australian port visit was the collision with a wharf at Brisbane in July 1983 by the USS Texas.[68] The implicit suggestion was that the accidents had posed or might have posed a nuclear hazard. However no evidence was cited that this was the case.

5.39 It can be argued that these accidents indicate, contrary to the views of those referring to them, that nuclear powered vessels can be involved in quite severe conventional accidents

----

65. e.g. 'Submarines of U. S. Stage Spy Missions Inside Soviet Waters', New York Times, 25 May 1975, p. 42 (US submarine aground in Soviet waters for two hours); 'Return of Carrier Enterprise to San Francisco Bay Proves Sticky Situation', Los Angeles Times, 29 April 1983, part 1, p. 18 (carrier aground for several hours trying to enter home port of Alameda); UK, Parliamentary Debates (Commons), 6th series, vol. 97, Written Answers, 9 May 1986, col. 266; vol. 106, Written Answers, 24 November 1986, col. 76; and vol. 106, Written Answers, 1 December 1986, col. 440 (USS Nathaniel Greene ran aground in the Irish Sea, sustaining major damage); 'Atomic Craft Aground Off Washington Coast', New York Times, 1 May 1988, p. A38 (submarine USS Sam Houston aground for 10 hours).
66. e.g. 'Blast on Atom Submarine Kills One: Damage Heavy', New York Times, 16 June 1960, p. 5 (oxygen explosion and fire in aft torpedo room of USS Sargo; room flooded to prevent further explosions); '24 Die, 85 Hurt on Carrier Enterprise As Blasts Follow Fire on 2 Plane Decks', New York Times, 15 January 1969, pp. 1, 40 (rockets, bombs and 20mm amunition explode in fires); 'Jet Crashes on Deck of Carrier; 14 Die, 48 Hurt', Los Angeles Times, 28 May 1981, pp. 1, 10 (fire on USS Nimitz took 70 minutes to extinguish).
67. The most detailed list of accidents presented to the Committee was that in the submission from Greenpeace Australia (NSW) Ltd, pp. 20-22. See also Stockholm International Peace Research Institute, World Armament and Disarmament: SIPRI Year Book 1977, (MIT Press, Cambridge, Mass., 1977), pp. 68-70 for a table of nuclear weapon incidents which includes over 20 fires, collisions, etc., on US nuclear powered vessels. These listings are best seen as relating to allegations of accidents and incidents, rather than confirmed occurrences. The seriousness of the events listed also varies widely.
68. See for example submissions from Coalition Against Nuclear Armed & Powered Ships, p. 4 (Evidence, p. 1376); Friends of the Earth, p. 1. See also Evidence, p. 1393 (Coalition Against Nuclear Armed & Powered Ships). Media reports suggested the the USS Pintado nearly ran aground on rocks during a 1981 visit to HMAS Stirling; e.g. see the West Australian, 27 June 1988, p. 1, 'Tug saved N-sub during storm'. But the captain of a tug at the scene was reported as saying that the incident was being over-dramatised and that it would never have led to a nuclear incident: Canberra Times, 28 June 1988, p. 1, 'WA Government questions report of N-ship mishap'.

without any nuclear accident eventuating.[69] These conventional accidents tend to bear out the claim that the design and construction of nuclear powered warships incorporates a safety margin for combat stresses, battle damage, depth charging and the like. This margin assists in withstanding peacetime navigational hazards.

Accidents to Land-Based Reactors

5.40 Some submissions referred to the accident record of land-based reactors.[70] The differences between these reactors and naval reactors were set out in the previous chapter. The Committee took the view that, due to these differences, the accident record relating to land-based reactors was very much a second-best in the context of assessing the safety of naval reactors. Because of the extensive record relating directly to naval reactors, the Committee saw little need to consider the land-based reactor accident record as such in any detail.[71]

5.41 Briefly, the Committee notes, however, that there has never been an uncontained meltdown involving a land-based pressurised water reactor - that is, the type of reactor in use in western navies.[72] There has been only one contained core meltdown in such a reactor, that at the Three Mile Island reactor

----

69. cf. Evidence, p. 1393 (Coalition Against Nuclear Armed & Powered Ships).
70. e.g. submissions from Mr R. Bolt, pp. 7-8 (Evidence, pp. 957-58); Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 8 (Evidence, p. 794); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822). See also for example Evidence, pp. 979-80 and 981 (Mr R. Bolt).
71. The types of accidents that have occurred in land-based reactors are, of course, relevant to consideration of the types of accidents that may occur to naval reactors. But this is a diferent issue to the use of the accident frequency history of one type of reactor to assess the possible frequency of accidents to another.
72. See the table of reactor accidents that involved core damage in M. Eisenbud, Environmental Radioactivity from Natural, Industrial, and Military Sources, (3rd edn., Academic Press, Orlando, Fla., 1987), p. 225.

in 1979.[73]

5.42 Because so many submissions referred to the 1986 reactor accident at Chernobyl it is helpful to indicate the very limited ways in which the Committee saw that accident as relevant to its inquiry.[74] The accident indicates in a very general way that official statements by experts that an accident is unlikely may not be be borne out by events.[75] Similarly, it indicates that reactor operators cannot always be relied upon to follow safety rules. The fact that explosions occurred as the accident developed needs to be examined in evaluating possible accident scenarios for naval reactors. The consequences of the accident are of some relevance to assessing the consequences of a meltdown in an Australian port, were it to occur.

5.43 But beyond these points, the Committee saw the Chernobyl accident as having little bearing on its inquiry. The Chernobyl reactor, unlike the reactors on warships visiting Australian ports, did not have complete containment as part of its design. Moreover, it is physically impossible for the type of accident that occurred to the graphite-moderated reactor at Chernobyl to

----

73. cf Evidence, pp. 404-05 (ANSTO): '... in terms of history the event that has come closest to the reference accident we have used in our berth assessment was in fact Three Mile Island'. During 1988 media publicity was given to reports of accidents, some apparently involving damage or potential damage to fuel, at the US Department of Energy's Savannah River complex: e.g. see Australian Financial Review, 4 October 1988, p. 54, 'Accidents at nuclear plant in US kept secret'. The reactors involved are cooled and moderated by heavy water, not the light water used in naval reactors, and are designed for the production of plutonium and tritium, not power generation: see generally T. B. Cochran and others, Nuclear Weapons Databook, Volume II: U. S. Nuclear Warhead Production, (Ballinger, Cambridge, Mass., 1987), pp. 60-70.
74. cf. Evidence, pp. 994-95 (Mr R. Bolt).
75. As a matter of strict logic an estimate that a particular accident will happen only once in, say, 10,000 years is not falsified if the accident happens tomorrow. Assuming the accident is a random event and that the estimate is correct, the single accident is just as likely to happen tomorrow as on any other day in the 10,000 year period. But the occurrence so early in the period intuitively leads to serious doubt as to the accuracy of the original estimate. See generally Evidence, p. 392 (ANSTO); pp. 686-87, 689 (Dr T. P. Speed).

occur to a pressurised water reactor.[76] There is no justification for including in the accident record relevant to naval reactors an accident that cannot occur to those reactors.[77]

5.44 The Committee was referred to projections that have been made of the likelihood of a serious land-based reactor accident derived from the historical accident record of such reactors.[78] The methodology of these studies differs in some respects from the theoretical quantitative risk assessment studies referred to in chapter 3. It was put to the Committee that these projections should be used to estimate the probability of a serious accident occurring to a naval reactor.

5.45 The Committee did not consider the accident record of land-based reactors to be a helpful basis upon which to assess the likelihood of a naval reactor accident. The directly relevant record showing the absence of serious accidents involving United States Navy reactors is available. There is no need to refer to what can in this circumstance only be a second-best source.

5.46 In addition, any attempt to use the historical accident record of land-based reactors encounters the threshold difficulties of what reactor types should be considered

----

76. M. Eisenbud, Environmental Radioactivity from Natural, Industrial, and Military Sources, (3rd edn., Academic Press, Orlando, Fla., 1987), p. 377. This is because a graphite moderator does not have the self-regulating effect of a water moderator (this effect is explained at para. 4.5 above), but instead an increase in power level can make the core more reactive. In other words, the core power level is inherently unstable and requires operator or automatic control. Control was lost at Chernobyl due to a combination of circumstances, a very rapid power increase occurred, and explosions followed.

77. cf. Evidence, p. 443.448 (ANSTO). Another reason why the Chernobyl accident is of little relevance to assessing the possiblity of a naval reactor accident is that the former occurred during an experiment, yet experiments are not permitted during port visits to Australia.

78. e.g. submissions from Scientists Against Nuclear Arms (WA) and Medical Association for the Prevention of War (WA), p. 8 (Evidence, p. 794); Scientists Against Nuclear Arms (Tas), p. 3 (Evidence, p. 822).

relevant,[79] what allowance should be made for the many differences between land-based and naval reactors,[80] and how to exclude accident categories not relevant to port visit conditions.[81] Further difficulties arise with respect to particular historical studies.[82] Allowance needs to be made for what is widely accepted as the major increase in the safer operation of commercial reactors in the United States since the

----

79. A number of submissions referred to a 1986 calculation based on actual accidents which showed the probability that a major reactor accident could happen during the next ten years was 86%: S. Islam and K. Lindgren, 'How many reactor accidents will there be?', Nature, 21 August 1986, vol. 322, p. 691. The mathematics of the calculation generated correspondence; letters in Nature, 4 December 1986, vol. 324, p. 417 and 18 December 1986, vol. 324, p. 622. Whatever the merits of the mathematics, the conclusion has little relevance to naval reactors because it was based on two accidents, one of which was Chernobyl: see Evidence, p. 433.448 (ANSTO). See also above, paras. 5.42-5.43 on the relevance of Chernobyl.

80. See the previous chapter for these differences.

81. e.g. accidents happening during reactor refuelling, reactor repairs, acceptance trials, none of which activities occur during port visits to Australia.

82. e.g. Mr R. Bolt referred the Committee to a study based on the historical record relating to land-based reactors licensed by the Nuclear Regulatory Commission: submission, pp. 8, 9-10 (Evidence, pp. 958, 959-60) and Evidence, pp. 981, 993-94. He suggested that this study indicated that the risk of a major reactor accident was far more likely that that indicated by theoretical risk assessments. However, the preface to the report of the study states:

> Inevitably, the results of this report will be compared with the data in the Reactor Safety Study (WASH-1400) and other probabilistic risk assessment studies. Although the casual reader may interpret ... [this report's] results as incompatible with other core damage estimates, it is quite likely that because of the statistical uncertainty, no significant difference exists. That, of course, remains to be demonstrated.

J. W. Minarick and C. A. Kukielka, Precursors to Potential Severe Core Damage Accidents: 1969-1979 - A Status Report, (Oak Ridge Nat. Laboratory for the Nuclear Regulatory Commission, NUREG/CR-2497, June 1982), vol. 1, p. viii. A follow-up based on later data and reviewers' comments on the initial report showed a decrease by a factor of ten in the likelihood of severe core damage compared to the original reported results: W. B. Cottrell and others, Precursors to Potential Severe Core Damage Accidents: 1980-1981 - A Status Report, (Oak Ridge Nat. Laboratory for the Nuclear Regulatory Commission, NUREG/CR-3591, July 1984), p. xxvi. 'Likelihood of damage' as used in these reports has a specific, defined meaning.

Three Mile Island accident in 1979.[83] Past accidents, while unfortunate, have provided costly lessons that nonetheless add to current safety.

Conclusions

5.47 The Committee accepts that, as a matter of logic, the fact that an accident has not yet happened does not prove in any absolute sense that it will not happen tomorrow. However, the safety record of United States Navy reactors extends over a large number of reactors across more than thirty years. In the Committee's view this safety record provides very persuasive evidence that the probability of any accident involving a significant release of radiation during a visit to an Australian port is extremely small.

5.48 At the same time the Committee recognises that reactor accidents are classed as rare events. Because of this it is prudent not to rely exclusively on the historical record, even the present safety record extending for over three thousand reactor-years.[84] Some regard for the theoretical accident likelihood is also appropriate and this is considered in chapter 7.

----

83. e.g. US, Nuclear Regulatory Commission, Reactor Risk Reference Document, (NUREG-1150 (draft), NRC, Washington, 1987), p. ES-1: as a result of the Three Mile Island accident, 'numerous modifications to U. S. light-water reactor plant designs and operating procedures were made'.

84. As a very rough guide to the degree to which the historical record is not a reliable means of assessing accident probability and outcome, one study has suggested in passing that if something like 50,000 reactor-years of commercial operation had taken place direct reliance on the historical record would yield more accurate results than theoretical approaches: W. B. Cottrell and others, Precursors to Potential Severe Core Damage Accidents: 1980-1981 - A Status Report, (Oak Ridge Nat. Laboratory for the Nuclear Regulatory Commission, NUREG/CR-3591, July 1984), p. 2-3. It might be expected that the naval reactor-years required would be somewhat less as there are far fewer naval reactor designs and types, and less variation in operating standards.